Energy Audit Summary Report

Audit No. 49

CAMST

Udine, Italy

Food Industry

Industrial catering

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: 2009

(Date of the visit on site: 14-06-2011)

2.1. General information of the company

Company, location	CAMST, Udine (Italy)	
Sector	Food – Industrial catering	
Products	Meals	
Yearly production	1.235.000 meals	
Turnover	4,8 M€	
No. of employees	56	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- natural gas	1.168	1.168
- electricity	563	n.a.

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

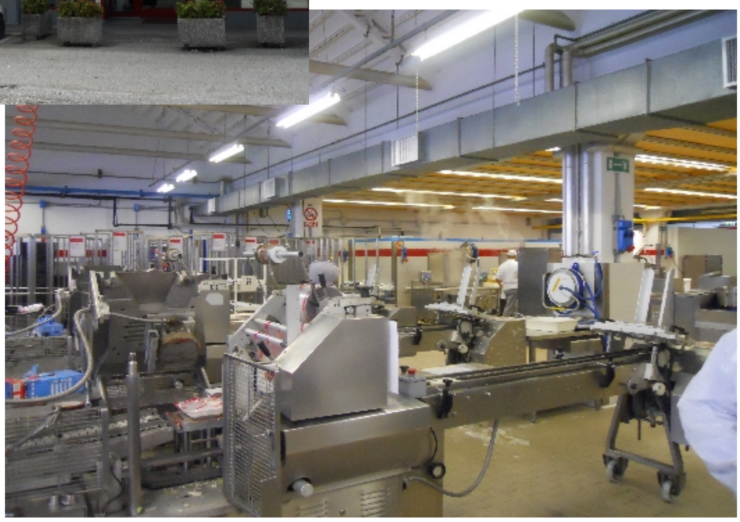

Figure 1. Overview of the industrial kitchen: building and production hall

2.2. Description of the company

a) Productive process

The company is an industrial kitchen delivering meals to schools (core business) and to other customers such as offices and hospitals.

Depending on the deperibility, the food ingredients are either stored in cooling and freezing chambers or used as delivered.

The kitchen is equipped with several cookers, mostly gas fired. Hot water is used for cooking (pasta, rice and soups) and for cleaning (mainly dish-washing).

Figure 2. Cookers

Once the meals have been cooked or assembled, they are either shortly stored at controlled temperature or simply packaged and delivered.

Almost all rooms (production halls and offices) are equipped with ventilation, space heating and cooling systems.

