Energy Audit Summary Report

Audit No. 38

Food Industry

Production of salami and cooked ham

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

January 2011

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) 39)

1. Contact data of the auditors

Claudia Vannoni, Hans Schweiger

energyXperts.NET, Barcelona (Spain) - Berlin (Germany)

www.energyxperts.net

info@energyxperts.net

2. Description of the company (status quo)

Reference year of data/information: 2010

Level of confidentiality: anonymous data

2.1. General information of the company

Sector	food	
Products	salami, cooked ham and pre-cooked pork meat products	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- natural gas	7.018	7.018
- electricity	6.419	3.383

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

2.2. Description of the company

a) Productive process

The company produces several pork meat based products (charcuterie), mainly salami and cooked hams. Fresh meat is delivered daily to the company, and then frozen and/or stored in cooling chambers.

The following salami production cycle can be divided in two main phases: the preparation of the mixture, and the maturation process during which the final products are dried and stabilised in humidity and temperature controlled chambers.

The (cooked) ham is preliminarly conditioned and then cooked, pasteurised and cooled down.

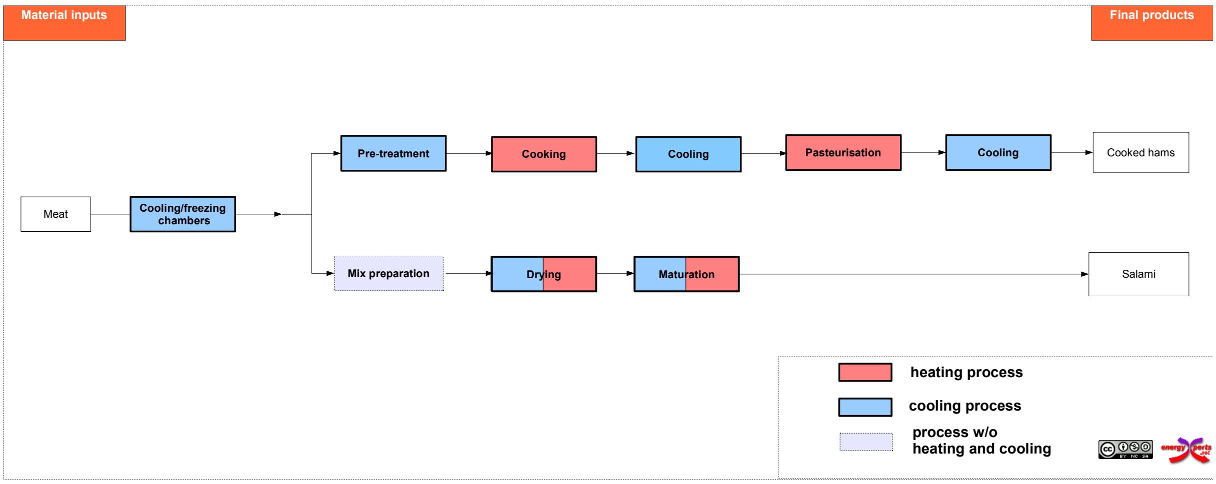

Figure 1. Simplified production flow sheet

Heat in the company is used for cooking and sterilisation the coooked products; for cleaning and space heating; for humidity control and SHW preparation respectively at medium (above 100ºC) , low (about 60ºC) and very low temperature (about 40ºC).

The raw and intermediate material is partially frozen in freezing tunnels (at -20ºC) and partially temporarly stored in cooling chambers (above 0ºC). Production halls are air conditioned all year long and ground- and chilled water is used to cool down the hams respectively after cooking and pasteurisation.

b) Energy supply system

The heat used in the company is supplied by a gas fired thermal oil heater equipped with a steam generator and an economiser.

Heat is distributed at 3 different temperatures: steam at 120 - 130ºC, hot water at 60ºC and warm water at 40ºC. Process water at 60ºC is prepared with the steam condensate (and with steam) while process water at 40ºC is produced recovering the heat rejected by the chillers (and with steam).

Cooling at different temperatures is provided by (water cooled) electrically driven chillers. A cooling pipe at -6/-8ºC supplies the cooling chambers at temperatures above the 0ºC while cooling is provided to the production halls via a distribution pipe at about 8/10ºC. Cooling of cooked hams after cooking is done via groundwater while post- pasteurization via chilled water at -2ºC.

