Energy Audit Summary Report

AEE INTEC

Audit no. *16* – UK06

Food Industry

Potato Processing

AEE INTEC
INSTITUT FÜR NACHHALTIGE TECHNOLOGIEN

15th of November 2011

Supported by INTELLIGENT ENERGY EUROPE

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AUDIT n. 16 – UK06

1. Data of the auditor

1.1. Contact data of the auditor

Name: Matthäus Hubmann
Organisation: AEE INTEC
Country: Austria
Profession: engineer
Number of audits performed: 8
Date of the audit: 15/11/2011
Duration of the audit: 4 weeks

2. Introduction

2.1. Objectives

Main objectives of this audit was to integrate the already existing CHP plant into the heat and cold demand of the company

3. Status Quo: processes, distribution, energy supply

3.1. General info of company

The company works in the food industry, potato processing. In the year 2010 around 170.000 tons of potatoes were processed.

3.2. Flow sheet of the whole manufacturing side (processes, distribution, energy supply) in form of a block diagram

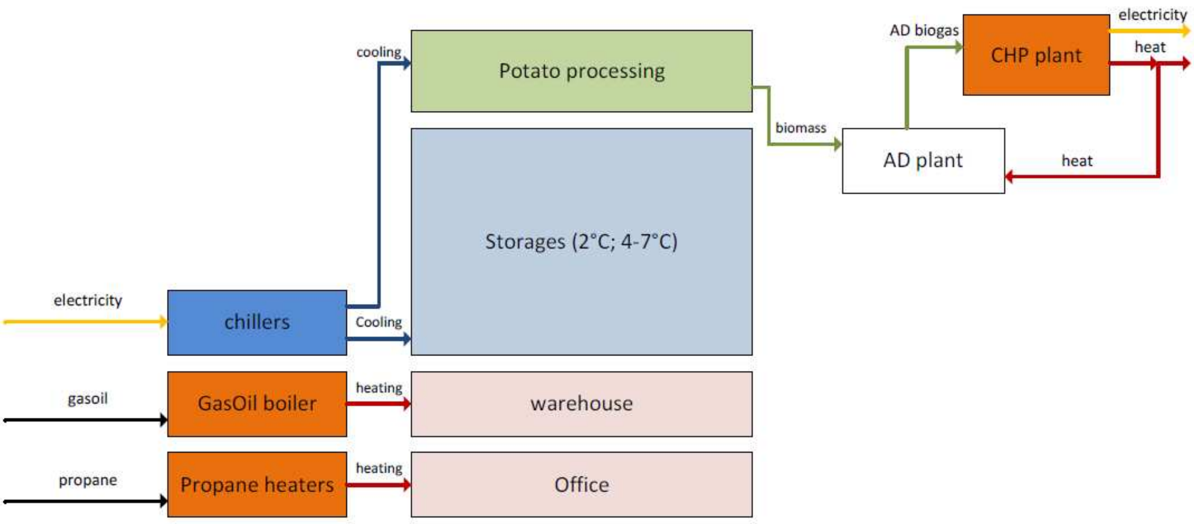

Figure 1: simplified flow sheet diagram; CHP (combined heat and power); AD (anaerobic digestion)

The nine different Storages with a desired temperature of 2°C in the new storage and temperatures of 4-7°C in the remaining storages are supplied by different chillers.

3.3. Description of the existing system

The evaluation of the present state can be seen in the following tables (Table 1 to Table 5) and figures (Figure 2 to Figure 14). The results of the EINSTEIN calculation match to the real state of the production line that could be well split based on the data made available by the company.

- **Energy Supply:**

  Primary energy consumption, Final energy consumption (FEC) per fuel, final energy demand thermal (FET),

Table 1: 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	4,213	35.51	3,201	52.15
Total electricity	7,653	64.49	2,937	47.85
Total (fuels + electricity)	**11,866**	**100.00**	**6,138**	**100.00**

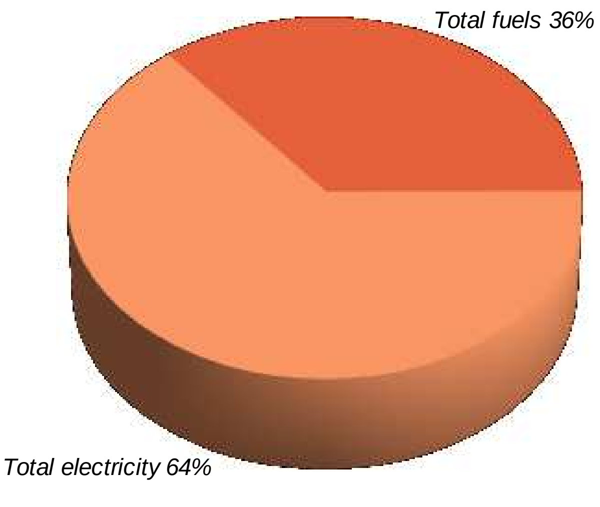

Figure 2: Distribution of PEC by fuel type

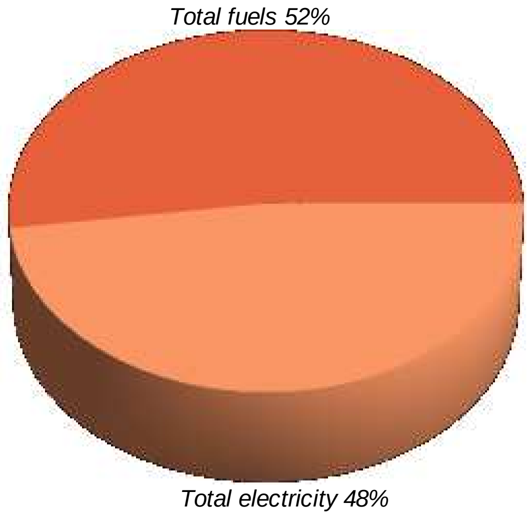

Figure 3: distribution of PET by fuel type

Table 2: **Total final energy consumption (FEC) and final energy for thermal use (FET); present state**