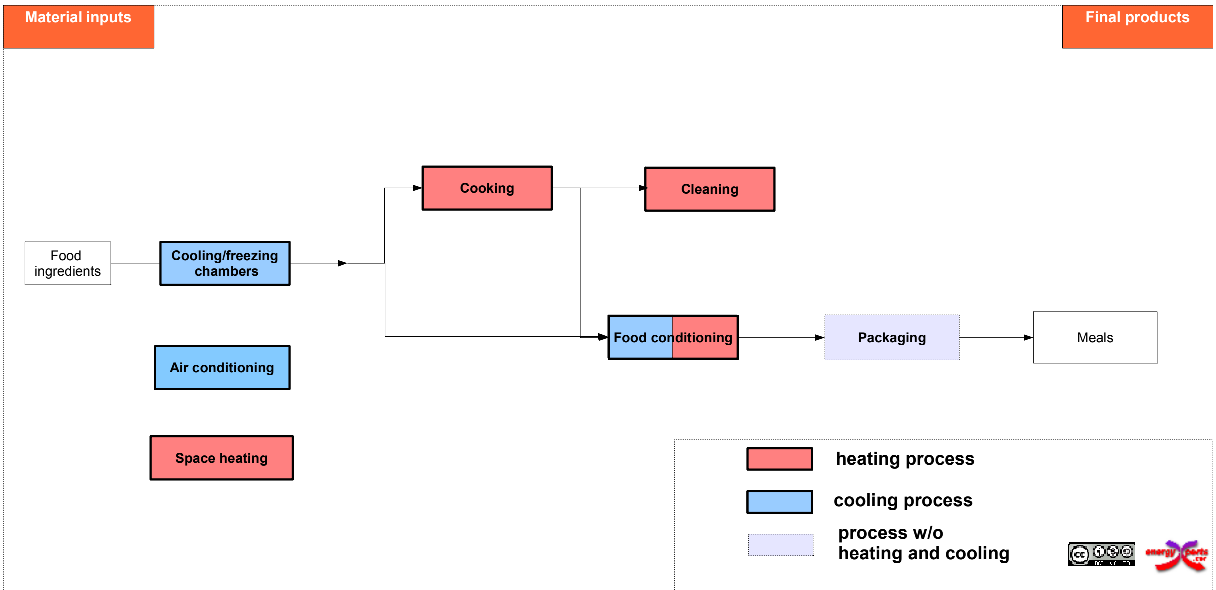

Figure 3. Simplified production flow sheet

Heat is mainly needed for cooking (around 50% of the demand) at different temperatures depending on the recipe. Heat is also used for space heating and for dish washing (at 90ºC and at 35ºC).

Cooling is needed for air conditioning and in the production process since the food ingredients are stored in cooling chambers at 0 – 8ºC, while frozen products are maintained at lower temperature (- 18ºC).

b) Energy supply system

The heat used in the company is generated in different equipments. Cookers and ovens are mainly equipped with natural gas burners while 2 gas fired condensing boilers produce hot water for space heating and process hot water. An additional hot water boiler running only in winter time is used for space heating of the offices.

Cooling for air conditioning is provided by a water cooled electrically driven chiller via a water chilled pipe at 7/12ºC. The heat rejected by this equipment is recovered and used to pre-heat the process hot water.

Cooling and freezing chambers are equipped with individual air cooled electrically driven split chiller units.