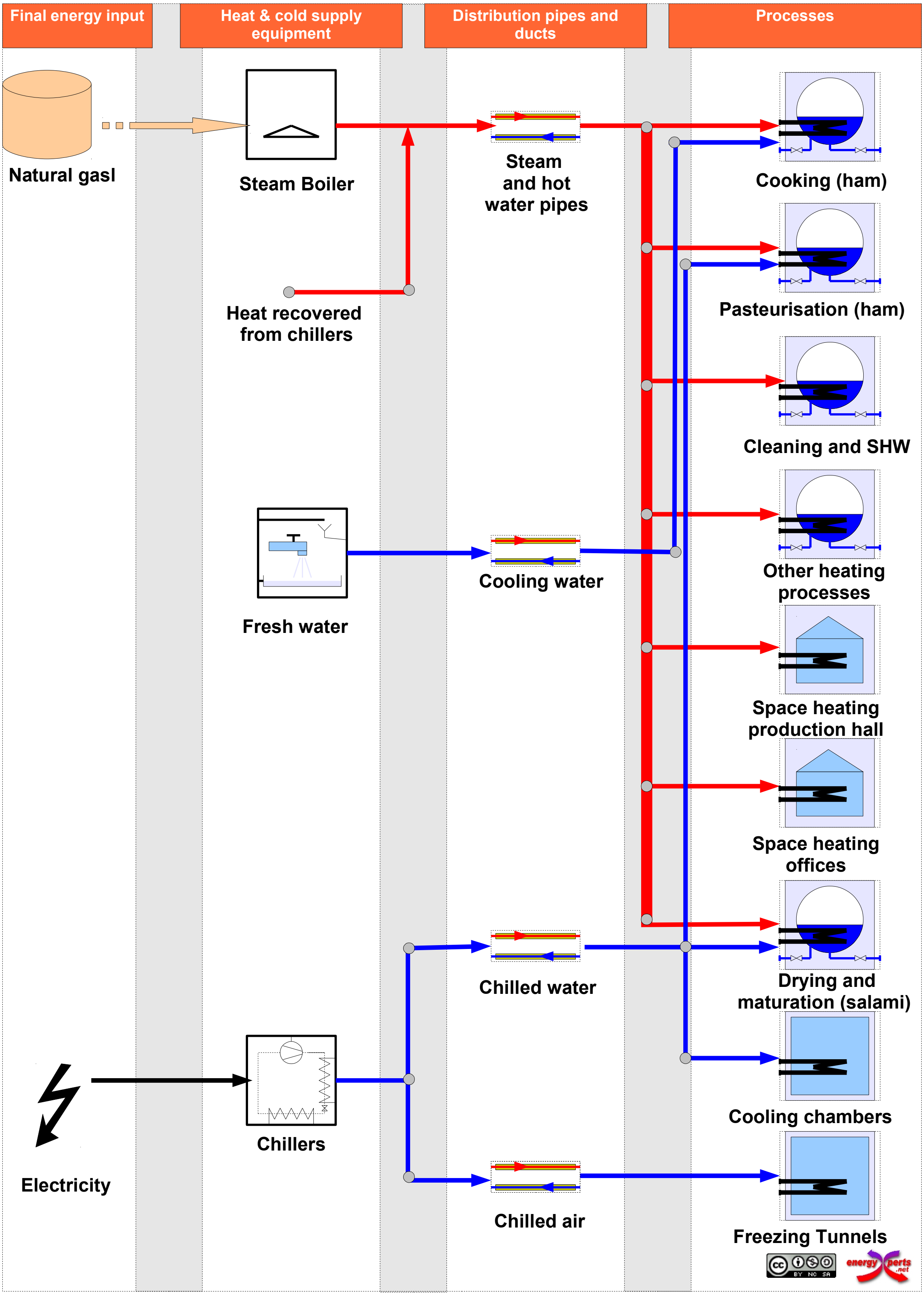

Figure 2. Overview of the heat and cold supply system

2.3. Additional comments

Peculiarities of the company

Huge availablily of heat at low temperature associated to the chillers heat rejection, much higher than the heating demand in this range of temperatures.