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Gas oil	761	8	761	9
AD biogas	6,752	67	4,727	79
Propane	0	0	0	0
Electricity	2,551	25	979	12
Total	10,065	100	6,467	100

Fuel type **FEC** **FET**

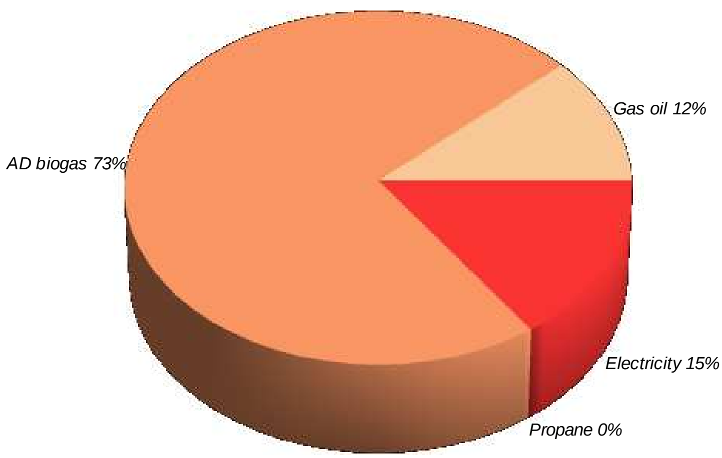

Figure 4: Total final energy consumption for thermal use (FET); present state.

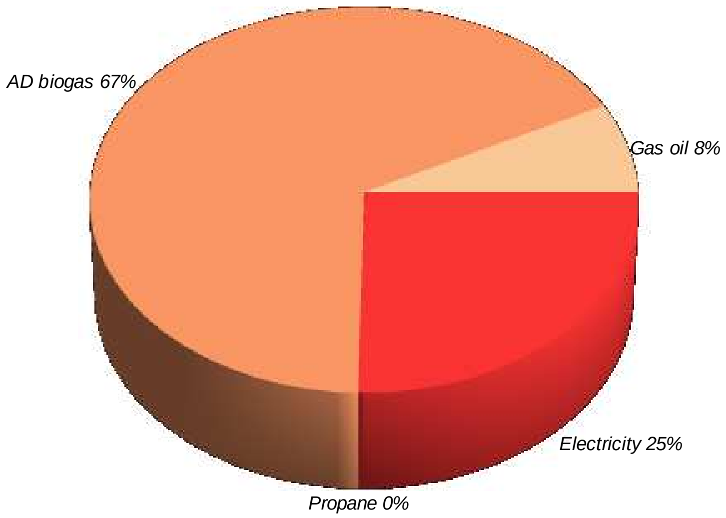

Figure 5: Total final energy consumption (FEC); present state.

Table 3: **Final energy consumption for thermal use (FET) by equipment (present state).**

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
chillers intake	Electricity	495	5.83
chiller FIFO	Electricity	248	2.92
chillers storage 11	Electricity	72	0.85
chillers storage 12	Electricity	163	1.92
chillers new storage	Electricity	1,221	14.37
chillers Kirks Yard	Electricity	131	1.55
chiller storage 10	Electricity	100	1.18
chiller storage 13	Electricity	197	2.32
chiller dispatch	Electricity	377	4.44
GasOil boiler	Gas oil	761	8.97
Propane heater	Propane	0	0.00
AD CHP	AD biogas	4,727	55.67
Total		**8,492**	**100.00**

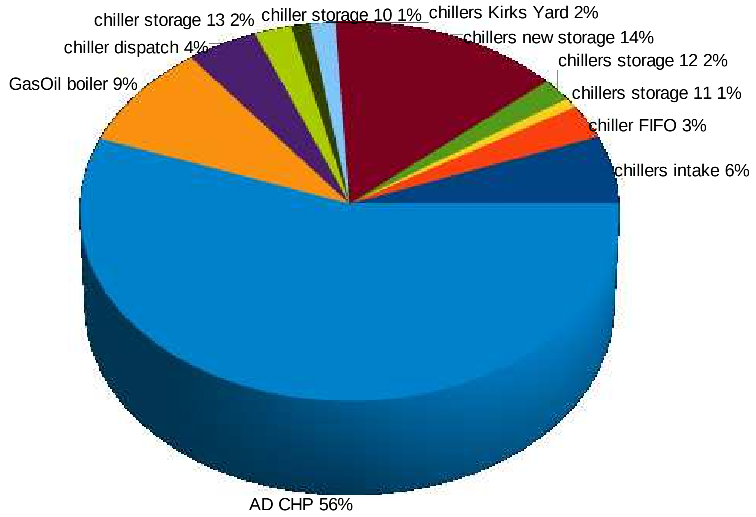

Figure 6: Final energy consumption for thermal use (FET) by equipment

Table 4: Useful supply heat (USH) by equipment; present state

Equipment	USH by equipment	
	[MWh]	[% of Total]
GasOil boiler	615	13.32
CHP	3,999	86.68
propane heater	0	0.00
Total	**4,614**	**100.00**