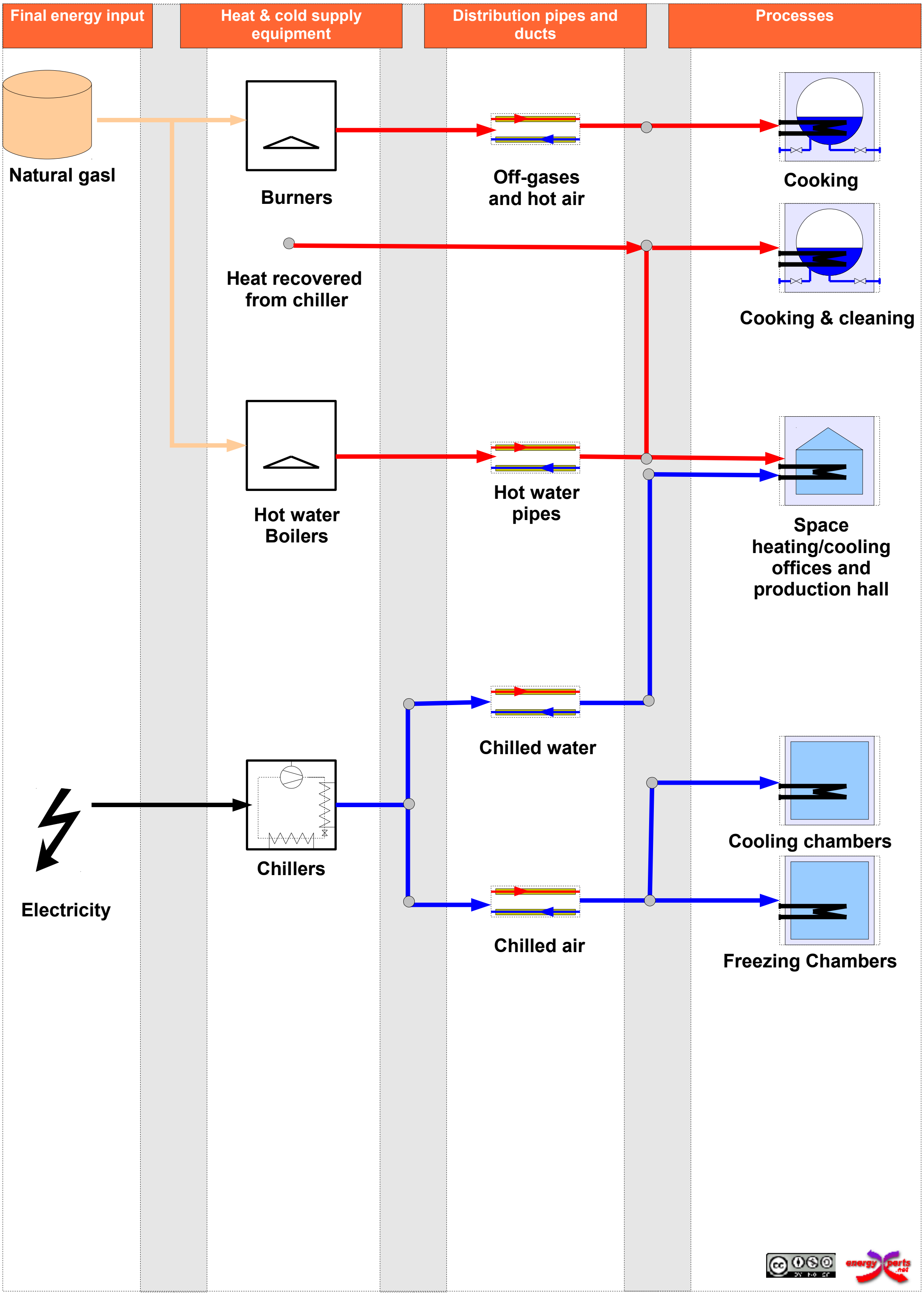

Figure 4. Overview of the heat and cold supply system

2.3. Additional comments

Peculiarities of the company

- Remarkable weekly and monthly variability of the production and of the energy demand.
- 45% of the fuel is burned directly in the process equipment (e.g. gas fired ovens and cookers)
- Vapours and smokes are collected, cleaned and ejected actively during the cooking processes without heat recovery.

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.

Table 1. Overview of the alternative proposals studied

Short Name	Description
HR	Heat recovery from the smokes and vapours of the kitchen and from the wasted hot process water via a heat exchanger network (70 kW)
HR+CHPengine	- Heat recovery from the smokes and vapours of the kitchen and from the wasted hot process water via a heat exchangers network (70 kW) - Cogenerative gas fired engine (Nominal power: 93kWt/50 kWe)
HR+ST	- Heat recovery from the smokes and vapours of the kitchen and from the wasted hot process water via a heat exchanger network (70 kW) - A solar thermal plant for hot water production (installed capacity: 110 kWt; 157 m2 of flate plate collectors; storage: 8 m3)
HR+ST+TC	- Heat recovery from the smokes and vapours of the kitchen and from the wasted hot process water via a heat exchanger network (70 kW) - Solar cooling with a solar thermal plant (installed capacity: 100 kWt; 142 m2 of evacuated tubes collectors; storage: 7 m3) and a thermal chiller (nominal capacity: 40 kWt)

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State	2.506	---	---
HR	2.332	174	6,95
HR+CHPengine	2.268	238	9,49
HR+ST	2.255	251	10,02
HR+ST+TC	2.237	269	10,74