Specific assumptions

The results of this study are based on specific assumptions which affects the magnitude of the heat recovery potential and the design of the alternative energy supply system.

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 the alternatives are first shortly described and then the results of the comparative study are presented.

3.1. Proposed alternatives

The 4 technical potential alternatives that have been investigated are listed in Table 1.

The objectives to be achieved and the criteria used to design the alternatives were the followings:

a) to reduce the distribution inefficiencies,

b) to satisfy the heating demand in the range of 35 - 60ºC (medium-low temperature) as much as possible by using the wasted heat available in the company (by means of heat recovery, process integration and heat pump),

c) to improve the energy performance of the air treatment units through the internal heat recovery among out- and in-flows,

d) to provide the residual cooling and heating needs with energy-efficient and renewable supply systems.

Table 1. Overview of the alternative proposals studied

Short Name	Description
O+HR	Distribution and supply systems iprovement Optimization of the cooling after the sterilisation process Heat exchangers network for waste heat recovery (462 kWth)
O+HR+CHP	Distribution and supply systems iprovement Optimization of the cooling after the sterilisation process Heat exchangers network for waste heat recovery (462 kWth) CHP gas turbine (750 kWth/400 kWel)
O+HR+HP+CHP	Distribution and supply systems iprovement Optimization of the cooling after the sterilisation process Heat exchangers network for waste heat recovery (462 kWth) Heat pump (300 kWth) CHP gas turbine (750 kWth/400 kWel)
O+HR+ST+CHP	Distribution and supply systems iprovement Optimization of the cooling after the sterilisation process Heat exchangers network for waste heat recovery (462 kWth) Solar thermal plant – flat plate collectors (700 kWth) CHP gas turbine (750 kWth/400 kWel)

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	21.841	---	---
O+HR	18.981	2.860	13,09
O+HR+CHP	17.768	4.073	18,65
O+HR+HP+CHP	17.308	4.532	20,75
O+HR+ST+CHP	17.329	4.512	20,66

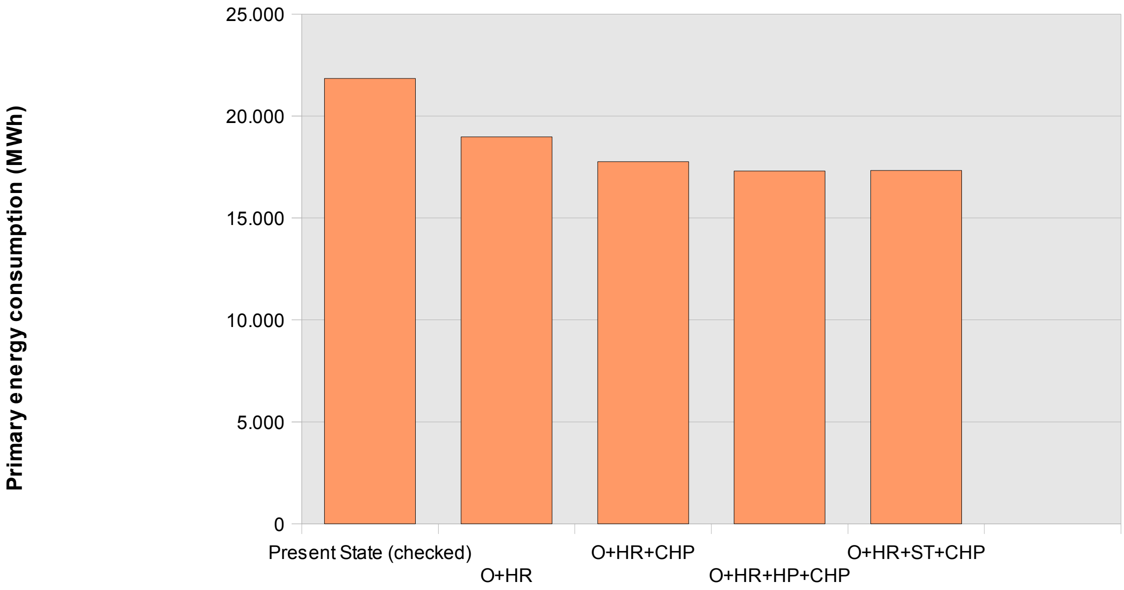

Figure 3. Comparative study: yearly primary energy consumption.

