Energy Audit Summary Report

Audit No. 71

Food Industry

Confectionery

energyXperts.NET
Berlin (Germany) / Barcelona (Spain)

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1. Contact data of the auditors

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2. Description of the company (status quo)

Reference year of data/information: 2011

(Date of the visit on site: 08 – 05 - 2012)

2.1. General information of the company

Sector	Food (confectionery)	
Products	Cream and other half-finished products	
Yearly production	2.155 t	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- gasoil	542	542
- electricity	190	36

(*) fuel consumption in terms of MWh lower calorific value (LCV)

2.2. Description of the company

a) Productive process

The company produces cream and other semi-processed food products.

Concerning the main production line (cream), fats and glucose are first conditioned and then mixed together with hot water and other ingredients in order to produce the cream, which is then pasteurised and cooled down.

A CIP (clean in place) system is daily run to clean the production equipments and the containers used to store and to transport the cream.

Offices are equipped with space heating and air conditioning systems.

Figure 1. Cream pasteurisation

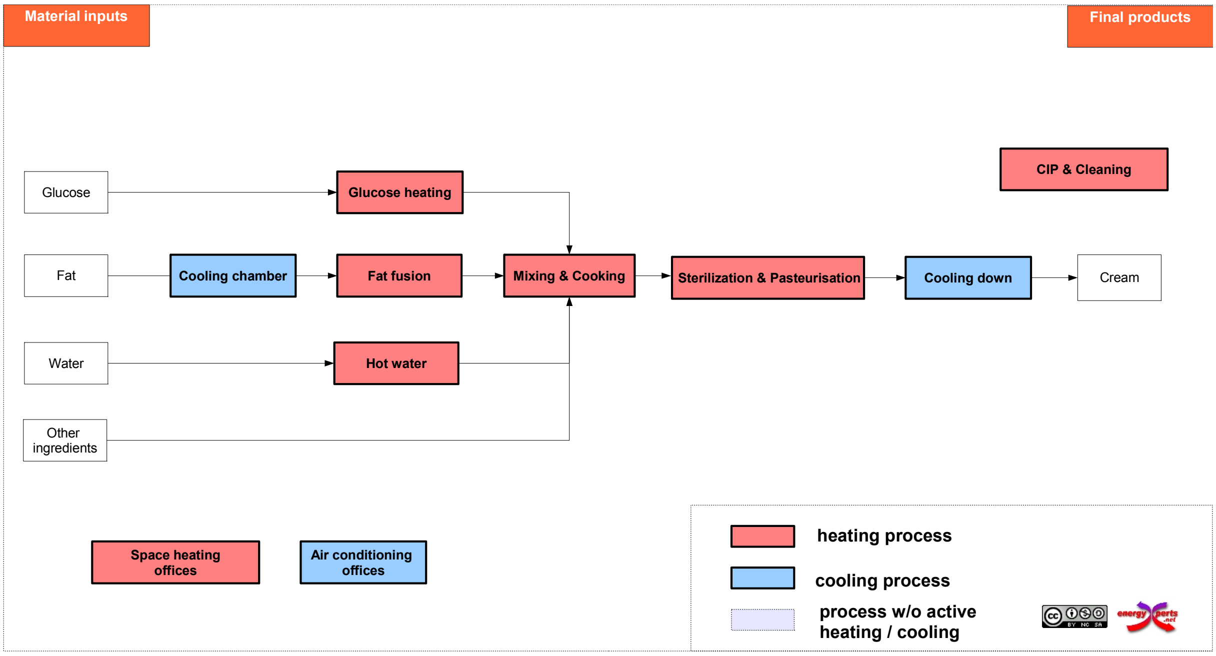

Figure 2. Simplified production flow sheet

On the one hand, the most consuming heating processes in the company are the cream preparation, cleaning and sanification of containers and equipments, and space heating.

On the other hand, cooling down of the cream after pasteurisation and air – conditioning generate the most important cooling demands.

b) Energy supply system

The heat used in the company at low and medium temperature is generated in two gasoil fired steam boilers. An additional hot water boiler supplies heat in wintertime to the space heating circuit (radiators).

