Energy Audit Summary Report

AEE INTEC

Audit no. 42 – BUL04

University

14th of February 2012

Supported by INTELLIGENT ENERGY EUROPE

This energy audit has been carried out with cofunding of the European Commission (EACI) in the Framework of the EU funded project EINSTEIN-II (ProjectNo. IEE/09/702/SI2.558239)

AUDIT no. 42 - BUL04

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 2011.

3.1. General information of the company

Sector:	Education
Products:	no products
No. of employees:	620 employees, 420 teachers, 10500 students

Current primary energy consumption 13,756 [MWh/a]

3.2. Flow sheet of the whole manufacturing side

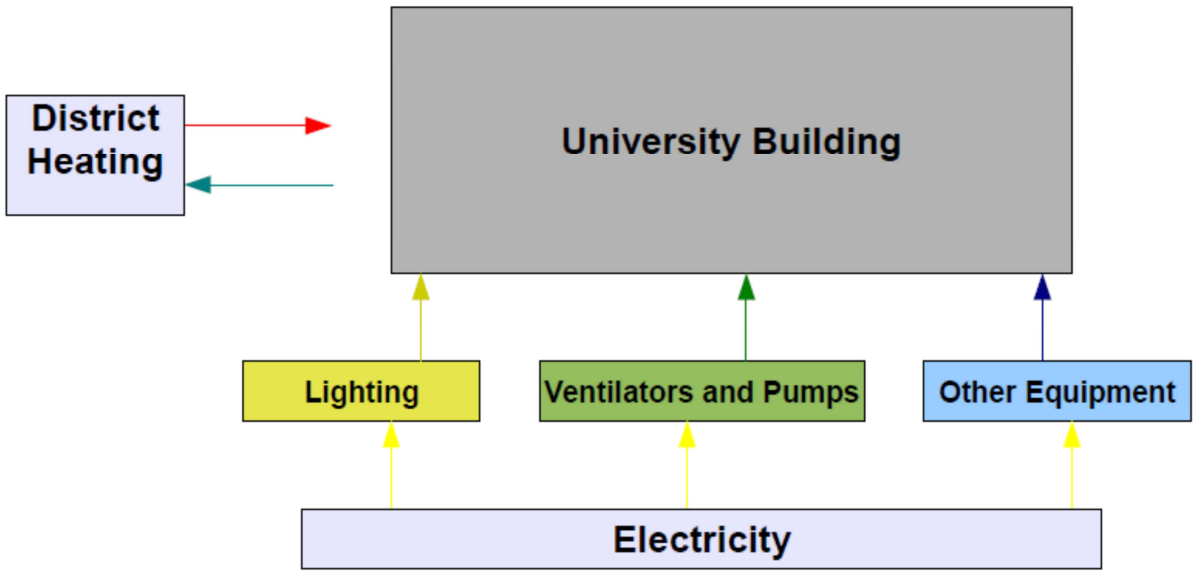

Figure 1: Flow sheet of school

3.3. Description of the existing system

- **Energy Supply:**

The university is mainly consuming energy for heating purposes especially in the winter period. In addition it has electrical consumption for lighting and the electrical devices within the university.

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	7,223	52.51	7,223	90.74
Total electricity	6,533	47.49	737	9.26
Total (fuels + electricity)	**13,756**	**100.00**	**7,960**	**100.00**

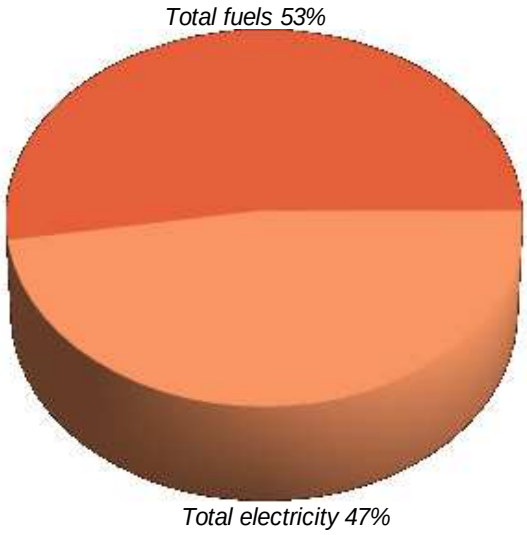

Figure 2: distribution of PEC by fuel type

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

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
district heating	6,566	74.45	6,566	96.27
Electricity	2,253	25.55	254	3.73
Total	8,819	100.00	6,820	100.00

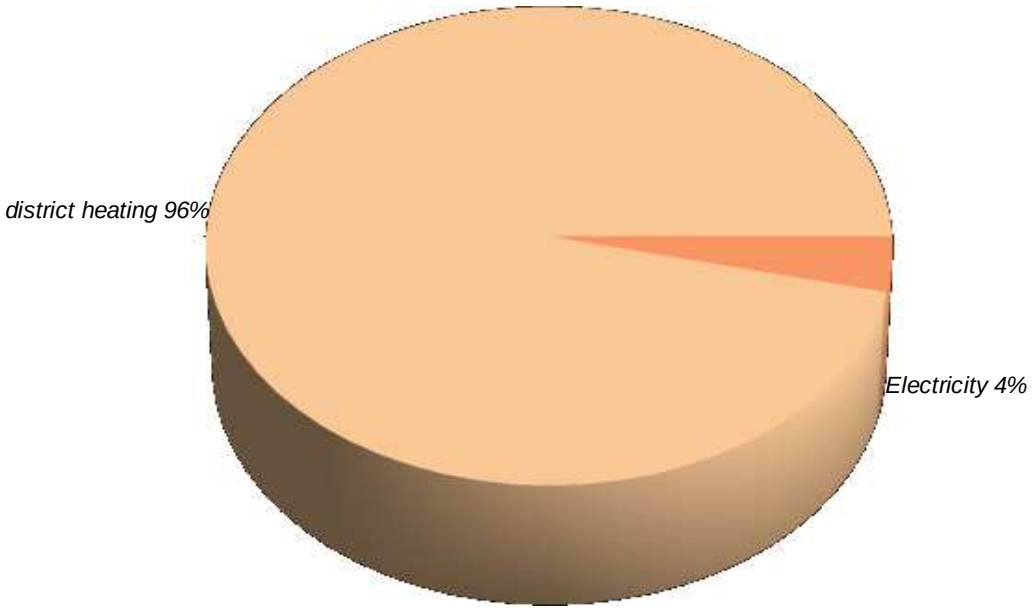

Figure 3: Total final energy consumption for thermal use (FET)

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]
AC chiller	Electricity	40	0.58
district heating	district heating	6,570	96.34
hot water flow heaters	Electricity	210	3.08
Total		**6,820**	**100.00**

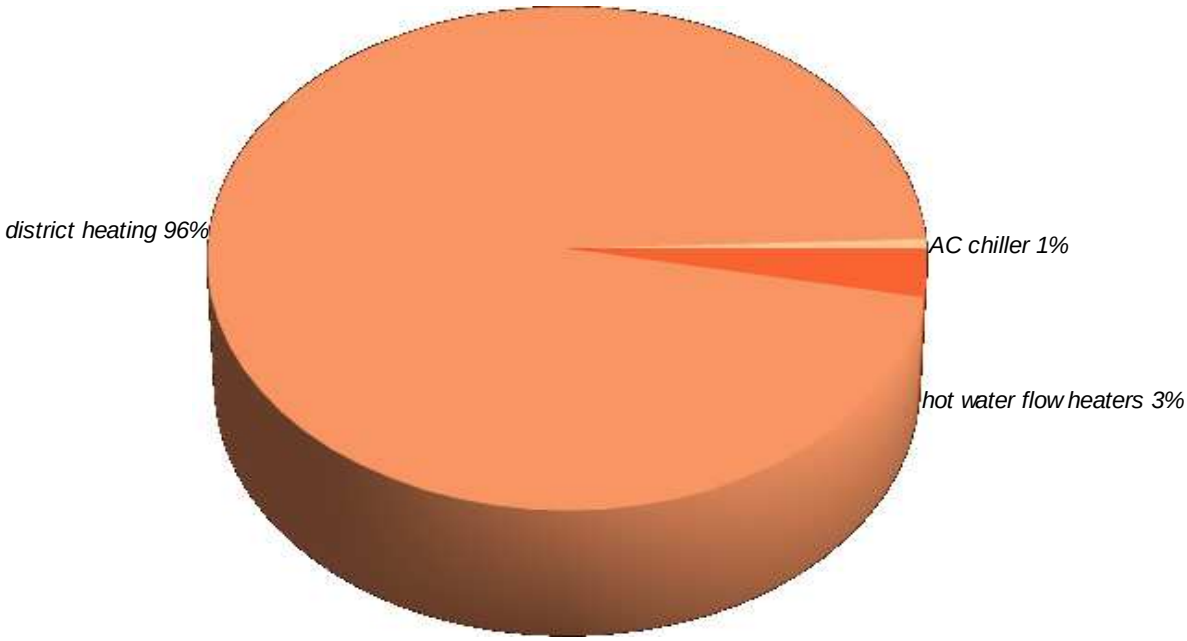

Figure 4: Final energy consumption for thermal use (FET) by equipment

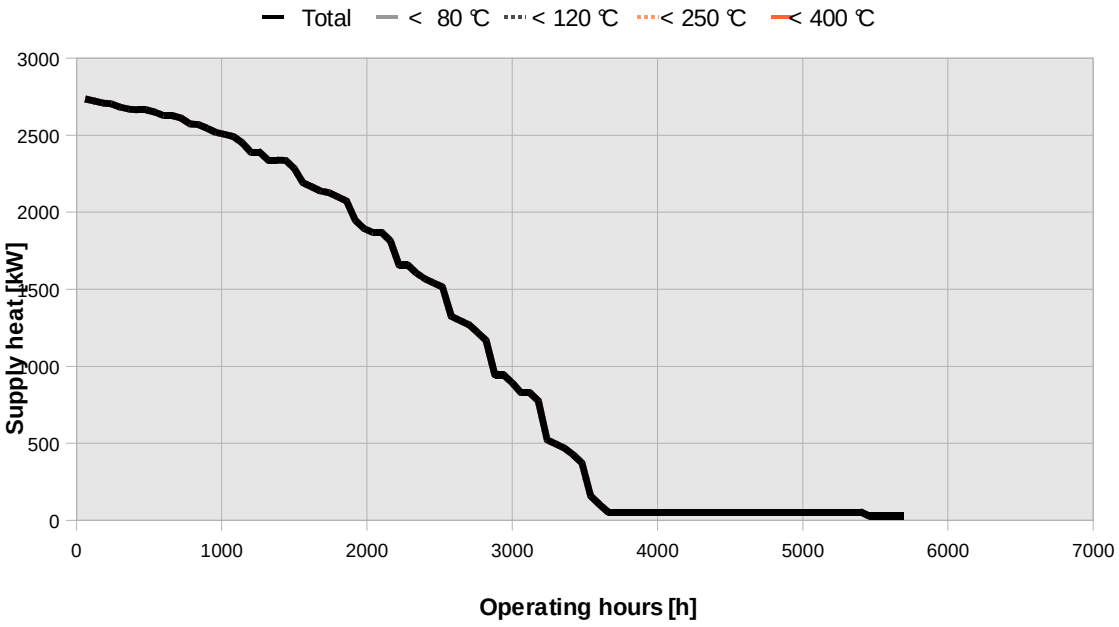

Figure 5: Distribution of supply heat by temperature levels and annual operating hours. Present state.