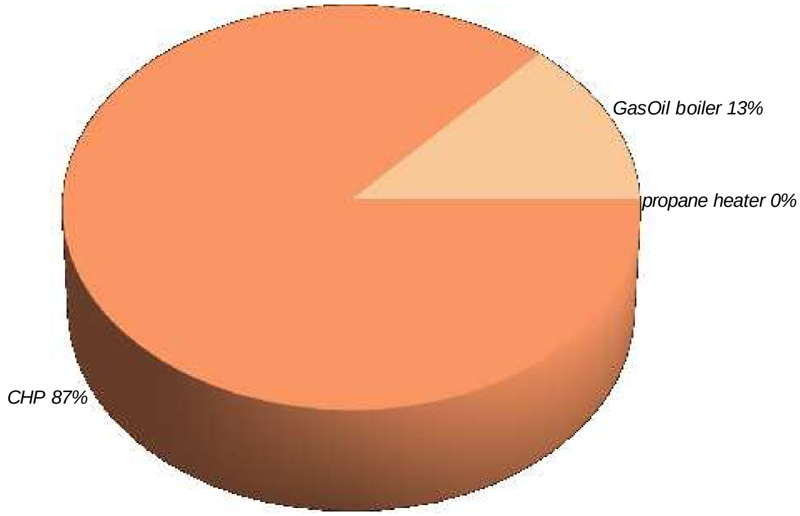

Figure 7: Useful supply heat (USH) by equipment. Present state.

Table 5: **Useful supply cooling (USC) by equipment; present state**

Equipment	USC by equipment	
	[MWh]	[% of Total]
chillers intake	1.196	15,92
chiller FIFO	594	7,91
chillers storage 11	171	2,28
chillers storage 12	388	5,16
chillers new storage	3.226	42,93
chillers Kirks Yard	316	4,21
chiller storage 10	240	3,19
chiller storage 13	477	6,34
chiller dispatch	905	12,05
Total	**7.513**	**100,00**

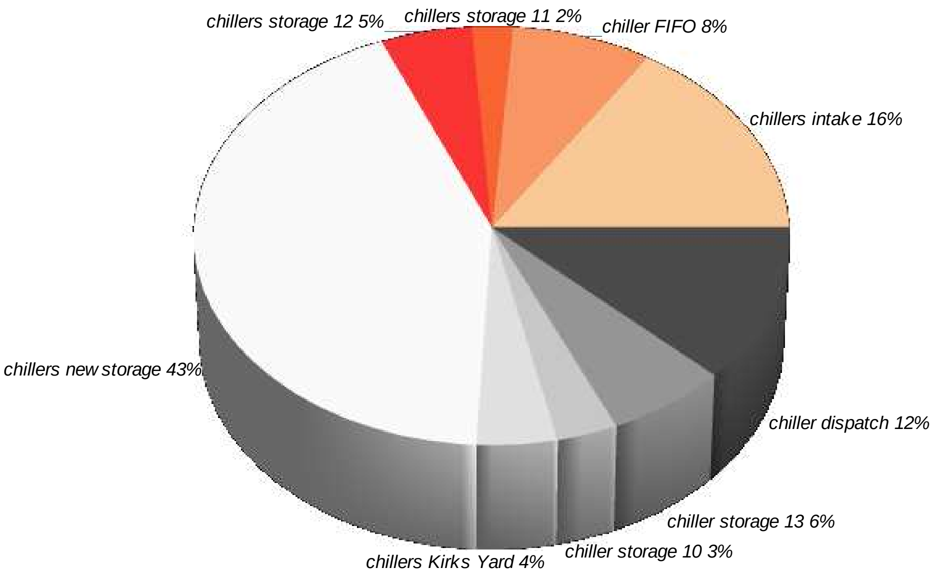

Figure 8: Useful supply cooling (USC) by equipment. Present state.