Cooling is provided to the processes by a cooling tower (wet) and by two electrically driven chillers. Moreover, various split units are installed in the offices for air conditioning in summertime.

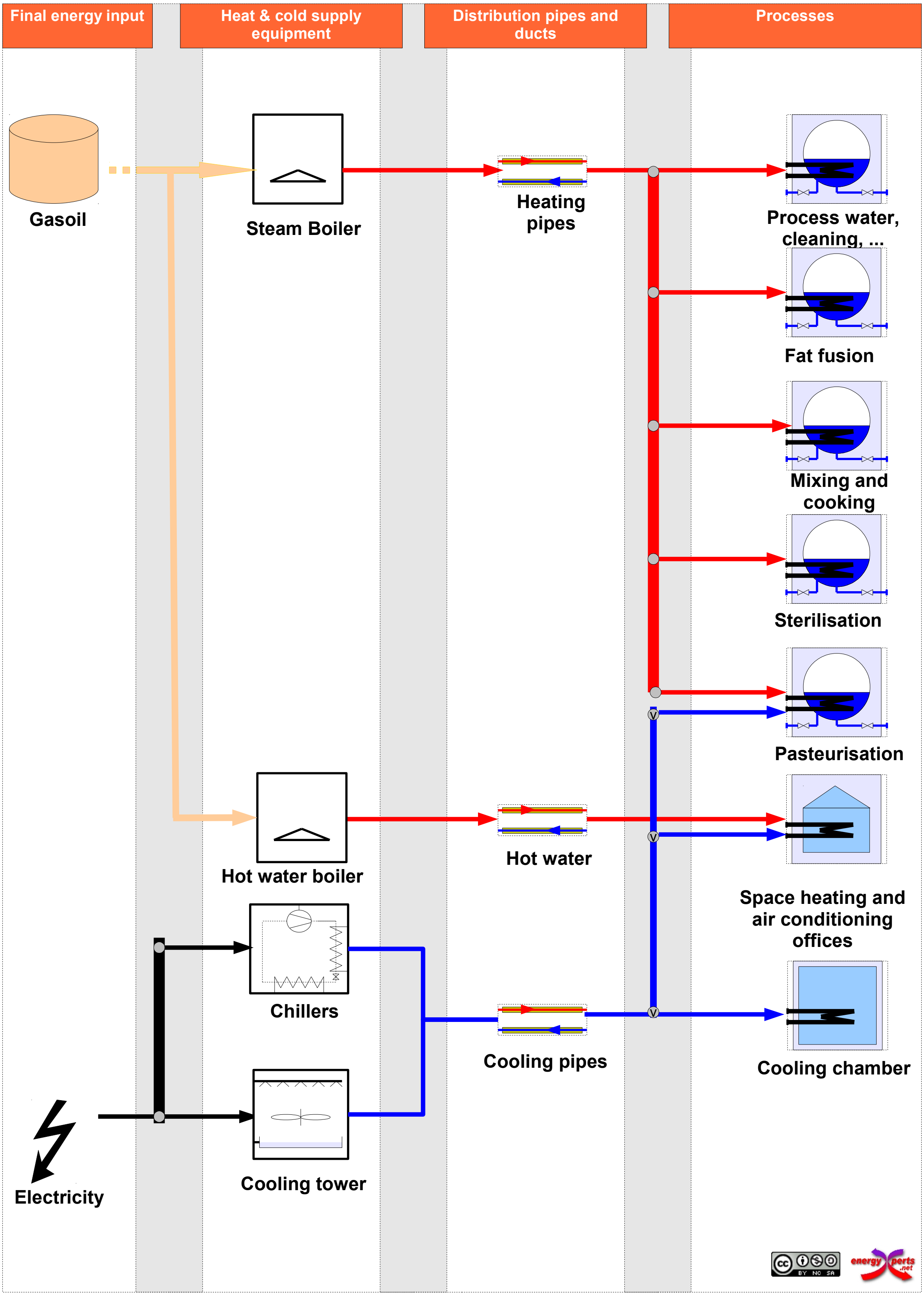

Figure 3. Overview of the heat and cold supply system

2.3. Additional comments

Peculiarities of the company

- High gasoil tariff. At the time of the audit, not possible to shift to natural gas.
- Heating process temperature up to 90ºC.