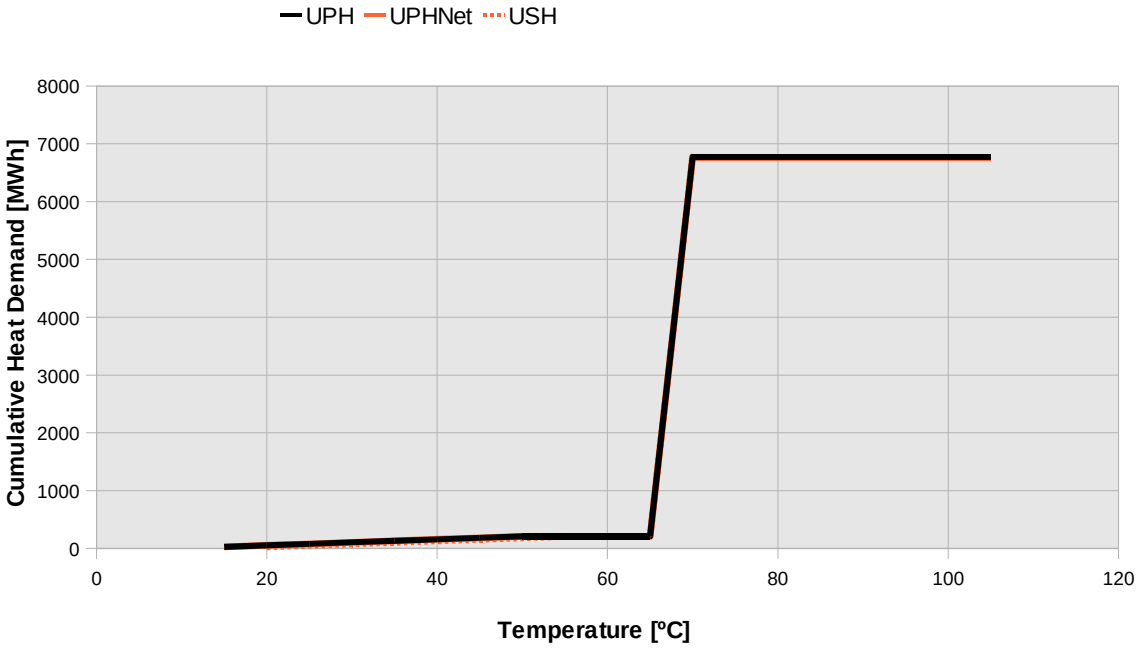

Figure 6: Distribution of the heat demand by temperature levels

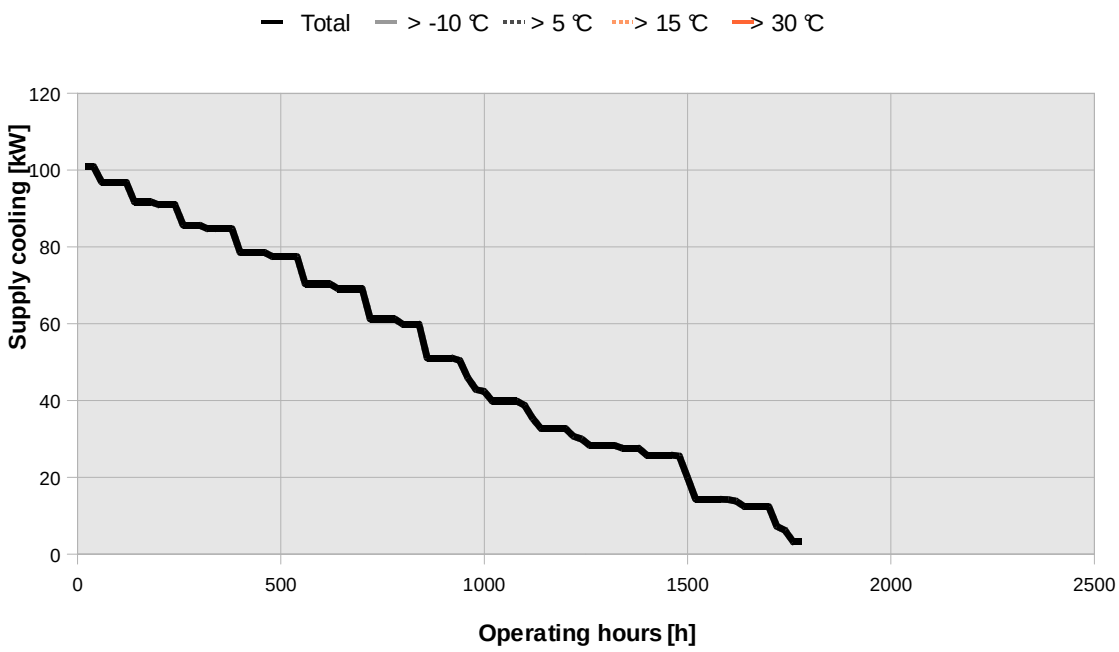

Figure 7: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

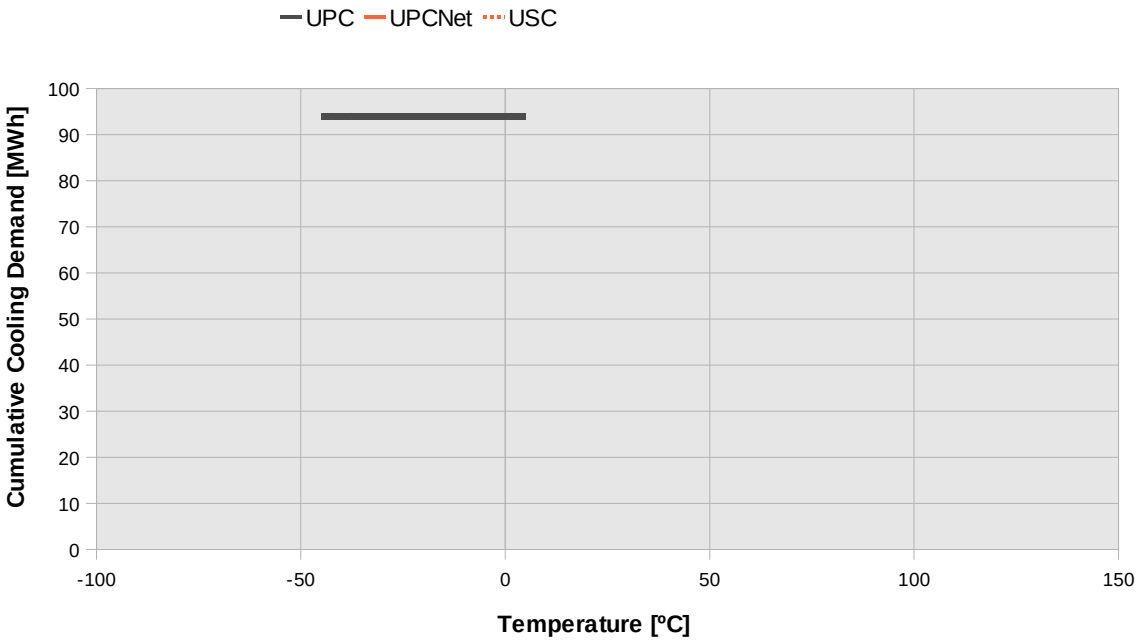

Figure 8: Distribution of the cooling demand by temperature levels

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
district heating	6,566	96.90
hot water flow heaters	210	3.10
Total	**6,776**	**100.00**

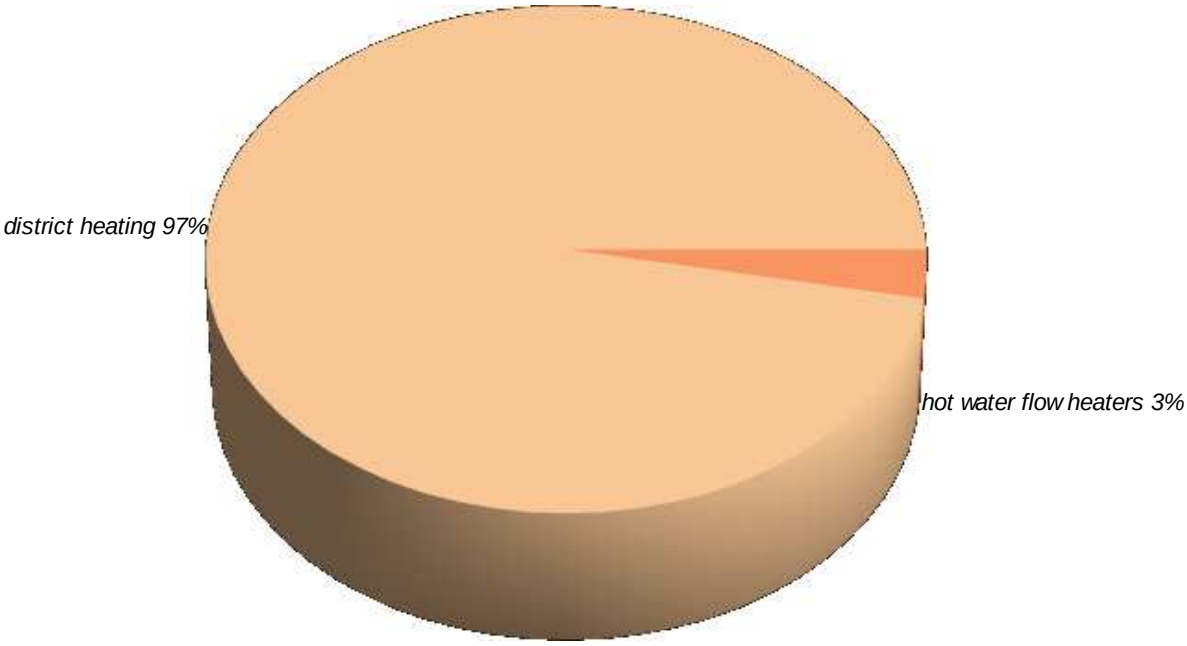

Figure 9: Useful supply heat (USH) by equipment. Present state.

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

Equipment	USC by equipment	
	[MWh]	[% of Total]
AC chiller	94	100.00
Total	**94**	**100.00**

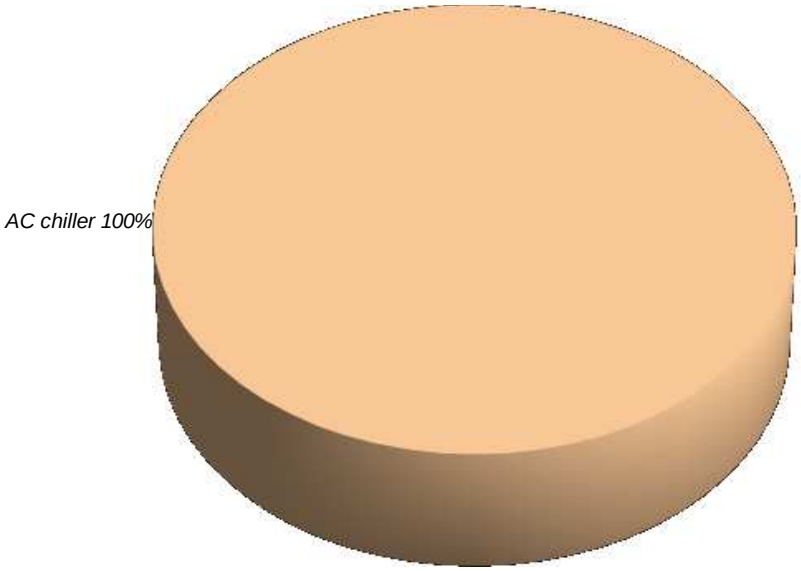

Figure 10: Useful supply cooling (USC) by equipment. Present state.