- **Distribution system:**

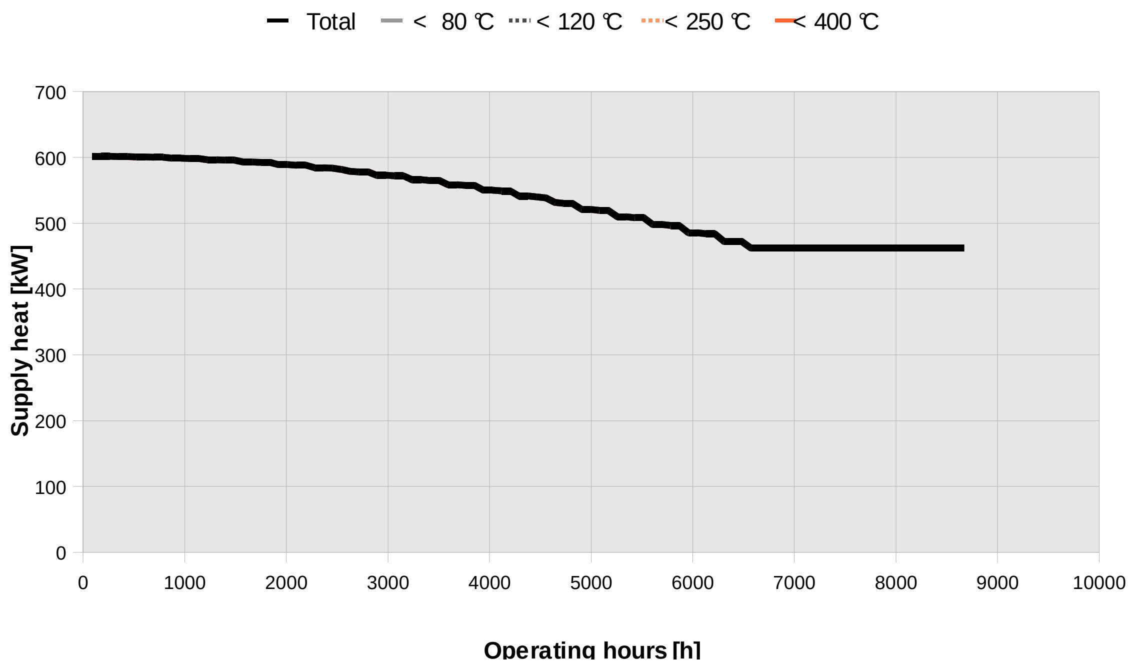

Figure 9: Distribution of supply heat by temperature levels and annual operating hours. Present state.