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 natural gas.

3.3. Economic performance

Table 3. Comparative study: investment costs.

Alternative	Total investment [€]	Subsidies [€]
Present State (checked)	---	---
O+HR	124.857	0
O+HR+CHP	584.857	0
O+HR+HP+CHP	659.857	0
O+HR+ST+CHP	995.164	0

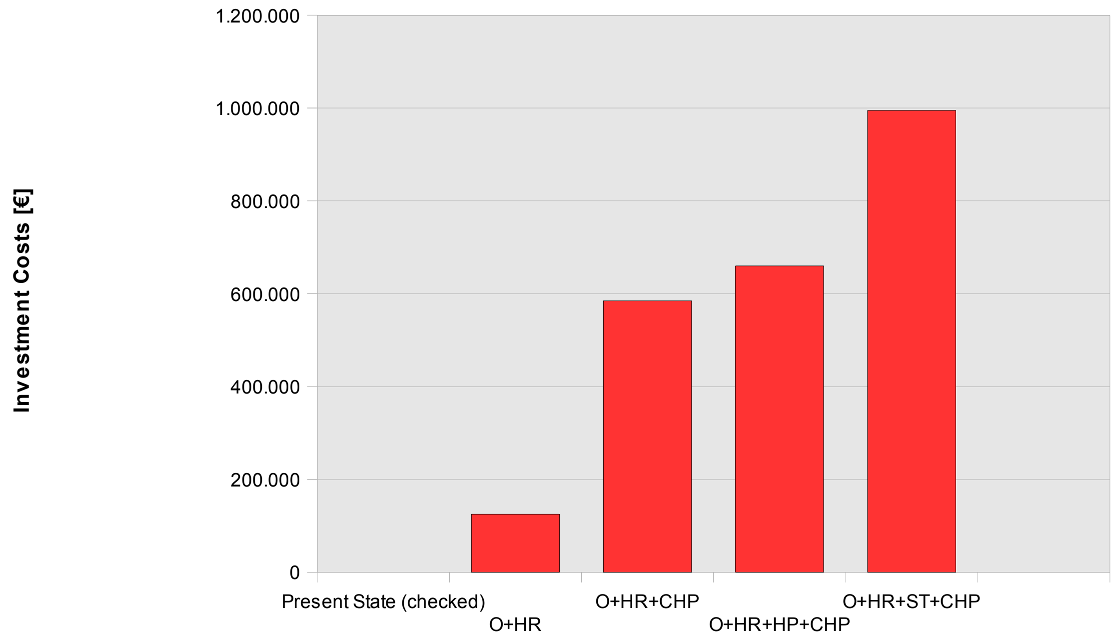

Figure 4. Comparative study: investment costs.

Table 4. Comparative study: annual costs including annuity of initial investment[2]. O&M costs are the additional costs associated to the new equipments.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]
Present State (checked)	---	1.000.001	0
O+HR	12.029	898.049	7.652
O+HR+CHP	56.346	781.949	22.426
O+HR+HP+CHP	63.572	783.162	21.810
O+HR+ST+CHP	95.876	771.031	30.354