3. Comparative study of alternative proposals

A comparative study of several technically feasible alternative proposals for energy saving has been carried out. In the following sections 5 of them are first shortly described and then the results of the comparative study are presented.

3.1. Proposed alternatives

The technical potential alternatives that have been investigated are listed in Table 1.

Table 1. Overview of the alternative proposals studied

Short Name	Description
Heat recovery (HR)	- Heat exchangers network for heat recovery from pasteurisation and chillers for process water pre-heating. Nominal power: 54 kW
Solar thermal ETC (ST ETC)	- Heat recovery (as above, alternative: HR) and - Solar thermal plant (evacuated tubes collectors) for process hot water and space heating. Nominal power: 150 kW (214 m2)
Heat pump (HP)	- Heat recovery (as above, alternative: HR) and - Reversible (air/water) heat pump for space heating in winter and air conditioning + SHW in summertime. Nominal heating power: 90 kW.
Heat pump and Solar thermal FPC (HP+ST FPC)	- Heat recovery (as above, alternative: HR) and - Reversible (air/water) heat pump (as above, alternative: HP) and - Solar thermal plant (flat plate collectors) for process water pre-heating. Nominal power: 60 kW (85 m2)
Heat pump and Solar thermal ETC (HP+ST ETC)	- Heat recovery (as above, alternative: HR) and - Reversible (air/water) heat pump (as above, alternative: HP) and - Solar thermal plant (evacuated tubes collectors) (as above, alternative: ST ETC)

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State	1.009	---	---
Heat recovery	874	135	13,34
Solar thermal ETC	728	281	27,82
Heat pump	794	215	21,32
Heat pump+Solar thermal FPC	743	266	26,37
Heat pump+Solar thermal ETC	656	353	34,98

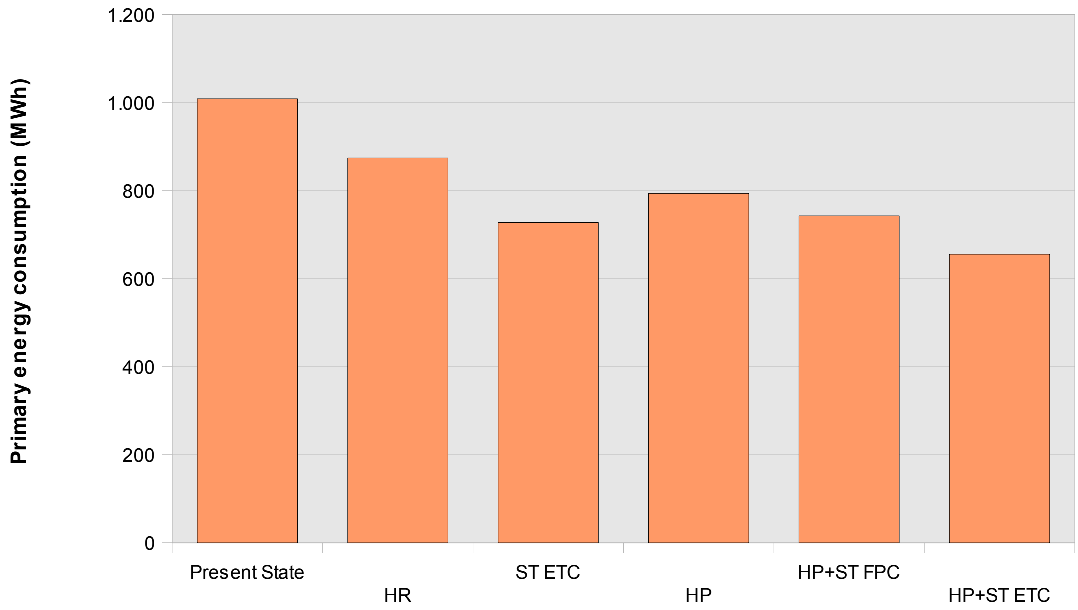

Figure 4. Comparative study: yearly primary energy consumption.

1 The factors for conversion of final energy (for fuels in terms of LCV) to primary energy used in this study are 2,17 for electricity and 1,1 for gasoil.