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

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Uni Ruse_heating	6,566	0	6,566	0
Uni Ruse_HW	210	210	0	0
Total	**6,776**	**210**	**6,566**	**0**

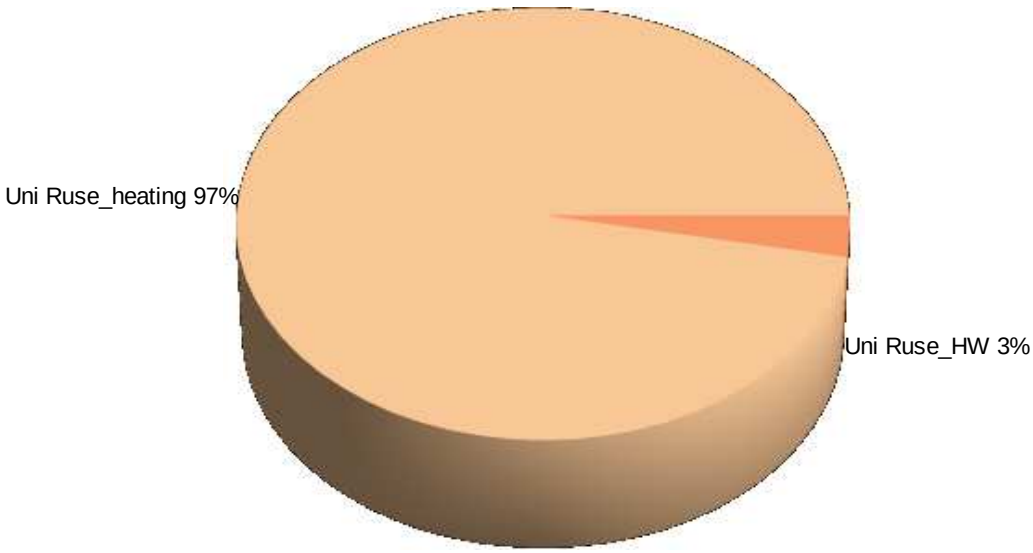

Figure 11: Useful process heat (UPH) by process

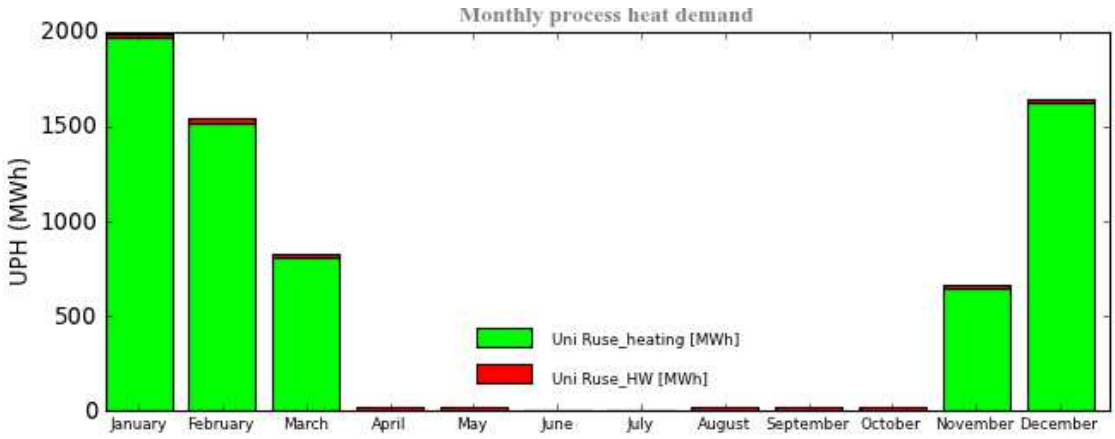

Figure 12: Distribution of useful process heat demand per month

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

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Uni Ruse_cooling	94	0	94	0
Total	**94**	**0**	**94**	**0**

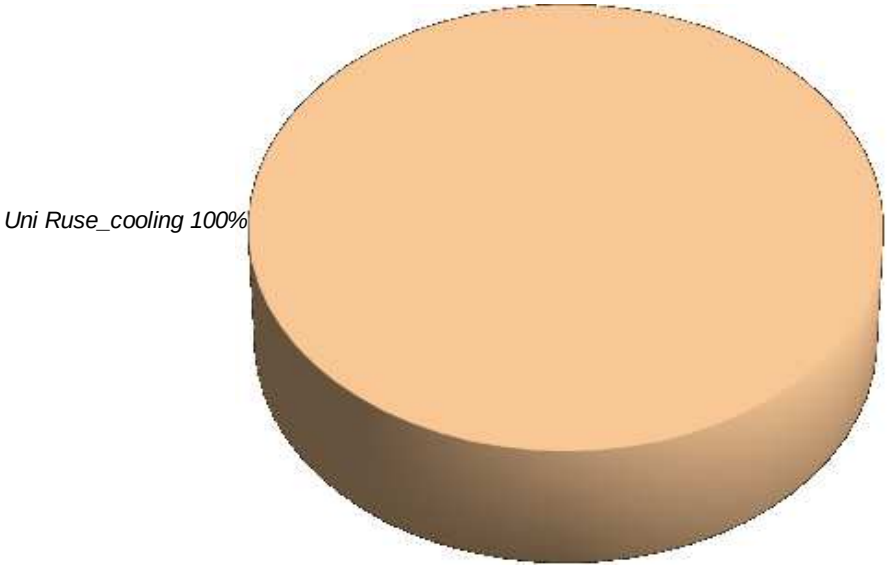

Figure 13: Useful process cooling (UPC) by process

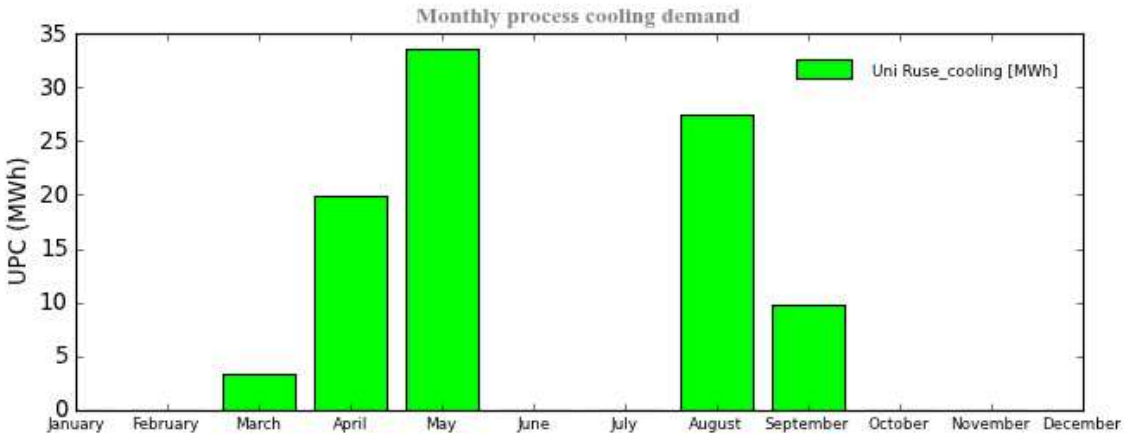

Figure 14: Distribution of useful process cooling demand per month

3.4. General

- The target room temperature during winter is 22 °C.
- The hot water demand was estimated to be 15 m³ per day which corresponds to a hot water consumption of around 8 litres per day and person.

4. Comparative study

4.1. Proposed alternatives

There are three proposals made in this study. In the first one the hot water is produced by a solar thermal plant. In the second proposal CHP (combined heat and power) system is installed and in the third one a better insulation for the building is proposed.

Table 8: Overview of the alternative proposals studied

Short Name	Description
solar	based on present state an additionally a solar thermal plant is installed
CHP	based on present state a CHP (combined heat and power) plant is installed
insulation	based on present state a better insulation of the building is suggested

4.1.1. Heat Supply

- **Solar:**

Collector type:	FPC (flat plate collectors)
Installed capacity:	662.2 kW
Installed collector area:	946 m²
Solar buffer storage volume:	47.3 m³
Solar fraction:	90.49 %
Annual energy yield:	287.2 kWh/kWa

Table 9: 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	662	190	2.81
AC chiller	104	94	100.00
district heating	3,000	6,586	97.19
Total	**3,766**	**6,870**	**200**

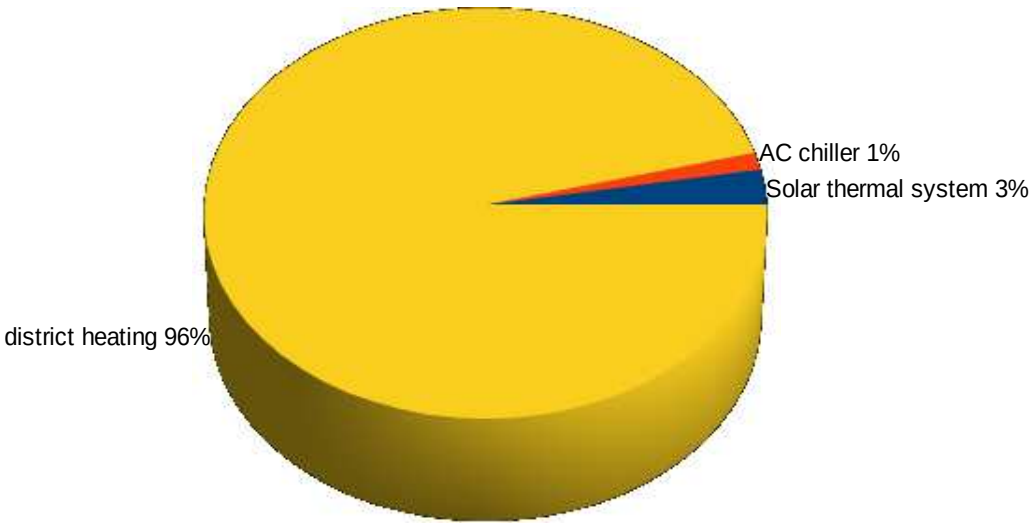

Figure 15: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by solar:

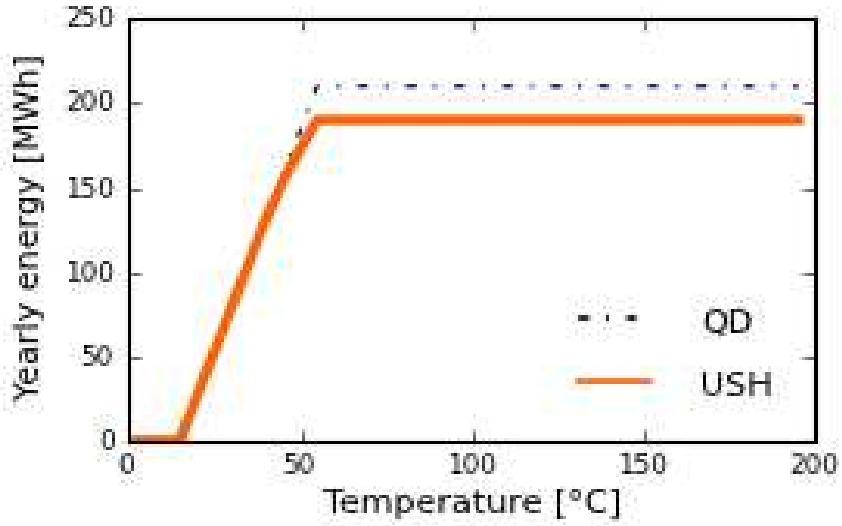

Figure 16: Heat demand and solar contribution

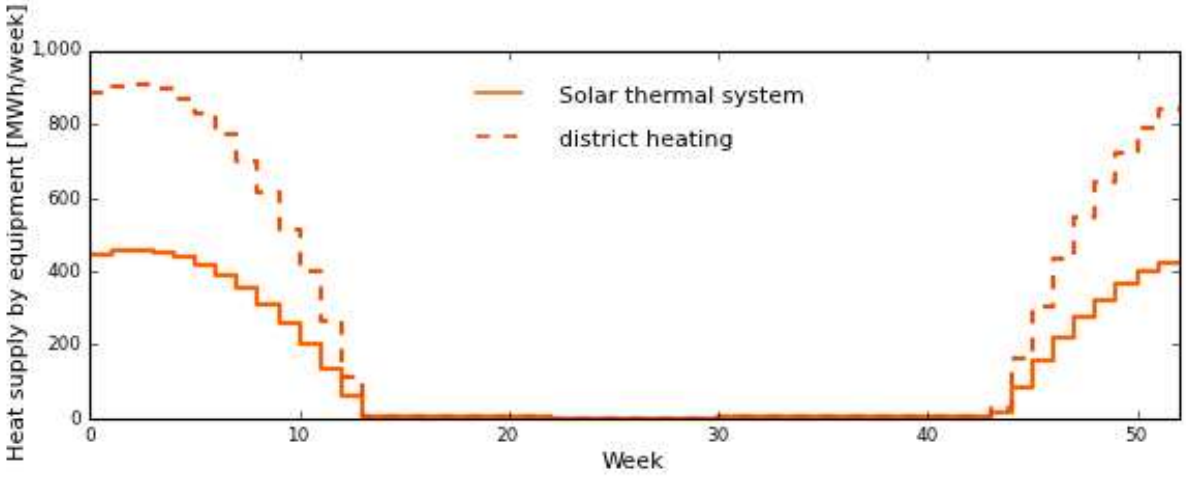

Figure 17: daily heat supply by equipment

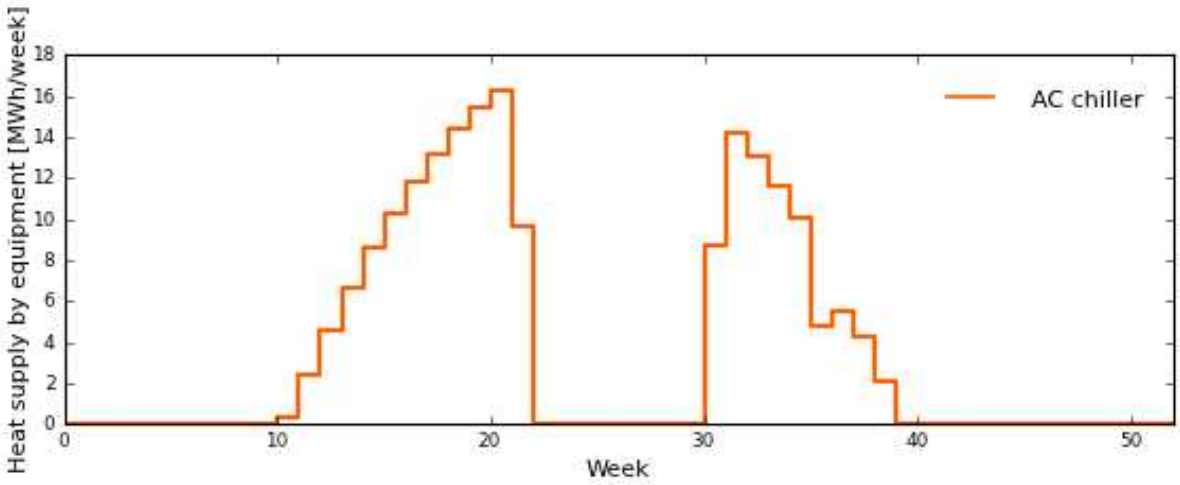

Figure 18: daily cold supply by equipment

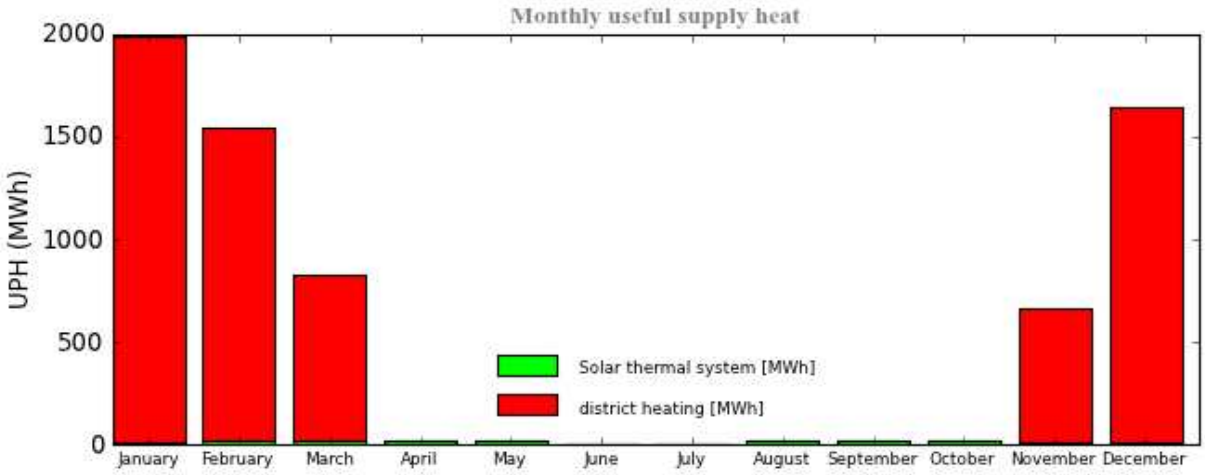

Figure 19: Distribution of useful process heat supply per month

Figure 20: Distribution of useful process cold supply per month

- **CHP:**

Type:	CHP natural gas motor
Installed thermal capacity:	1,219 kW
Installed electric capacity:	650 kW
Thermal efficiency:	0.6
Electric efficiency:	0.32
Operating hours:	4,064 h

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]	[%]
New CHP 1	1,219	3,524	52.01
AC chiller	104	94	100.00
district heating	3,000	3,201	47.24
hot water flow heaters	100	51	0.75
Total	**4,423**	**6,870**	**200**

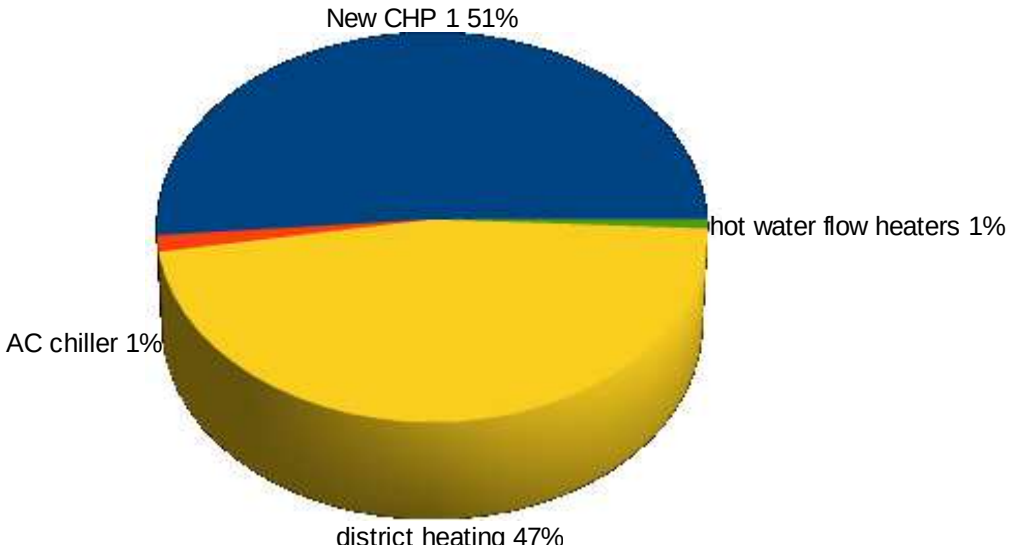

Figure 21: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by CHP:

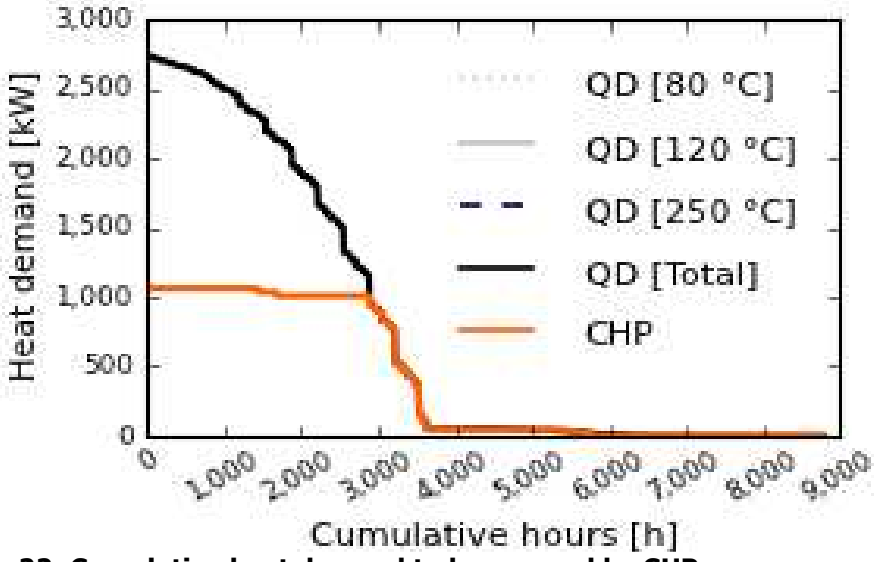

Figure 22: Cumulative heat demand to be covered by CHP

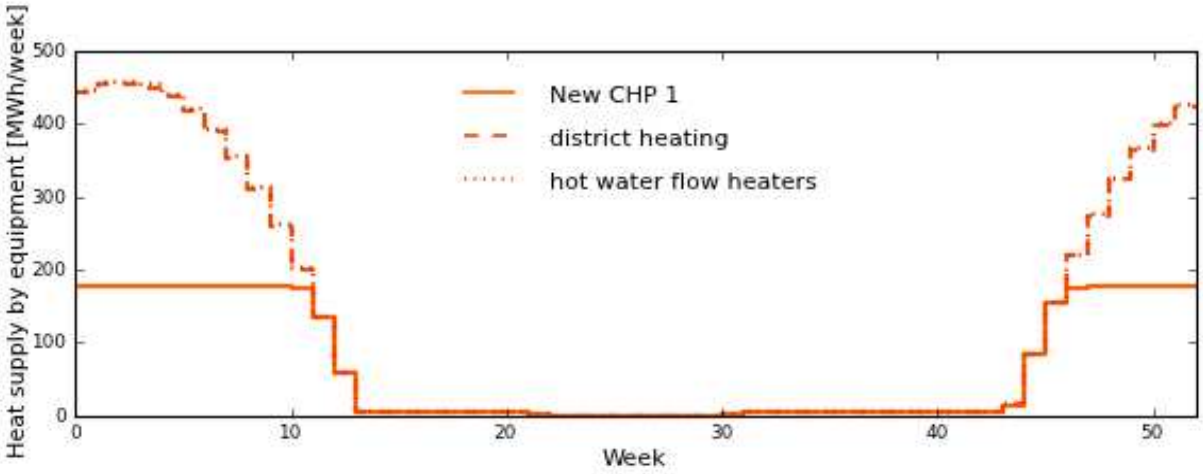

Figure 23: Daily heat supply by equipment

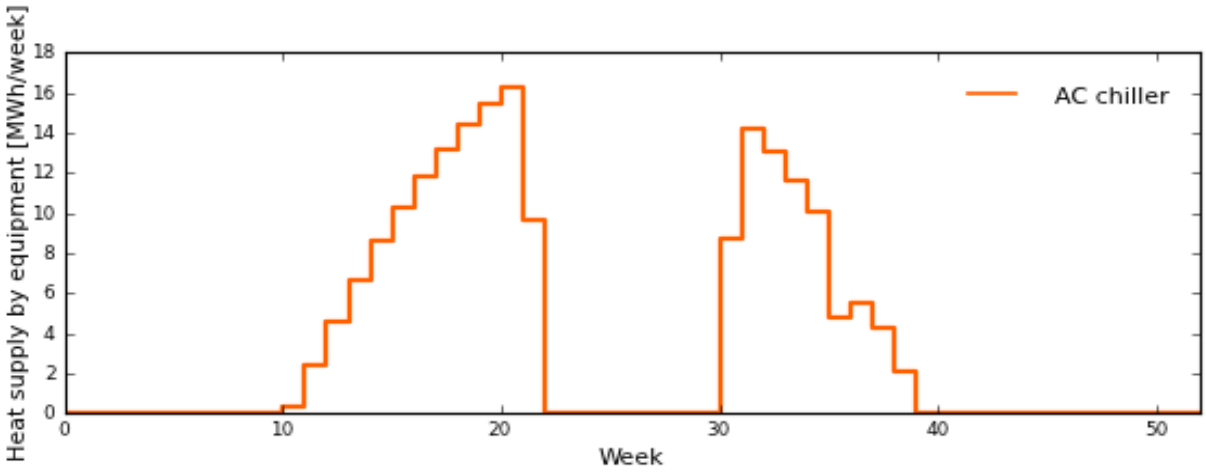

Figure 24: Daily heat supply by equipment

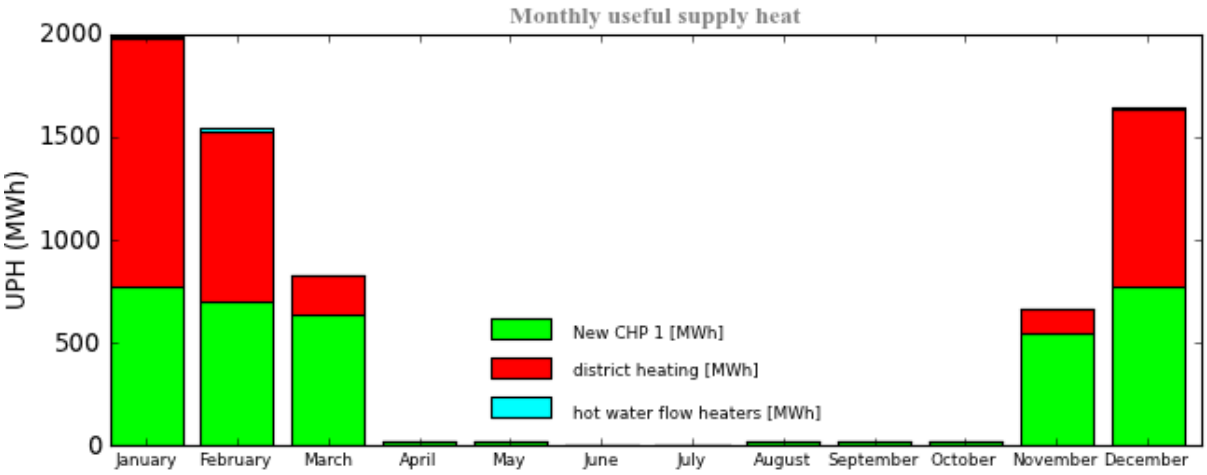

Figure 25: Distribution of useful process heat supply per month

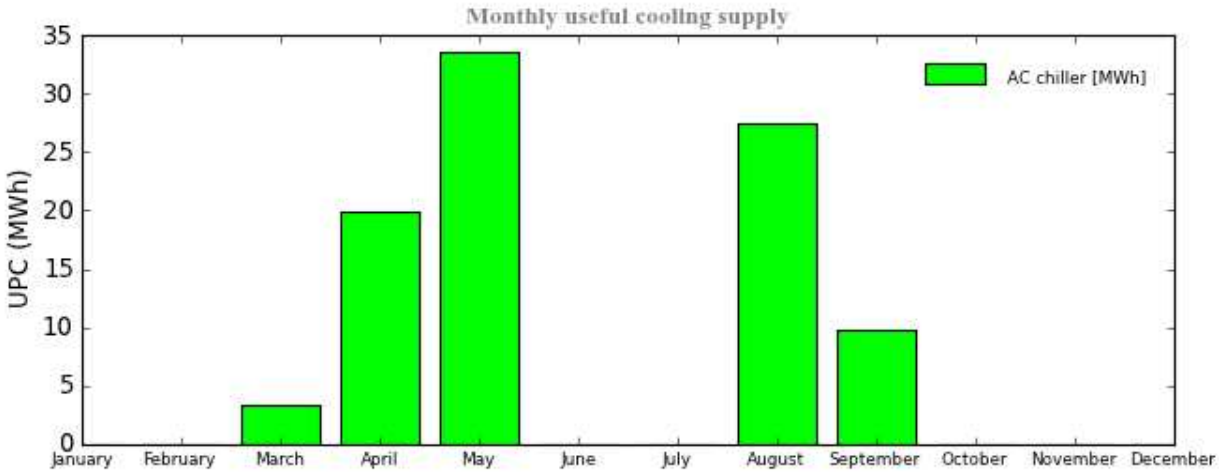

Figure 26: Distribution of useful process cold supply per month

- **Insulation:**

By increasing the insulation of the building, 2,498 MWh of final energy could be saved. At the present state the university has a heating demand per square meter of 145 kWh/m²a, with the insulation it was assumed that the heating demand will decrease to 90 kWh/m²a. This means that the previous heating demand is lowered around 38 %.

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]	[%]
AC chiller	104	94	100.00
district heating	3,000	4,068	95.09
hot water flow heaters	100	210	4.91
Total	**3,204**	**4,373**	**200**

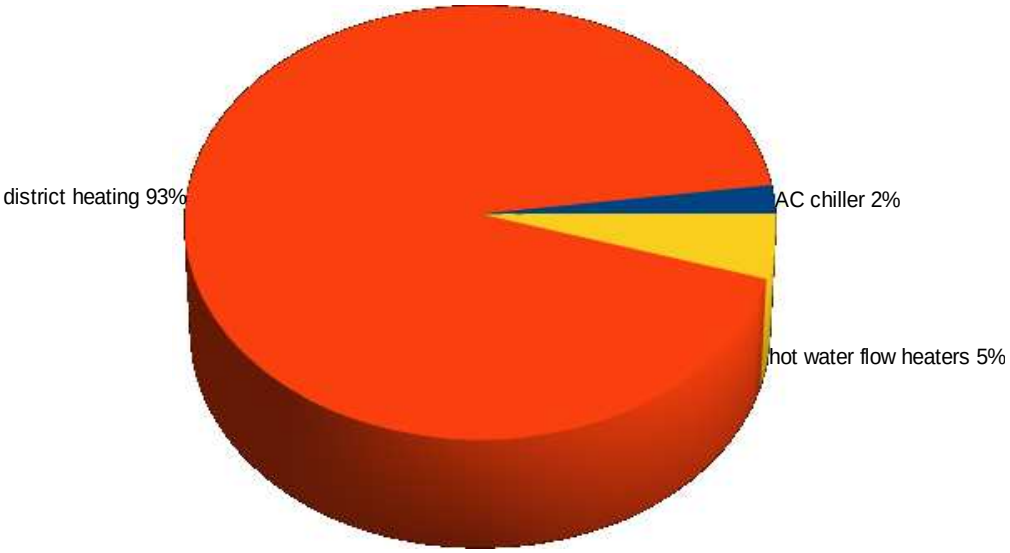

Figure 27: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by boilers:

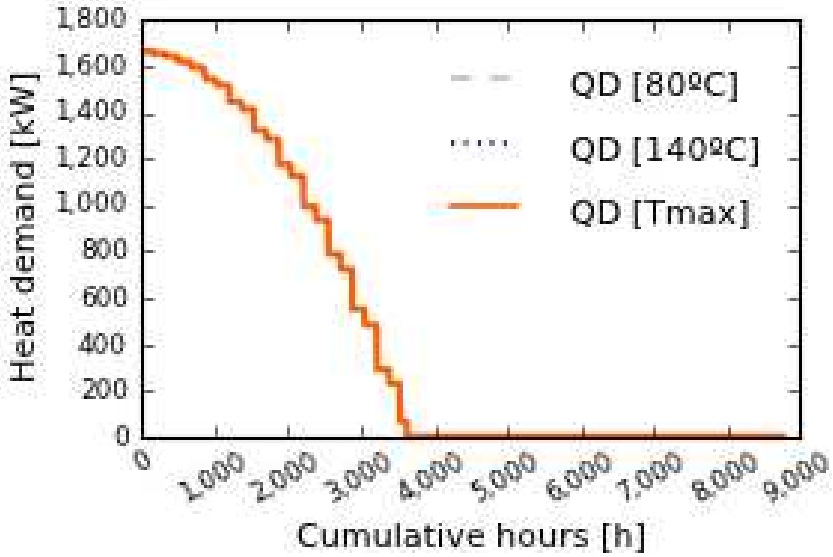

Figure 28: Cumulative heat supply to be covered by boilers

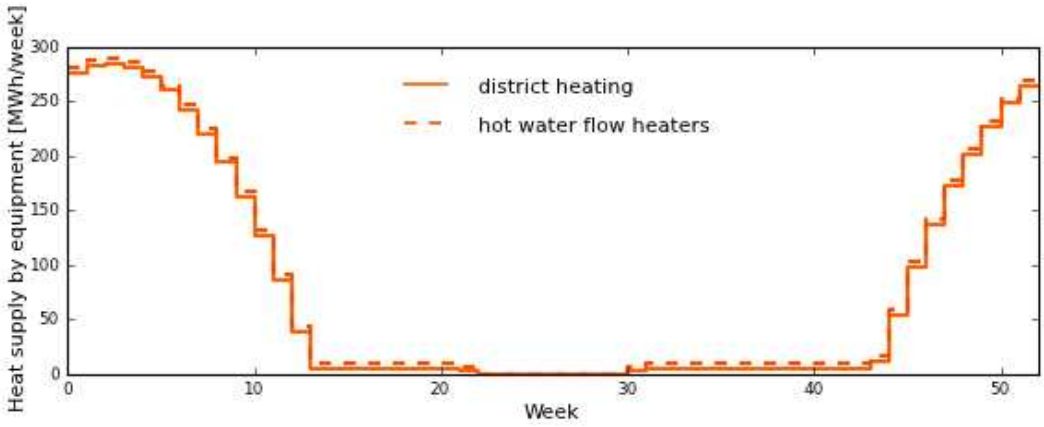

Figure 29: Daily heat supply by equipment

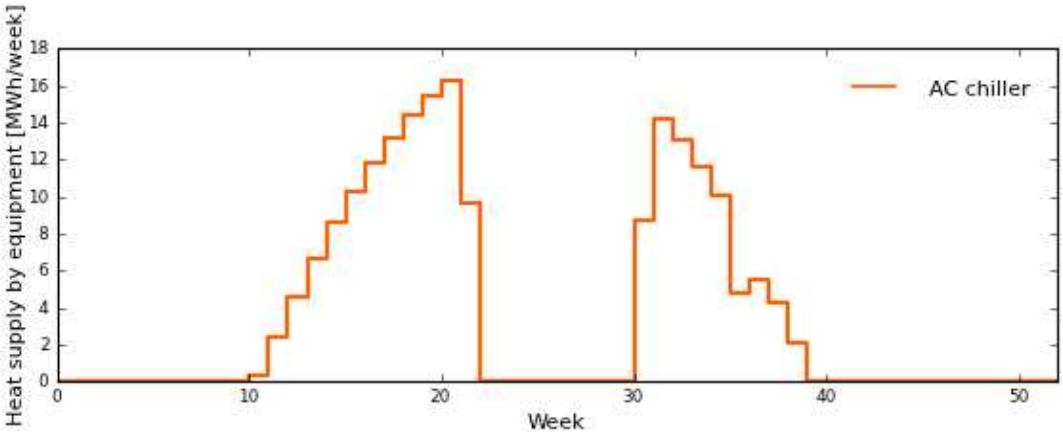

Figure 30: Daily heat supply by equipment

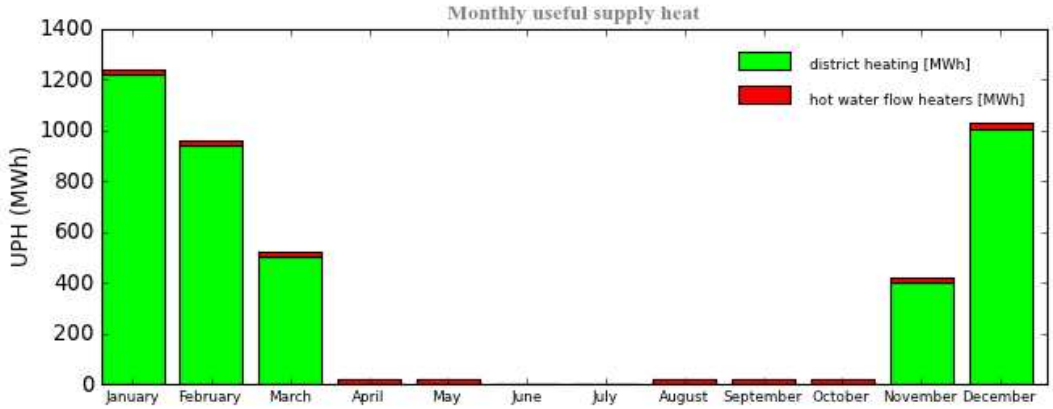

Figure 31: Distribution of useful process heat supply per month

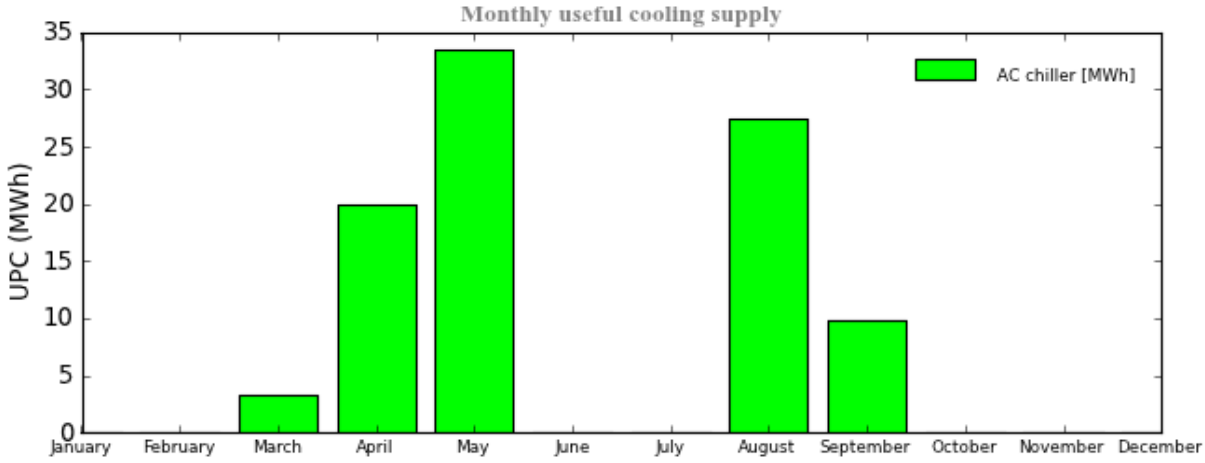

Figure 32: Distribution of useful process cold supply per month

- Primary energy consumption (PEC)

Table 12: primary energy consumption and savings

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	13,756	---	---
solar	13,175	581	4.22
CHP	10,809	2,947	21.43
insulation	11,005	2,751	20.00

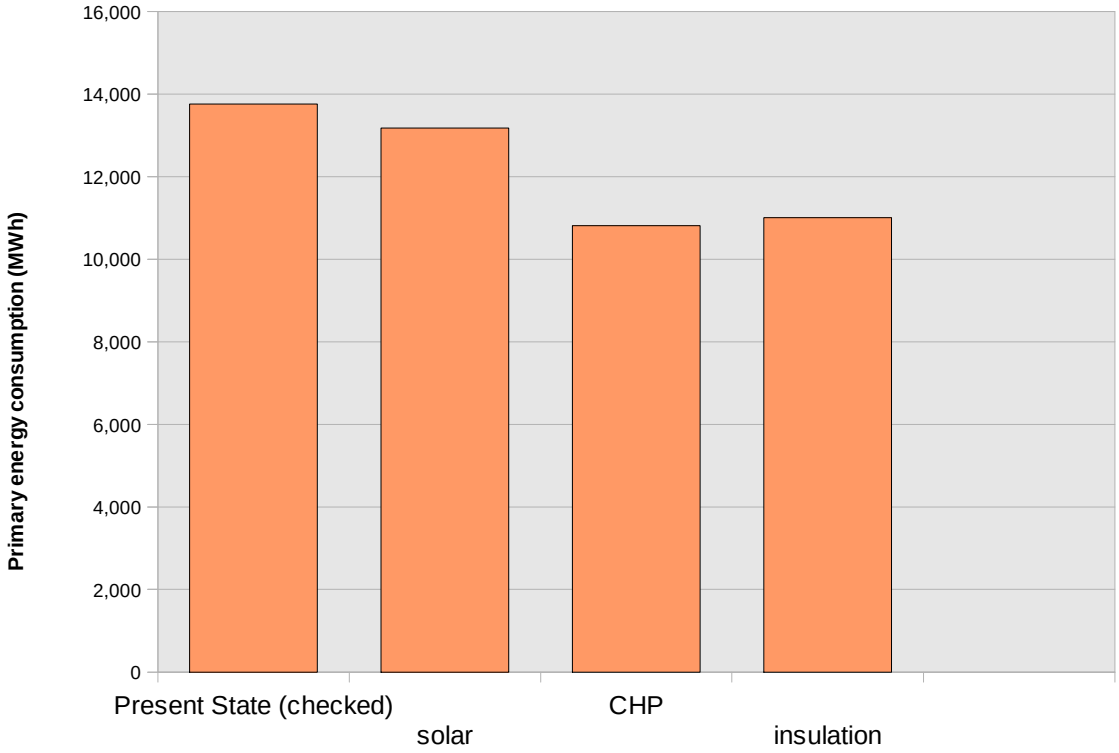

Figure 33: Comparison of alternatives: primary energy consumption

- 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 13: 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)	6,776	---	6,776	---
solar	6,776	0	6,776	0
CHP	6,776	0	6,776	0
insulation	4,279	2,498	4,279	2,498

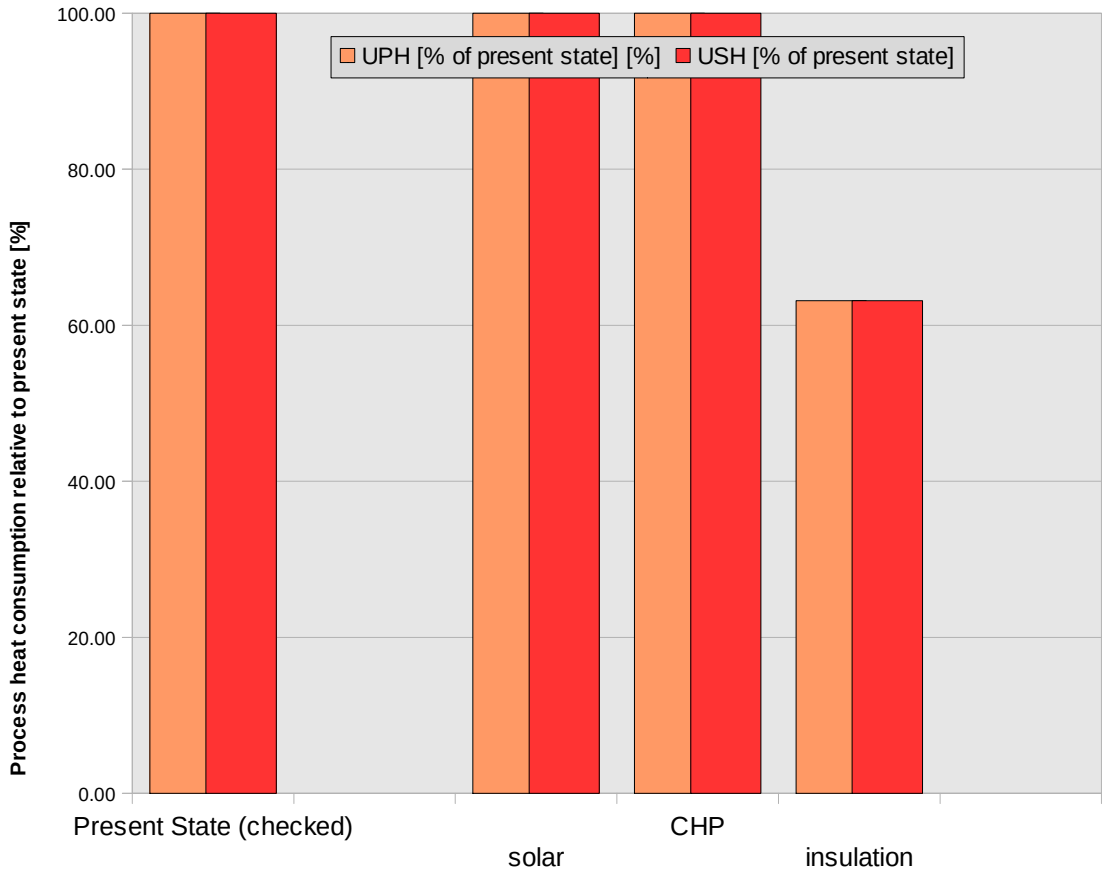

Figure 34: Comparison of alternatives: useful process heat supply

- 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 14: 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)	94	---	94	---
solar	94	0	94	0
CHP	94	0	94	0
insulation	94	0	94	0

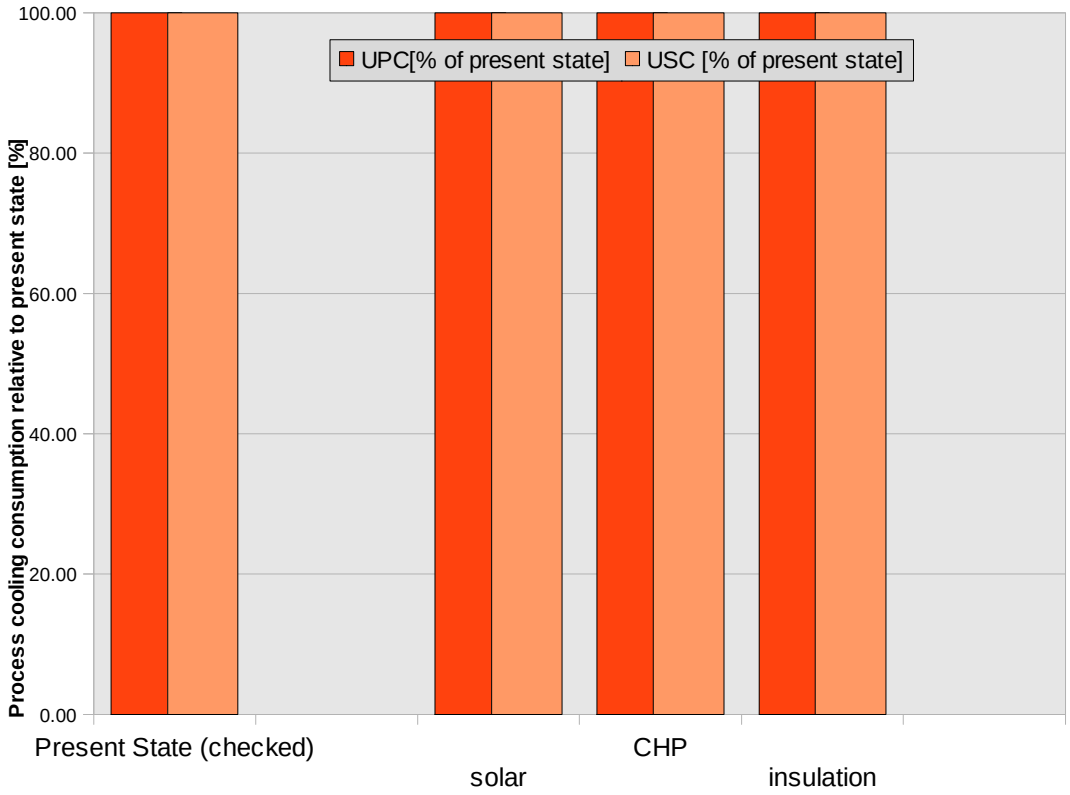

Figure 35: Comparison of alternatives: useful process cooling supply

- Environmental impact

Table 15: CO2 production and CO2 savings per year

Alternative	Production of CO2	Water Consumption
	[t]	[m3]
Present State (checked)	2767.93	0.00
solar	2669.05	0.00
CHP	2485.51	0.00
insulation	2142.95	0.00