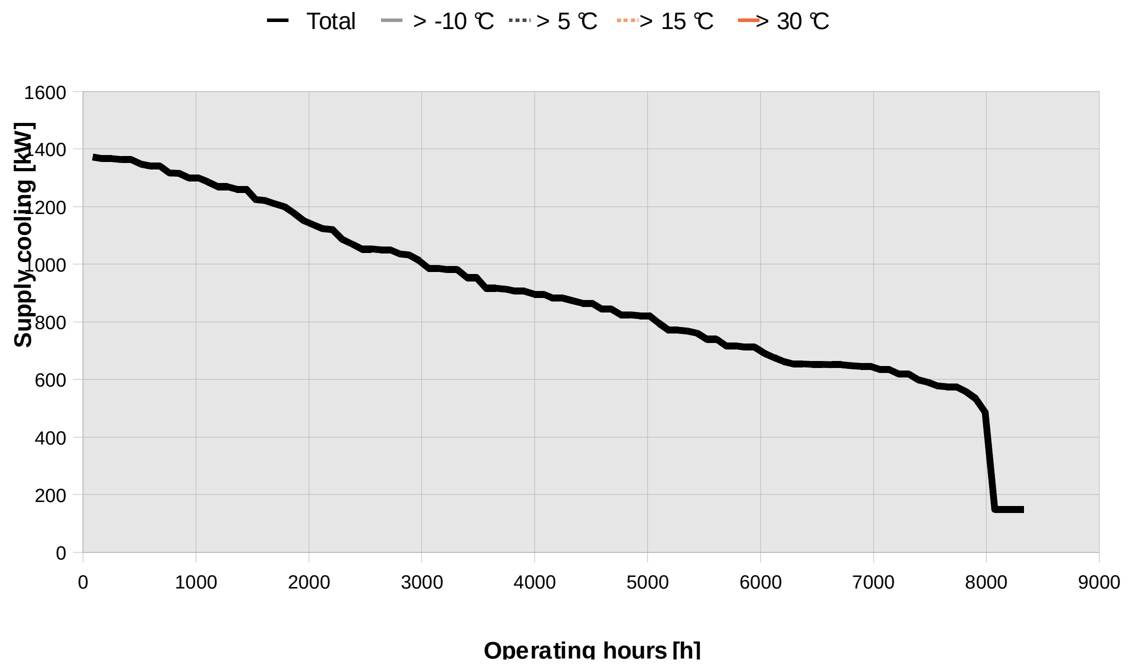

Figure 10: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

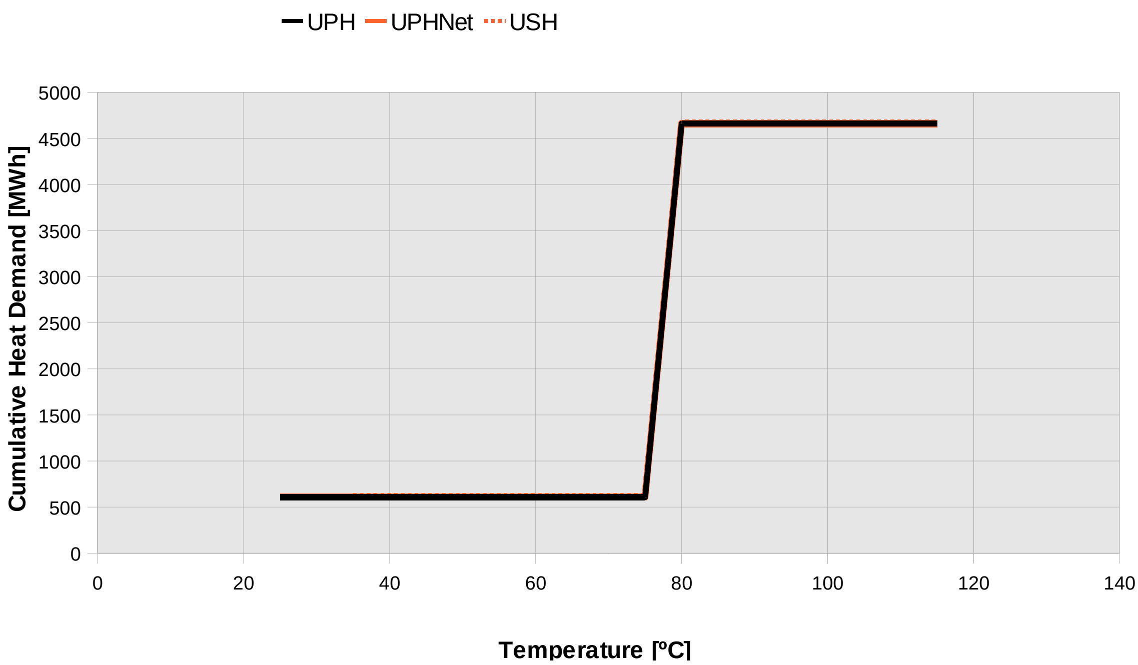

Figure 11: Distribution of the heat demand by temperature levels

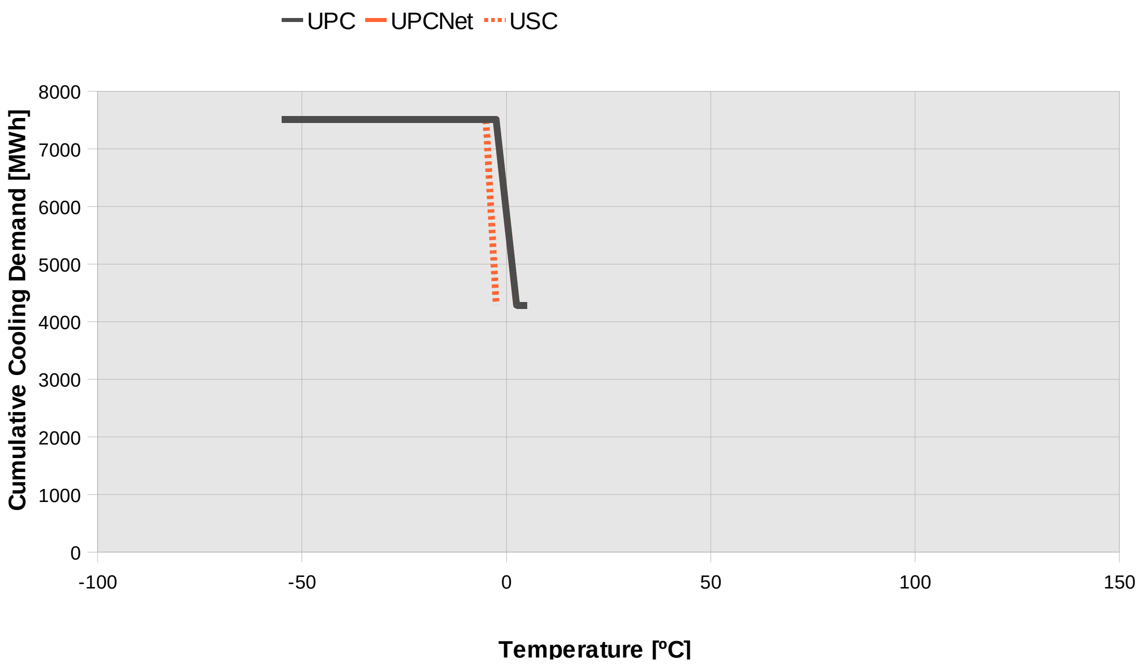

Figure 12: Distribution of the cooling demand by temperature levels

- **Main energy consuming energy processes and buildings:**

Table 6: Useful process cooling demand (UPC) by process. Present state

Process	Total [MWh]	Circulation [MWh]	Maintenance [MWh]	Start-up [MWh]
FIFO storage_cooling	594	0	594	0
storage 10_cooling	240	0	240	0
storage 11_cooling	171	0	171	0
storage 12_cooling	388	0	388	0
storage 13_cooling	477	0	477	0
new cold storage_cooling	3,226	0	3,226	0
Kirks Yard_cooling	316	0	316	0
dispatch_cooling	905	0	905	0
intake_cooling	1,196	0	1,196	0
Total	**7,513**			

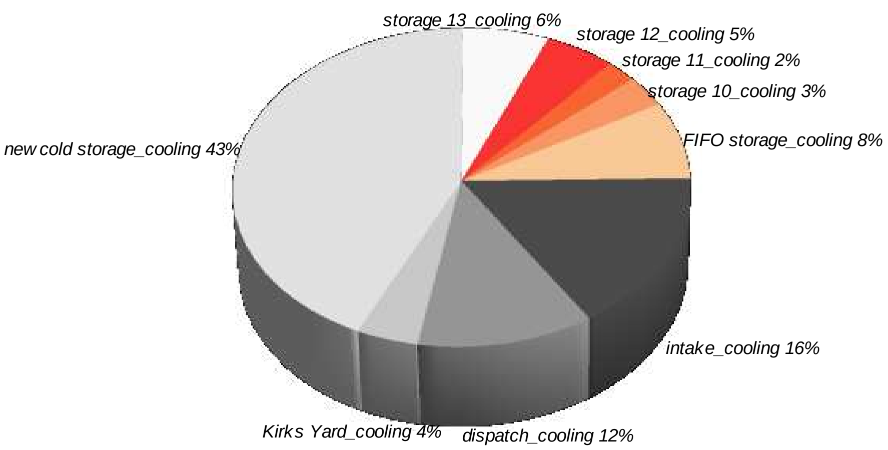

Figure 13: Useful process cooling (UPC) by process

Table 7: Useful process heat demand (UPH) by process. Present state

Process	Total [MWh]	Circulation [MWh]	Maintenance [MWh]	Start-up [MWh]
warehouse_heating	609	0	609	0
dump CHP heat	3,999	0	3,999	0
office_heating	0	0	0	0
Total	**4,660**			