3.3. Economic performance

Table 3. Comparative study: investment costs. In the alternatives including the new HP, the investment costs include additional H&C distribution costs and do not include possible revenues for the disposal of the actual split units. No susbsidies considered: the tax reduction foreseen for the solar thermal plant have been included in the economic assessment as non- recurring revenues.

Alternative	Total investment [€]	Subsidies [€]
Present State	---	---
Heat recovery	6.400	0
Solar thermal ETC	129.648	0
Heat pump	47.900	0
Heat pump+Solar thermal FPC	87.630	0
Heat pump+Solar thermal ETC	171.148	0

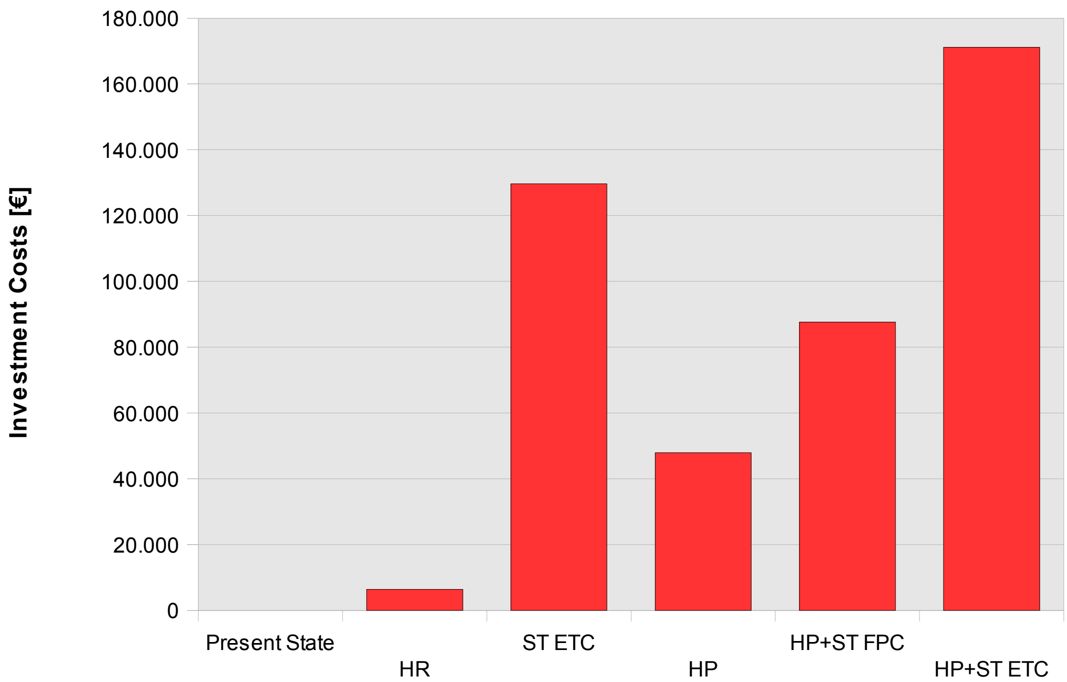

Figure 5. Comparative study: investment costs.

Table 4. Comparative study: annual costs including annuity of initial investment[2]. O&M costs are the additional costs associated to the new equipments. In this table, the total annual system costs is not discounted by the annual tax discount due to the solar thermal implementation.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]	Total [€]
Present State	---	96.106	0	96.106
Heat recovery	617	81.137	500	82.253
Solar thermal ETC	12.491	64.768	2.375	79.633
Heat pump	4.615	70.282	950	75.847
Heat pump+Solar thermal FPC	8.442	64.577	1.700	74.720
Heat pump+Solar thermal ETC	16.489	54.843	2.825	74.157