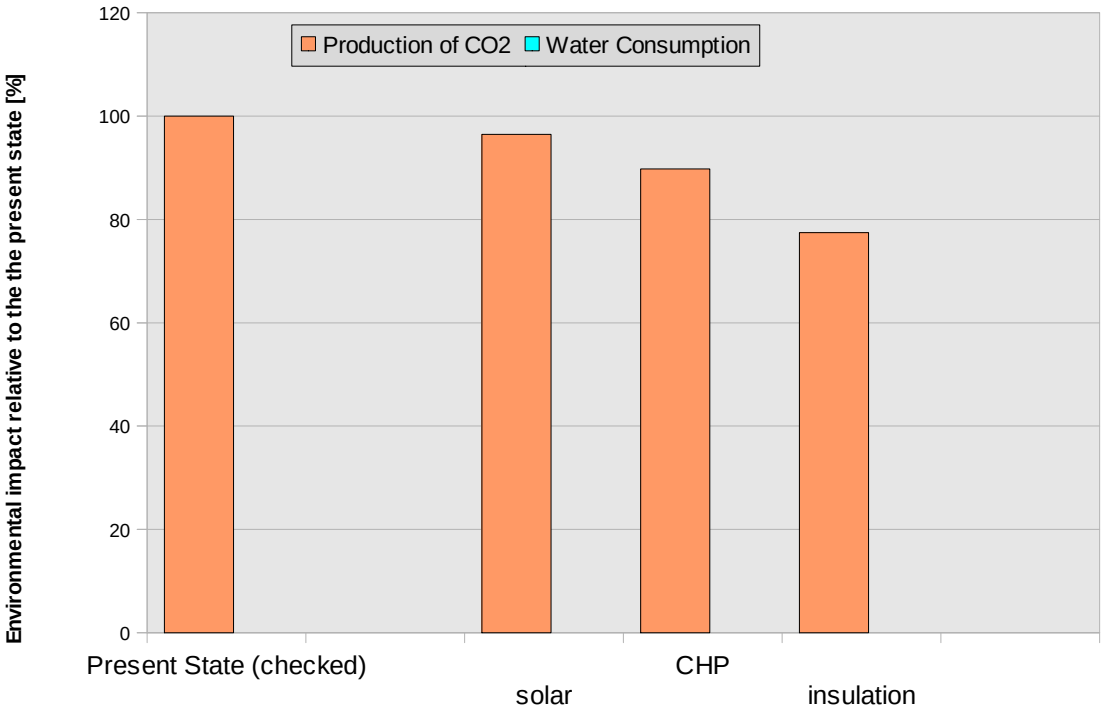

Figure 36: Comparison of alternatives: environmental impact

Table 16: Investment costs and subsidies of the proposals

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State (checked)	---	---	---
solar	430,430	301,301	129,129
CHP	722,500	722,500	0
insulation	800,000	800,000	0

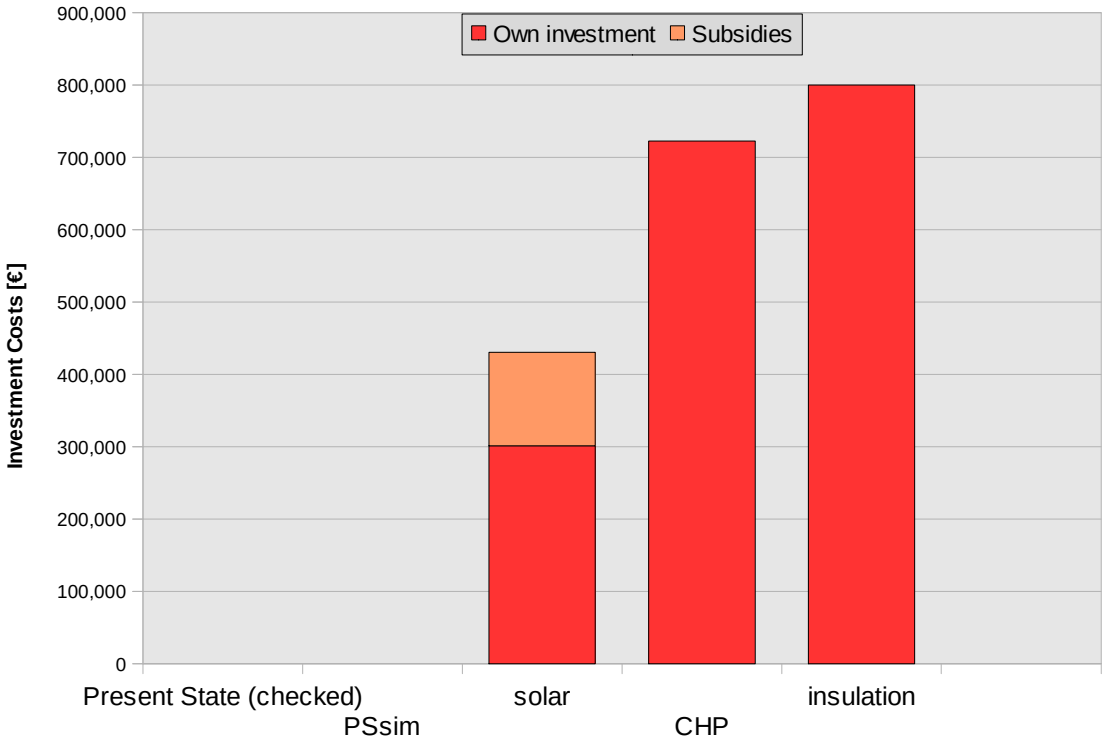

Figure 37: Comparison of alternatives investment cost

5. Selected alternative(s) and conclusions

5.1. Selected alternative

As selected alternative the "Insulation" 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)

As mentioned before, by increasing the insulation of the building, 2,498 MWh of final energy could be saved. At the present state the university has a heating demand per square meter of 145 kWh/m²a, with the insulation it was assumed that the heating demand will decrease to 90 kWh/m²a. This means that the previous heating demand is lowered around 38 %.

5.1.2. Heat Supply

- **Insulation:**

Table 17: 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]	[%]
AC chiller	104	94	100.00
district heating	3,000	4,068	95.09
hot water flow heaters	100	210	4.91
Total	**3,204**	**4,373**	**200**

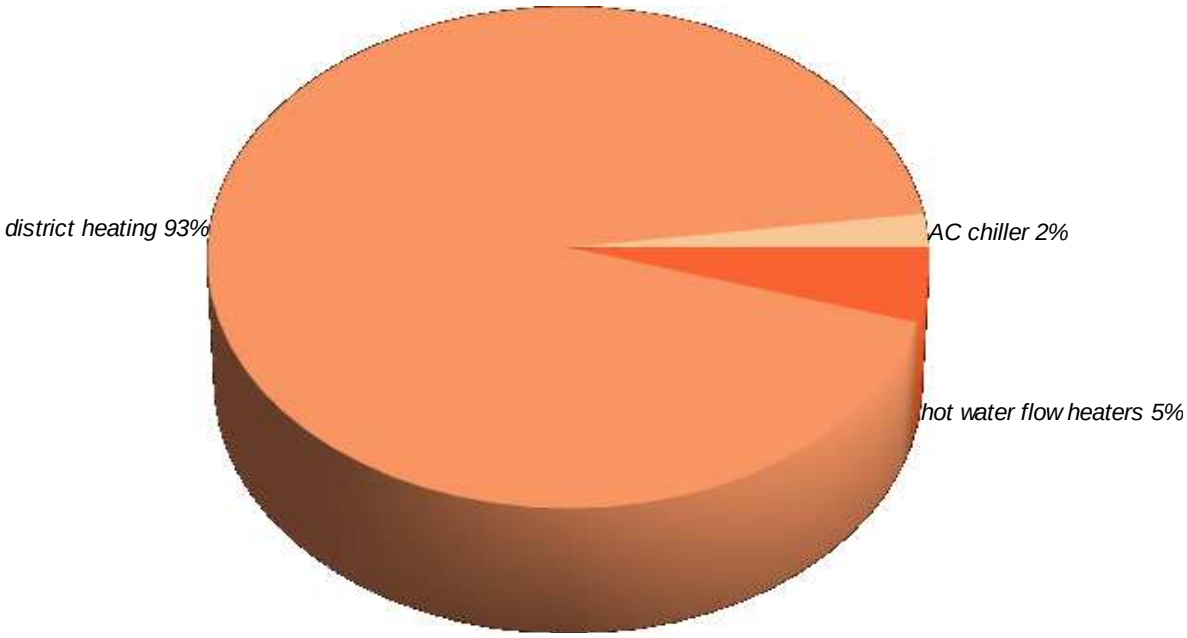

Figure 38: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

5.1.3. Energy Consumption

Table 18: Total primary energy consumption (PEC) and primary energy consumption for thermal use (PET)

Energy type (fuels / electricity)	PEC		PET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Total fuels	4,475	40.66	4,475	85.98
Total electricity	6,530	59.34	730	14.02
Total (fuels + electricity)	**11,005**	**100.00**	**5,205**	**100.00**

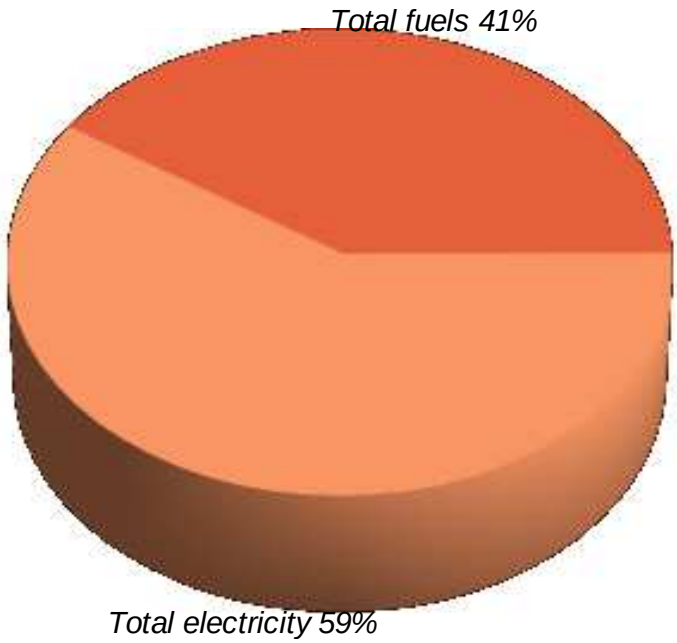

Figure 39: Distribution of PEC by fuel type

Table 19: 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]
district heating	4,068	64.37	4,068	94.17
Electricity	2,252	35.63	252	5.83
Total	**6,320**	**100.00**	**4,320**	**100.00**

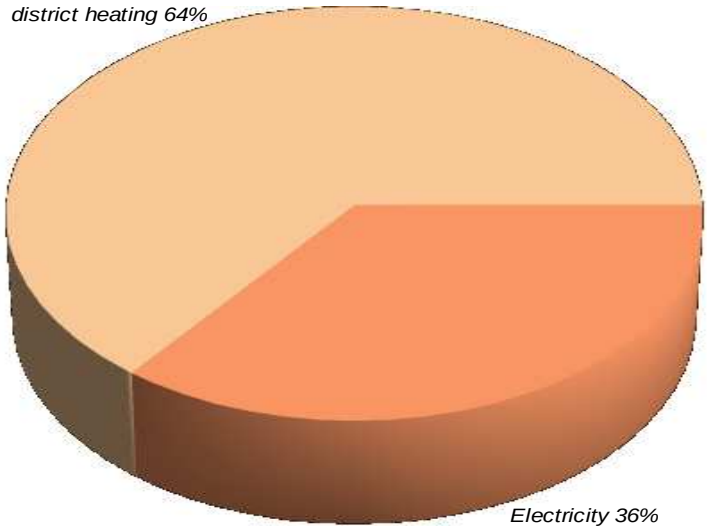

Figure 40: Total final energy consumption (FEC). Proposed final solution.