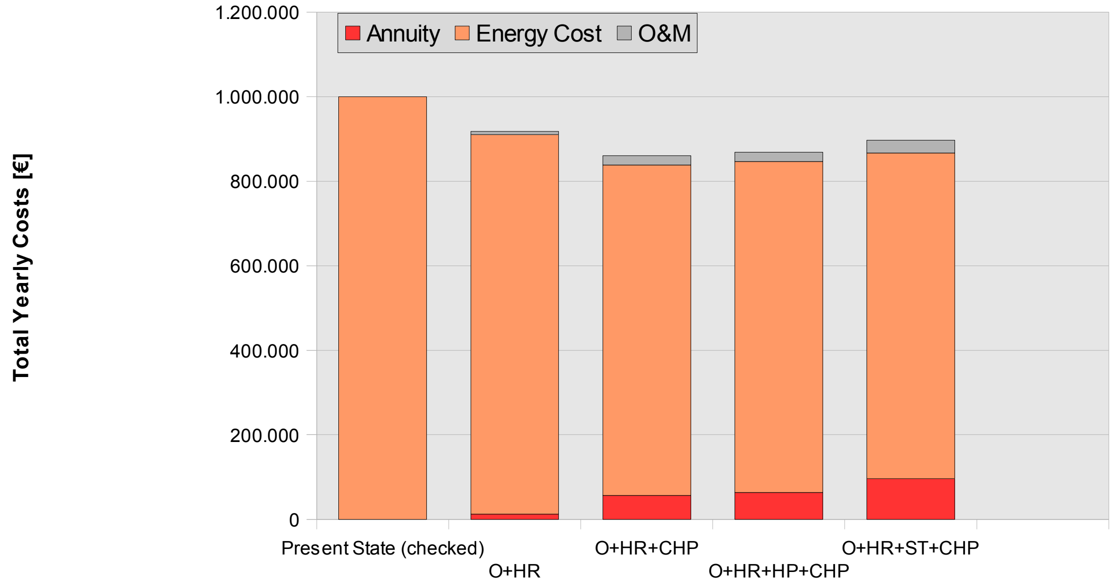

Figure 5. Comparative study: annual costs .

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 " Optimisation + Heat Recovery + Heat Pump + CHP gas turbine" (O+HR+HP+CHP) combines the general improvement of the energy system with a customized heat exchanger network (nominal power: 462 kW_{th}) and with the integration in the actual heat supply system of a heat pump (300 kW_{th}) and of a cogenerative gas turbine (400 kW_e /750 kW_{th}). It has been considered the best option among those analysed due to the following reasons:

- highest saving potential of primary primary energy
- significant energy cost reduction and pay-back time below 3 years.

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

4.1.1. System optimisation

The interventions proposed affects respectively:

a) the heat and cooling distribution and supply system

b) the cooling process after the sterilisation of the cooked hams.

a) It has been estimated a primary energy saving of about 3% improving the actual heat distribution piping (e.g. with a better insulation) and icreasing the cooling supply (and distribution) temperature to the processes above 0ºC, which in the actual configuration are connected to the pipe at -6/-8ºC. Implementing a second cooling dedicated pipeline at higher temperature, the chiller would work at a higher average temperature with a better EER.

b) Currently the cooling after the sterilisation process (at about 110ºC) is carried out in the autoclaves with chilled water at 2ºC, in order to shorten the process duration. Splitting the cooling processs in two phases, it would allow the recovery of the wasted heat at higher temperature (see heat exchanger HX5, in section 4.1.2). The first cooling step down to 70ºC infact could be carried out at approximately the same process speed with warm water at 35ºC to be used afterwards for cleaning at 60ºC; while the chilled water at 2ºC could be used for the second cooling step only.

Heat recovery

Heat recovery leads to an additional potential saving of around 10% with respect to the primary energy consumption after the optimisation measures.

The proposed heat exchanger network uses:

- the outflow of the cleaning process and the boiler's exhaust gases to pre-heat the process water (for cleaning) (HX4 and HX6),
- the humid air of the drying chambers and the exhaust air of the AHU in the offices building to pre-heat respectively the dry air (HX8) and the outside air (HX7).

For the description of the heat exchanger HX5 proposed between the cooling down after the sterilisation and the cleaning see section 4.1.1.

Table 5. List of heat exchangers proposed.

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX4	347	Cleaning	Cleaning	907	68,13%
HX5	19	Pasteurization	Cleaning	20	1,49%
HX6	59	Steam boiler_off-gases	Cleaning	110	8,24%
HX7	5	Offices heating_exhaust air	Offices heating_fresh air	25	1,86%
HX8	31	Drying salami_humid air	Drying salami_dry air	270	20,28%
	462			**1331,29**	**100,00%**

4.1.2. Heat and Cold Supply

In the new system proposed a cogeneration plant (gas turbine) has been added to the existing heat supply system. The CHP plant feeds heat into the existing steam network via a steam generator using the exhaust gases of the turbine (nominal power: 400 kW_{el}/750 kW_{th}). Furthermore, a new heat pump (nominal power: 300 kW_{th}.; expected COP: 4,8) has been proposed to produce heat in the temperature range of 35 - 55ºC using as source at low temperature the heat rejection of the chillers.