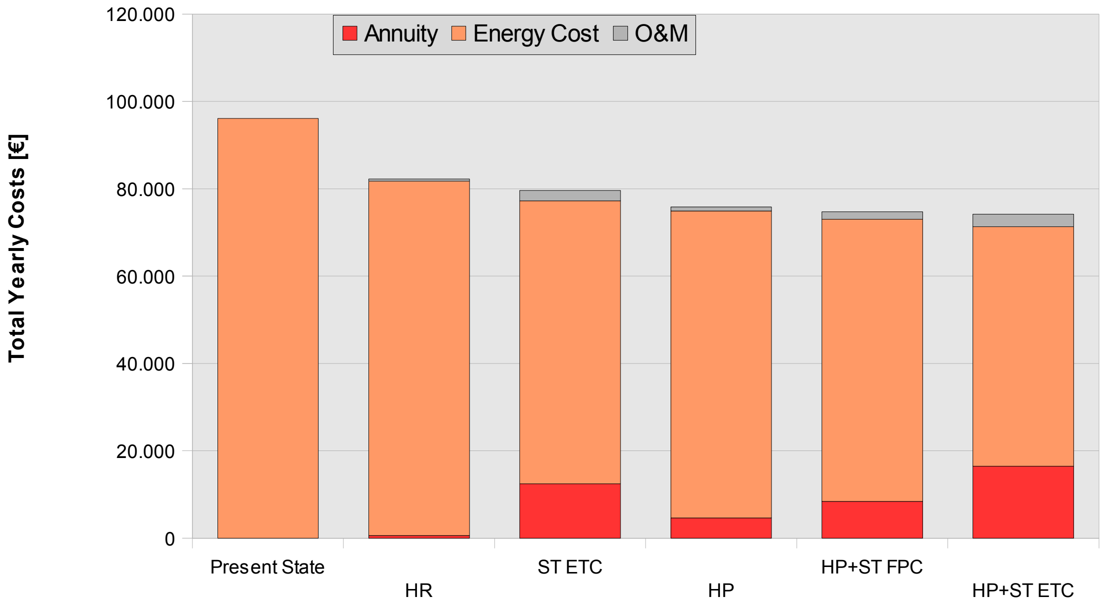

Figure 6. Comparative study: annual costs including annuity of initial investment.

2 Annuity of initial investment: 9,63 % of yearly payments, calculated based on 8% nominal interest for external financing, 3 % general inflation rate and 15 years of economic depreciation period.

4. Selected alternative and conclusions

4.1. Selected alternative

The alternative proposal "Heat pump and Solar thermal ETC" that combines a customized heat exchanger network and a new supply system including a solar thermal plant and a reversible heat pump has been considered the best option because it shows the biggest energy saving potential, and results to be economically feasible.

In the following sections, the selected alternative is described more in detail.

4.1.1. Process optimisation

No process optimisation measures foreseen.

4.1.2. Heat recovery

The proposed heat exchangers network (see Table 5) allows to produce process hot water:

- by recovering the heat rejected (and dispersed through the cooling tower at the present state) by the chillers
- and by cooling down the cream after pasteurisation (done, at the present state, by the cooling tower),

instead of burning gasoil to produce the required thermal energy.

This measure leads to a reduction of fuel, electricity and water consumption.
In particularly, the primary energy saving expected is 13%.

Table 5. List of heat exchangers proposed. Heat recovery from the new heat pump not included .

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX 1	16	Heat rejection chillers	Process hot water	33	31,73%
HX 2	38	Cream to be cooled down after pasteurisation	Process hot water	71	68,27%
	54			**104,47**	**100,00%**

4.1.3. Heat and Cooling Supply

The proposed energy supply system includes two new equipments:

- a solar thermal plant (nominal heating power: 150 kW. Gross surface area: 214 m^2 of evacuated tube solar thermal collectors) for process heat generation at low and medium temperature (expected solar fraction: 30%),
- a reversible electrically driven air/water heat pump (nominal heating/cooling power: 90 kW) for space heating in wintertime and air-conditioning (combined with hot water preparation) in summertime.

Table 6. Heat and cooling supply equipments . Selected alternative.

Equipment	Type	Nominal capacity	Contribution to tot
		[kW]	[MWh]
Solar thermal system	solar thermal (evacuated tubes)	150	108
Heat pump	reversible air/water heat pump	90	128
Steam boilers	steam boiler	1.575	148
Hot water boiler *	hot water boiler	233	2
Chillers cooling processes	compression chiller (water cooled)	68	57
Cooling tower	cooling tower (wet)	233	42
Chiller cooling chamber	compression chiller (air cooled)	8	18
Groundwater	cooling ground water	5	1

(*) In the proposed energy supply system , the exhisting gasoil boiler is used for redundancy and for peak load.