Table 20 : Final energy consumption for thermal use (FET) by equipment. Proposed final solution.

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
AC chiller	Electricity	39	0.90
district heating	district heating	4,071	94.24
hot water flow heaters	Electricity	210	4.87
Total		**4,320**	**100**

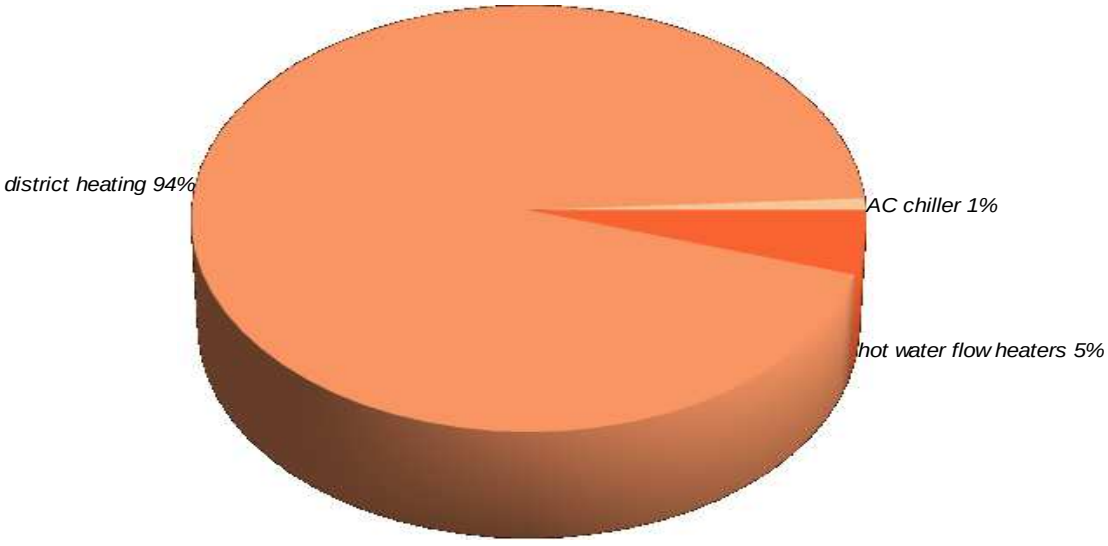

Figure 41: Final energy consumption for thermal use (FET) by equipment

Table 21 : Useful supply heat (USH) by equipment. Proposed final solution.

Equipment	USH by equipment	
	[MWh]	[% of Total]
district heating	4,068	95.09
hot water flow heaters	210	4.91
Total	**4,279**	**100**

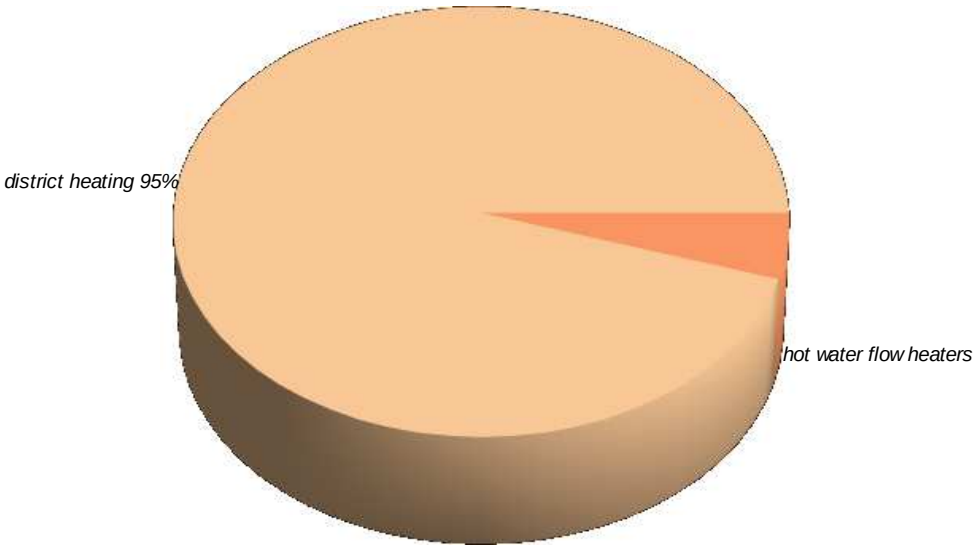

Figure 42: Useful supply heat (USH) by equipment. Proposed final solution

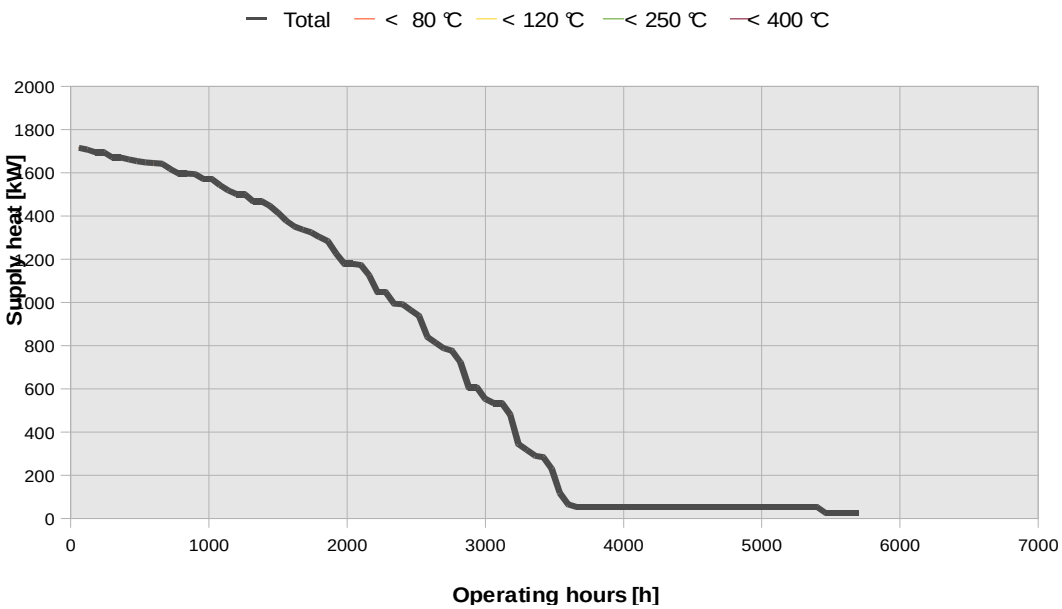

Figure 43: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

Table 22 : Useful supply cooling (USC) by equipment. Proposed final solution.

Equipment	USC by equipment	
	[MWh]	[% of Total]
AC chiller	94	100.00
Total	**94**	**100**

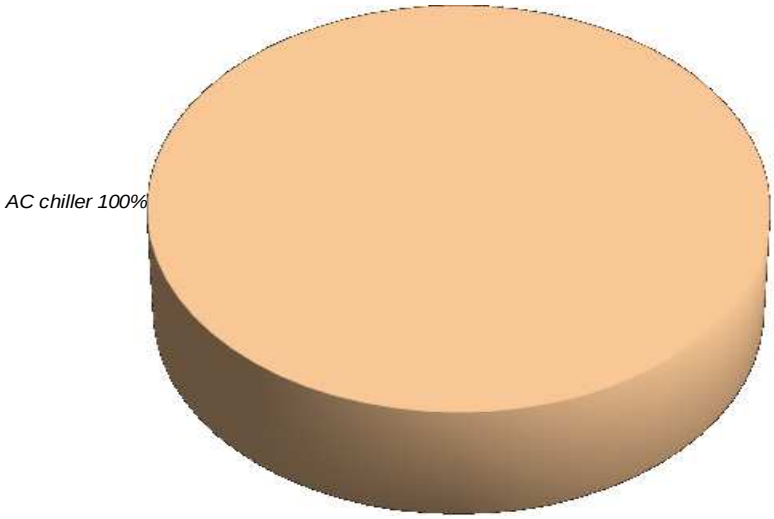

Figure 44: Useful supply cooling (USC) by equipment. Proposed final solution

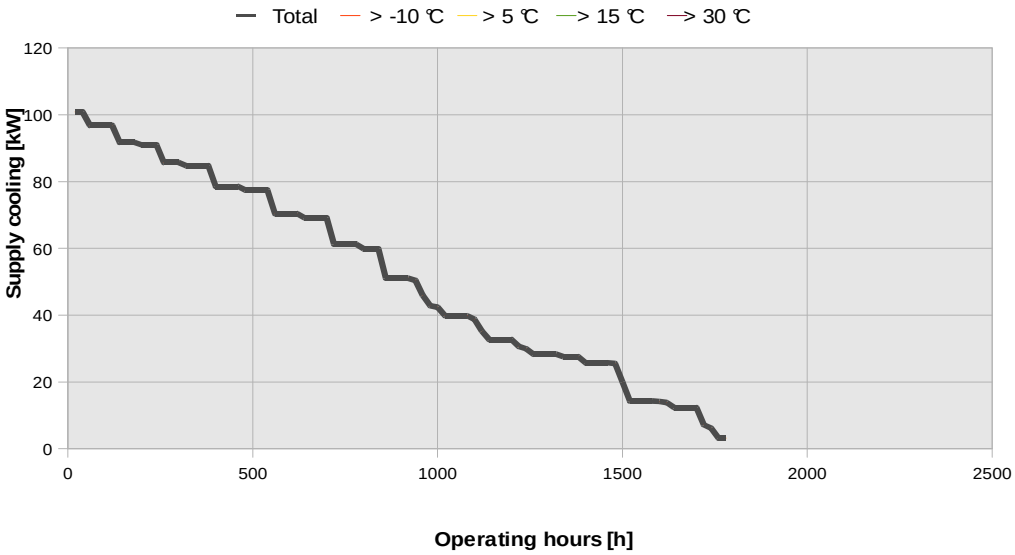

Figure 45: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

5.2. Comparative study and conclusions

5.2.1. Energy and environmental analysis

In the proposed alternative around 23 % of the CO_2 pollution can be saved.

5.2.2. Economic analysis

The payback period of about 10 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 solar thermal plants and have to be revised. Investment and installing cost are based on actual cost in Austria and not Bulgaria.

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

		Present state	Alternative	Saving	[% savings]
Total primary energy consumption (1)					
- total	[MWh]	13,756	11,005	2,751	20%
- fuels	[MWh]	7,223	4,475	2,748	38%
- electricity	[MWh]	6,533	6,530	3	0%
Primary energy saving due to renewable energy	[MWh]		-		
CO_2 emissions	[t/a]	2,767	2,143	624	23%
Annual energy system cost (2)	[EUR]	1,235,844	1,156,158	79,686	6%
Total investment costs	[EUR]		800,000		
Payback period (3)	[years]		10		

(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.