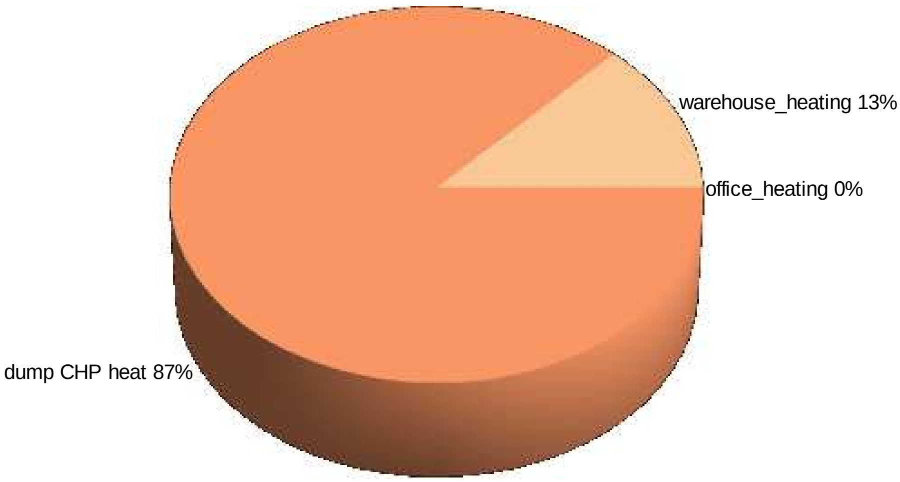

Figure 14: Useful process heat (UPH) by process

3.4. General

- The anaerobic digestion (AD) plant started working in the beginning of 2010. The highest biogas production was reached in March and April of 2011 due to this fact an average of this two month was taken to represent a maximum biogas production and further on a high electricity and heat production of the CHP during a whole year. This maximum biogas production was taken to represent the present state.
- As for the chillers only the electricity consumption is known and the technical manuals are not available, assumptions concerning the COP (thermal efficiency of the chillers) were made and have to be revised and checked if a detailed cooling demand is correct.

4. Comparative study

Table 8: Overview of the alternative proposals studied

Short Name	Description
CHP -> heating	based on present state + covering heat demand
CHP -> cooling	based on present state + absorption chiller

4.1. Proposed alternative 1: **CHP -> heating**

- CHP -> heating

No new equipment has been installed. The CHP waste heat is used to cover the heat demand of the warehouse and the offices.

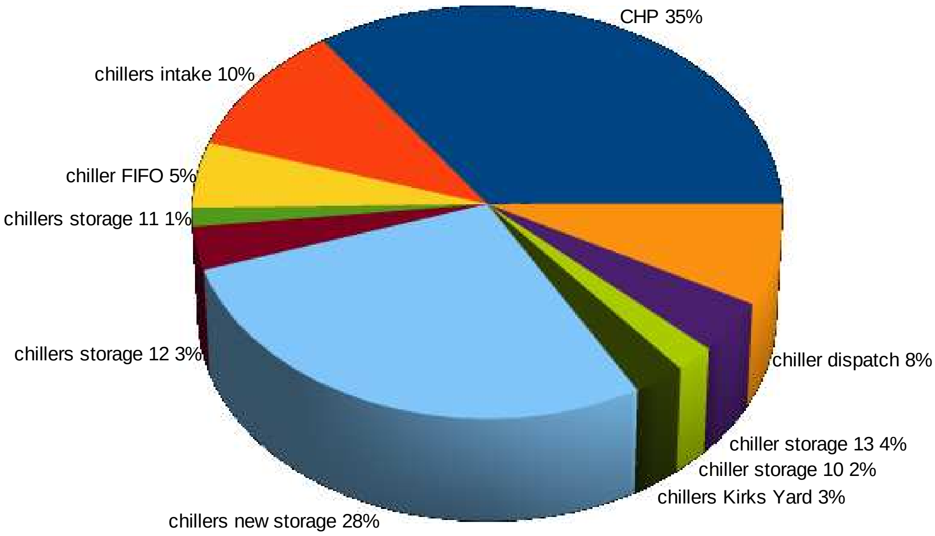

Figure 15: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

Table 9: equipment

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
CHP	CHP gas turbine	o==heat distribution==o o==propane heating==o o==distribution CHP==o	600	3,999	34.74
chillers intake	compression chiller (air cooled)	o==distribution intake==o	465	1,196	10.39
chiller FIFO	compression chiller (air cooled)	o==distribution FIFO==o	300	594	5.16
chillers storage 11	compression chiller (air cooled)	o==distribution storage 11==o	165	171	1.49
chillers storage 12	compression chiller (air cooled)	o==distribution storage 12==o	270	388	3.37
chillers new storage	compression chiller (air cooled)	o==distribution new storage==o	840	3,226	28.02
chillers Kirks Yard	compression chiller (air cooled)	o==distribution Kirks Yard==o	135	316	2.75
chiller storage 10	compression chiller (air cooled)	o==distribution storage 10==o	135	240	2.08
chiller storage 13	compression chiller (air cooled)	o==distribution storage 13==o	180	477	4.14
chiller dispatch	compression chiller (air cooled)	o==distribution dispatch==o	420	905	7.87
GasOil boiler	boiler	o==distribution w heating==o	250	0	0.00
Propane heater	heater	o==distribution office heating==o	1	0	0.00
Total			**3,761**	**11,512**	**100**

4.2. Proposed alternative 2: **CHP -> cooling**

- CHP -> cooling

  Equipment: absorption chiller

  Nominal cooling power: 480 kW

  COP (coefficient of performance): 0.67

The new installed chiller is connected to the storages and substitutes the existing electrical compression chiller.