The technical specifications and the economic parameters of the new solar thermal and heat pump systems are given in Table 7 and Table 8.

Table 7. Technical specifications and economics of the new solar thermal plant.

Parameter	Units	Data
Type of equipment	-	solar thermal
Model	-	evacuated tubes collectors
Nominal power (heat or cold output)	kW	150,00
Surface area (gross)	m2	214,29
Electricity power input	kW	1,50
Heat storage capacity	m3	10,00
Turn-key price	€	123.247
Annual operational and maintenance fixed costs	€	1.875

Table 8. Technical specifications and economics of the new heat pump.

Parameter	Units	Data
Type of equipment	-	electrically driven heat pump
Model	-	reversible air/water heat pump with heat recovery
Nominal power (heating and cooling)	kW	90,00
COP	-	4,00
EER	-	3,57
Turn-key price	€	31.500
Annual operational and maintenance fixed costs	€	450

The total and monthly contribution of the new equipments to the total heat supply (349 MWh) is shown respectively in Table 9, Figure 7 and Figure 8 while the contribution to the cooling supply (155 MWh) is shown in Table 10, Figure 9 and Figure 10.

Table 9. Contribution of the different equipments to the total useful heat supply (USH) in the company.

Equipment	USH by equipment	
	[MWh]	[% of Total]
Steam boilers	148	42,51
Hot water boiler	2	0,59
New Heat pump	90	25,91
New Solar thermal system	108	30,99
Total	**349**	**100**

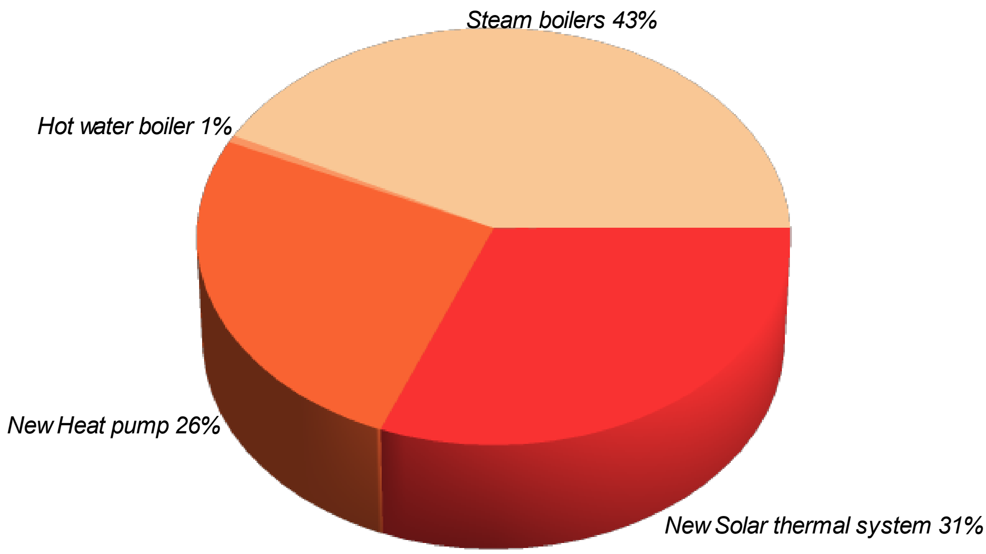

Figure 7. Contribution of the different equipments to the total useful heat supply (USH) in the company.