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

Equipment	Type	Nominal capacity	Contribution to total heat / cooling supply
		[kW]	[MWh]
New heat pump	compression heat pump	300	943
New CHP	CHP gas turbine	750	2.451
Steam boiler	steam boiler	3.256	993
Groundwater	groundwater	1.200	141
Chillers	compression chiller (water cooled)	2.638	7.924

The technical specifications of the new CHP gas turbine and of the new heat pump are given in Table 7 and Table 8.

Table 7. Technical specifications and economics of the new CHP gas turbine.

Parameter	Units	Technical data
Type of equipment	-	CHP gas turbine
Nominal power (heat or cold output)	kW	750,00
Fuel type	-	Natural gas
Fuel consumption (nominal)	kg/h	100,60
Electrical power generated (CHP)	kW	400,00
Electrical conversion efficiency (CHP)	-	0,32
Turn-key price	€	460000,00
Annual operational and maintenance fixed costs	€	3600,00
Annual operation and maintenance variable costs dependant on usage	€/MWh	4,00

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

Parameter	Units	Technical data
Type of equipment	-	compression heat pump
Nominal power (heat or cold output)	kW	300,00
Turn-key price	€	75000,00
Annual operational and maintenance fixed costs	€	750,00

The contribution of the new equipments to the total heat supply (4.387 MWh) is shown respectively in Table 9, Figure 6 and Figure 7.

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 boiler	993	22,63
New CHP	2.451	55,88
New heat pump	943	21,49
Total	**4.387**	**100**

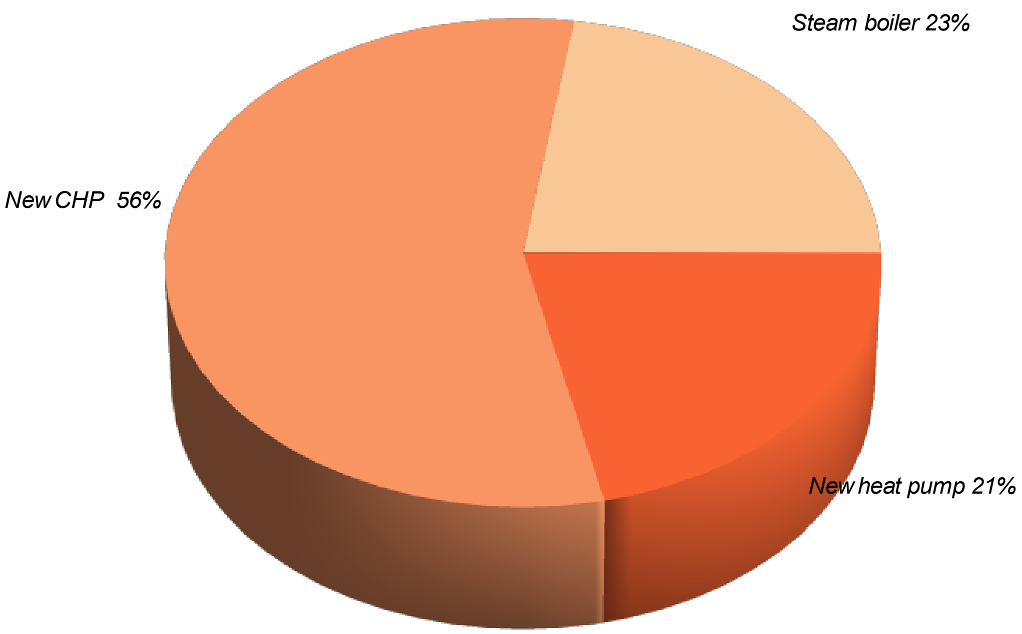

Figure 6. Contribution of the different equipments to the total useful heat supply (USH) in the company.