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

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
absorption chiller	absorption chiller (air cooled)	o==distribution storages==o	480	2,920	24.09
CHP	CHP gas turbine	o==distribution CHP==o	600	3,999	32.99
chillers intake	compression chiller (air cooled)	o==distribution intake==o	465	1,196	9.86
chiller FIFO	compression chiller (air cooled)	o==distribution FIFO==o	300	594	4.90
chillers storage 11	compression chiller (air cooled)	o==distribution storage 11==o	165	171	1.41
chillers storage 12	compression chiller (air cooled)	o==distribution storage 12==o	270	388	3.20
chillers new storage	compression chiller (air cooled)	o==distribution new storage==o	840	305	2.52
chillers Kirks Yard	compression chiller (air cooled)	o==distribution Kirks Yard==o	135	316	2.61
chiller storage 10	compression chiller (air cooled)	o==distribution storage 10==o	135	240	1.98
chiller storage 13	compression chiller (air cooled)	o==distribution storage 13==o	180	477	3.93
chiller dispatch	compression chiller (air cooled)	o==distribution dispatch==o	420	905	7.47
GasOil boiler	boiler	o==distribution w heating==o	250	609	5.02
Propane heater	heater	o==distribution office heating==o	1	0	0.00
Total			**4,241**	**12,121**	**100**

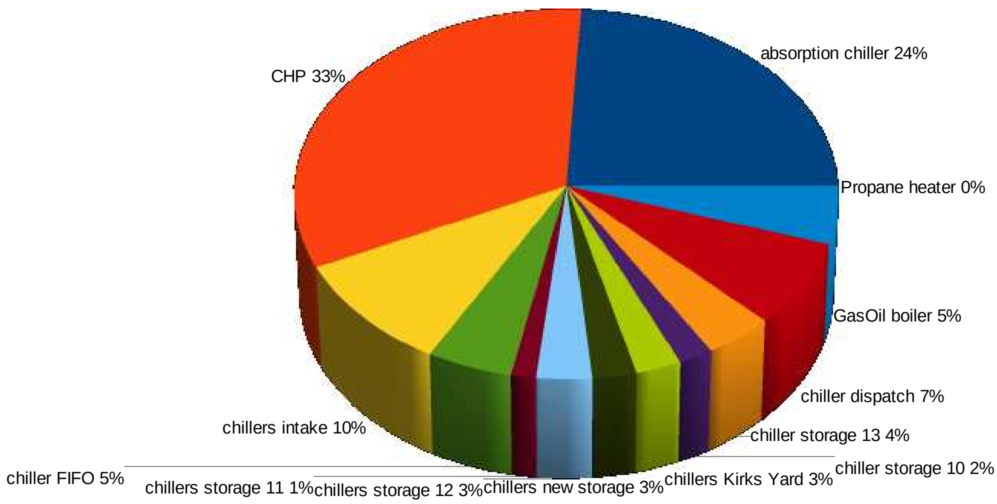

Figure 16: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

5. Selected alternative(s) and conclusions

Table 11: **Primary energy consumption: present state and alternative proposals**

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	11,866	---	---
CHP -> heating	11,029	837	7.05
CHP -> cooling	9,180	2,686	22.64

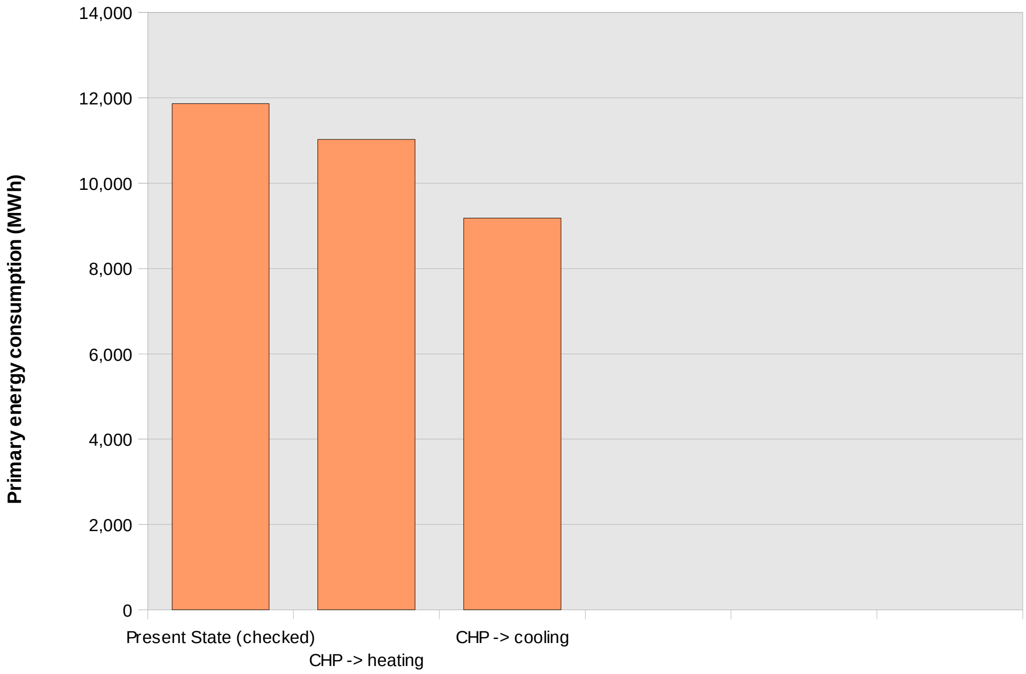

Figure 17: Comparison of alternatives: primary energy consumption

Table 12: 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)	4,614	---	4,614	---
CHP -> heating	3,999	609	3,999	609
CHP -> cooling	4,614	0	4,614	0