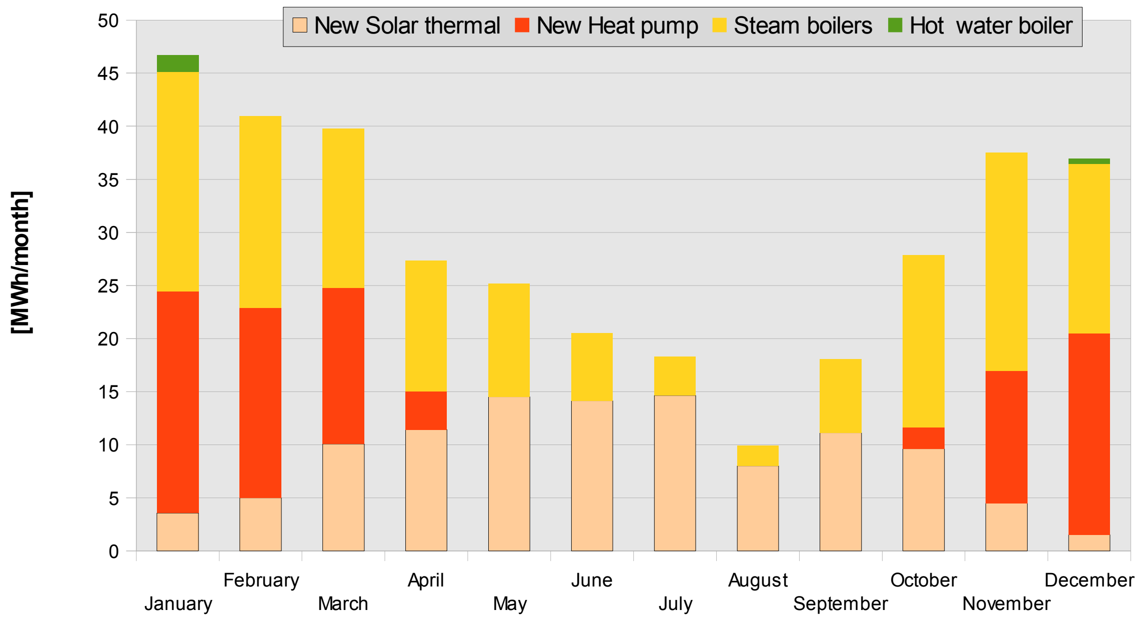

Figure 8. Contribution of the different equipments to the total useful heat supply (USH) per month.

Table 10. Contribution of the different equipments to the total useful cooling upply (USC) in the company.

Equipment	USC by equipment	
	[MWh]	[% of Total]
Chillers cooling processes	57	36,95
Cooling tower	42	27,16
Chiller cooling chamber	18	11,33
Groundwater	1	0,53
New heat pump	37	24,03
Total	**155**	**100**

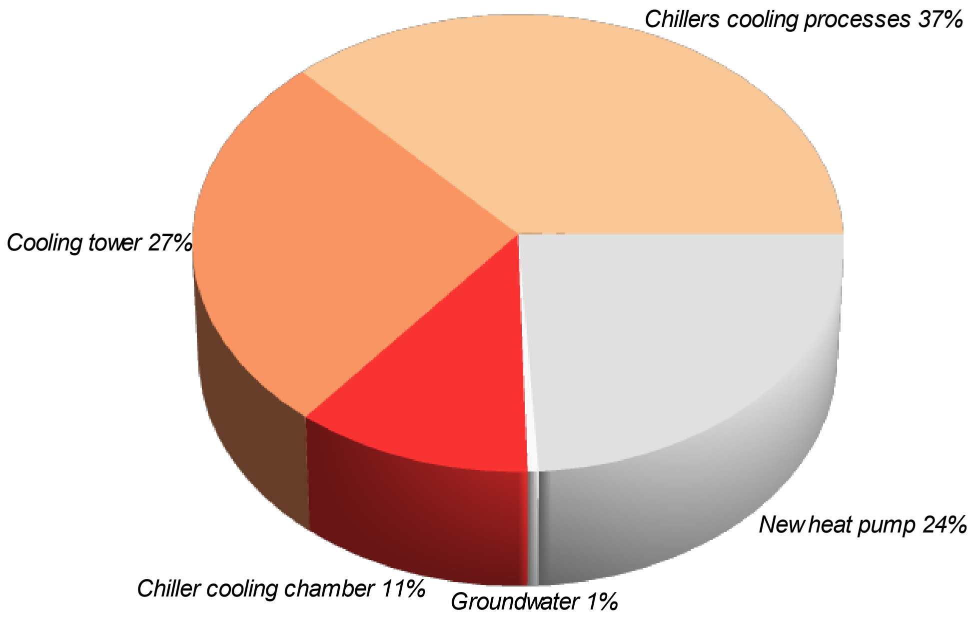

Figure 9. Contribution of the different equipments to the total useful cooling supply (USC)in the company.