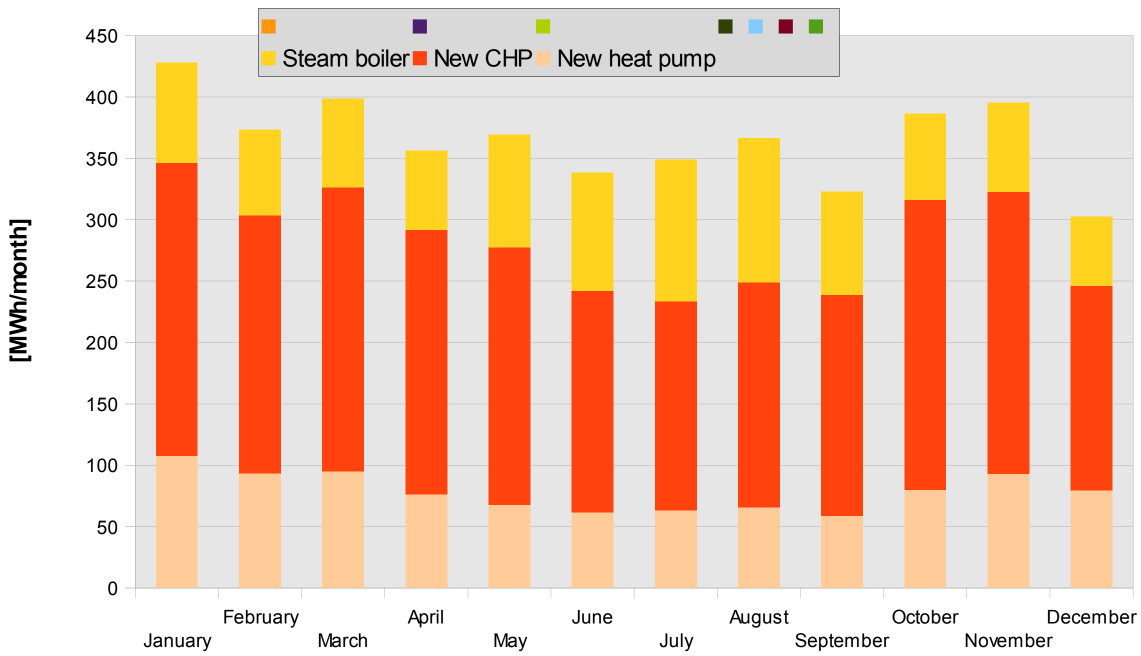

Figure 7. Contribution of the different equipments to the total useful heat supply (USH) per month.

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

The following measures are proposed:

- improvement of the distribution pipeline and optimisation of the cooling supply system
- optimisation of cooling after sterilisation, splitting the process in two temperature steps allowing heat recovery (at higher temperature)
- heat recovery: re - use of the waste heat from cleaning outflows, from the exhaust gases of the existing steam boiler, and from the humid and exhaust air
- improvement of the energy supply system: a new heat pump and a CHP gas turbine to supply the base load of the remaining heat demand.

These measures together allow to save 21% of the current primary energy consumption and around 22% of the current energy bill. The required investment is around 660.000 € and the expected pay-back time, taking into account a revenue for the white certificates, is shorter than 3 years (2,6).

Table 10. Comparison of the present state and the proposed alternative: saving potential and economic performance.

	U.M.	Present state	Alternative	Saving
Toal primary energy consumption (1)				
- total	*MWh*	*21.841*	*17.308*	*20,75%*
- fuels	*MWh*	*7.720*	*6.585*	*14,70%*
- electricity	*MWh*	*14.121*	*10.723*	*24,06%*
Primary energy saving due to renewable energy (2)	*MWh*	*0*	*0*	*-*
CO_2 emissions	*tons/year*	*4.579*	*3.680*	*19,63%*
Annual energy system cost (3)	*EUR*	*1.000.001*	*868.544*	*13,15%*
Total investment costs	*EUR*	*-*	*659.857*	*-*
Payback period (4)	*years*	*-*	*2,6*	*-*

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

(2) Heat pump not considered

(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 annual total non – recurring revenue for the white certificates

Recommandations and follow -up

- To carry out a measurement campaign of the key parameters for the assessment of the energy streams in the company
- and to analyse the technical and economical feasibility of the tri - generation (of electricity, heat and cooling), not proposed among the choosen alternatives in the framework of this study.