5.1. Selected alternative

Based on the fact that the company has already installed an anaerobic digestion plant to exploit the biomass residues of the potato processing to produce biogas the use of the entire energy which contains the biogas was the prior driving point. As the biogas is used in a CHP plant to produce electricity but without using the waste heat this proposal focuses on the implementation of the waste heat. This leads to a complete substitution of the fossil fuels used for heating the warehouse and offices.
Due to the fact of minor installation costs in comparison to an installation of absorption chiller this alternative has also a short payback period.

5.1.1. Process optimisation (written proposals)

Based on the available data no process optimisation was proposed.

5.1.2. Heat recovery

No additional heat recovery and installation of heat exchangers are suggested.

5.1.3. Heat and Cold Supply

As the CHP waste heat is not used in the present state the substitution of the gasoil heating of the warehouse and the office building is proposed.

5.2. Comparative study and conclusions

Table 13: Comparative study

		Present state		**Alternative**	**Saving**
Total primary energy consumption (1)	[MWh]	11,866		11,029	837
Allocation of energy consumption	[-]				
Total fuels		4,213		3,376	837
Total electricity		7,653		7,653	0
Share of renewable energy	[%]			31%	
CO_2 emissions	[tons/a]	1,450		1,348	102
Annual energy system cost (2)	[EUR]	292,323		241,580	50,743
Total investment costs	[EUR]			100,000	
Payback period (3)	[years]			2	

(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)

It was assumed that the own produced electricity through biogas has a primary energy factor of 0.5 and the electricity of the grid a factor of 3.

CO_2-emission savings chart:

Table 14: Environmental impact: present state and alternative proposals

Alternative	Production of CO2	Water consumption
	[t]	[m3]
Present State (checked)	1450.28	0.00
CHP -> heating	1348.00	0.00
CHP -> cooling	1126.00	0.00

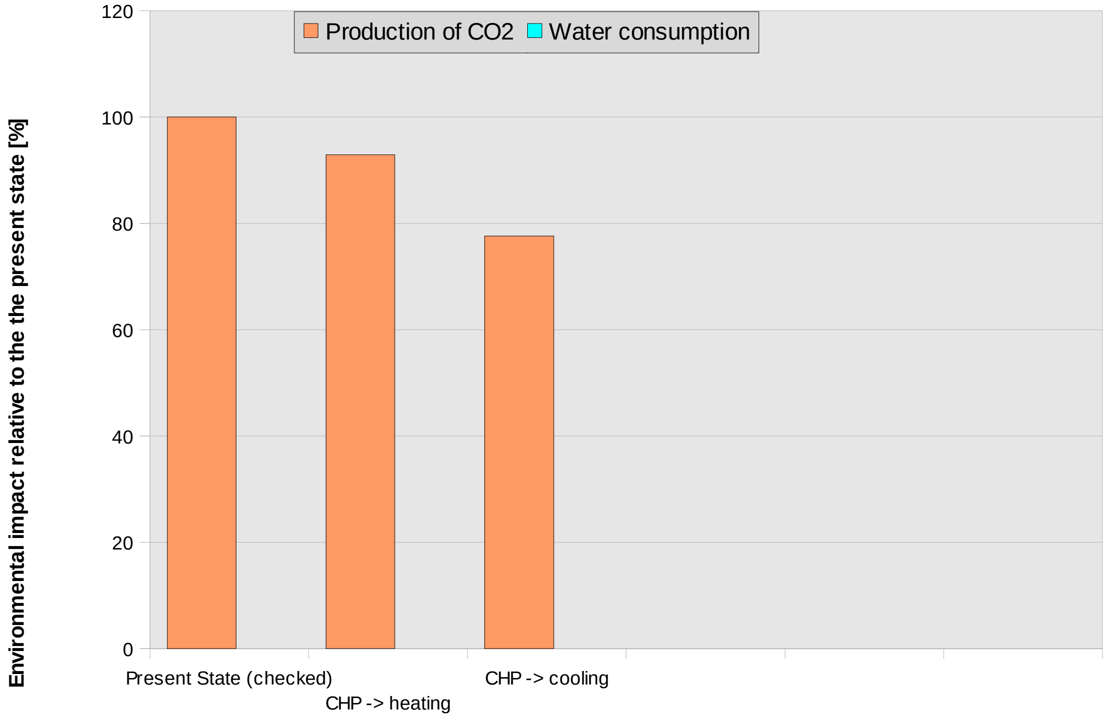

Figure 18: Comparison of alternatives: environmental impact

5.2.1. Energy and environmental analysis

By using the waste heat of the CHP plant and a minimum of imported electricity from the grid the CO2 production on the company site decreases highly. In the calculated case it decreases by 102 t of CO2 per year compared to the present state.

5.2.2. Economic analysis

By using the CHP waste heat for heating the warehouse and the offices the energy costs can be lowered by € 50,743 per year. The adaptation of the heat delivering system a total sum of € 100,000 was assumed and has to be revised and updated regarding the pipe length and necessary adaptations in the buildings.

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.