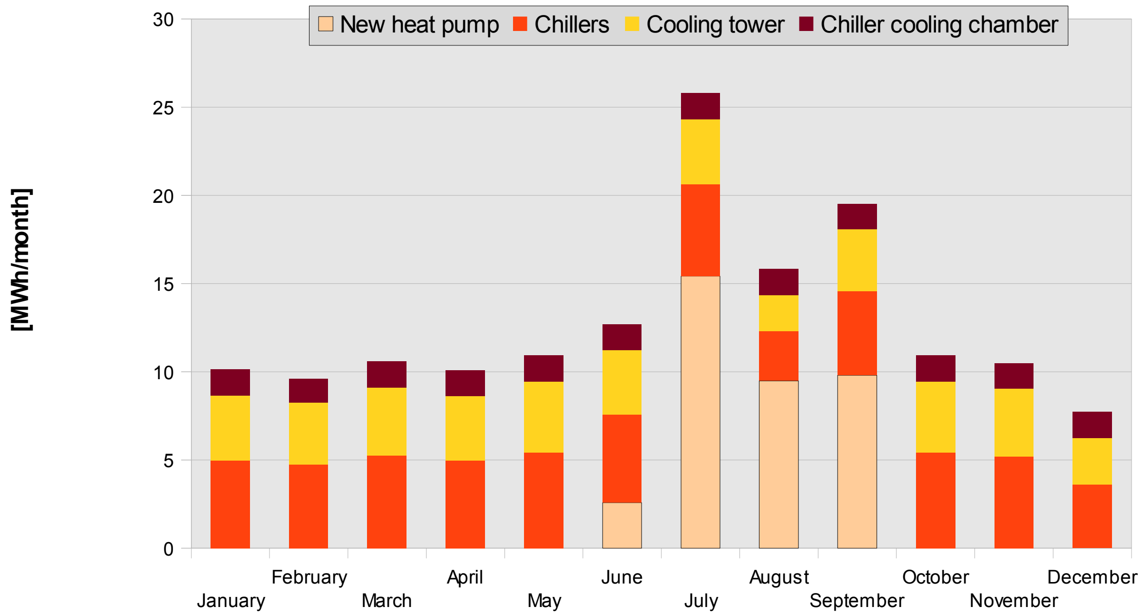

Figure 10. Contribution of the different equipments to the total useful cooling supply (USC) per month.

4.2. Summary: saving potential with respect to present state and economic performance

The following measures are proposed:

- heat recovery: prodution of process hot water, both, recovering the heat rejected by the chillers and cooling down the cream after pasteurisation
- energy supply systems: a solar thermal plant (evacuated tube collectors) for process heat generation at low and medium temperature, and a reversible heat pump for space heating, air conditioning and hot water preparartion.

These measures allow to save 35% of the current primary energy consumption and 43% of the current energy cost. The total estimated investment is 171.000 € and the expected pay-back is 4,1 years.

Table 11. Comparison of the present state and the proposed alternative: saving potential and economic performance.

	U.M.	Present state	Alternative	Saving
Total primary energy consumption (1)				
- total	*MWh*	*1.009*	*656*	*34,98%*
- fuels	*MWh*	*597*	*195*	*67,39%*
- electricity	*MWh*	*412*	*461*	*-11,91%*
Primary energy saving due to renewable energy (2)	*MWh*	*0*	*140*	*13,87%*
CO_2 emissions	t/a	*219*	*138*	*37,14%*
Annual energy system cost (3)	*EUR*	*96.106*	*74.154*	*22,84%*
Total investment costs	*EUR*	*0*	*171.148*	-
Payback period (4)	*years*	-	*4,1*	-

(1) including primary energy consumption for non-thermal uses

(2) use of solar energy instead of gasoil. The saving is calculated with respect to the current total primary energy consumption.

(3) including energy cost (fuel and electricity bills), operation and maintenance costs and annuity of total investment.

(4) the simple pay back time calculation includes the tax reduction expected for the solar thermal plant (estimated in 6.000 € at year 1)