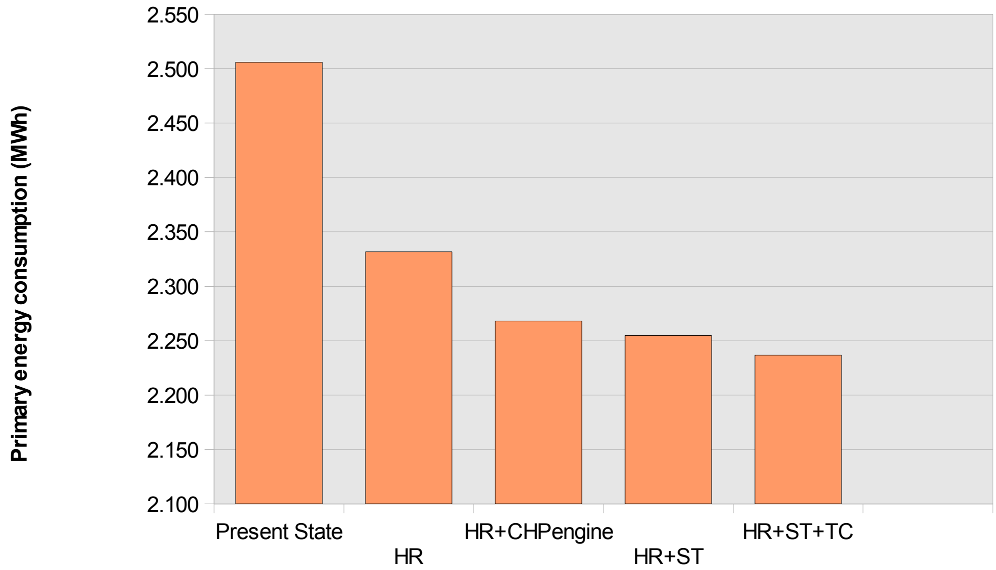

Figure 5. Comparative study: yearly primary energy consumption.

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. No susbsidies considered: the estimated income related to the white certificates trading and the tax reduction foreseen for the solar thermal implementation have been included in the economic assessment as non- recurring revenues.

Alternative	Total investment [€]	Subsidies [€]
Present State	---	---
HR	24.800	0
HR+CHPengine	87.300	0
HR+ST	96.349	0
HR+ST+TC	120.299	0

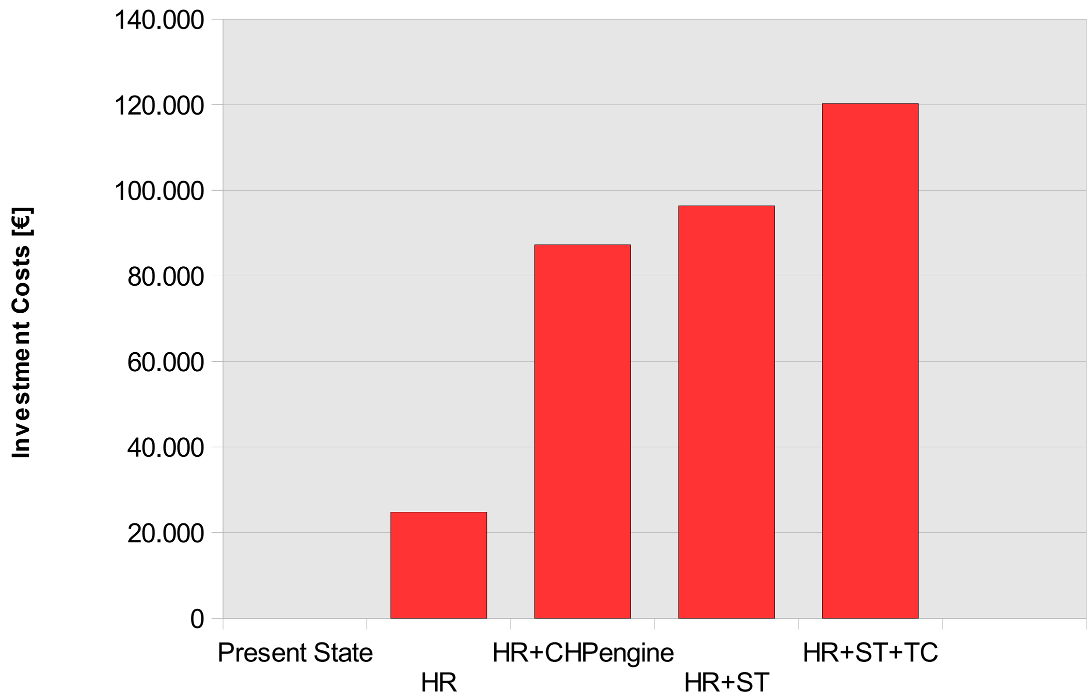

Figure 6. Comparative study: investment costs.

Table 4. Comparative study: annual costs including annuity of initial investment[2]. O&M costs are the additional costs associated to the new equipment. The annual energy costs reported in the table includes the fuel and electricity annual costs and do not include the expected revenues for the white certificates and the tax reduction foreseen for the solar thermal implementation.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]	Total [€]
Present State	---	130.335	0	130.335
HR	2.389	123.665	752	126.806
HR+CHPengine	8.411	107.663	4.950	121.024
HR+ST	9.283	120.782	2.127	132.191
HR+ST+TC	11.590	119.661	2.422	133.673

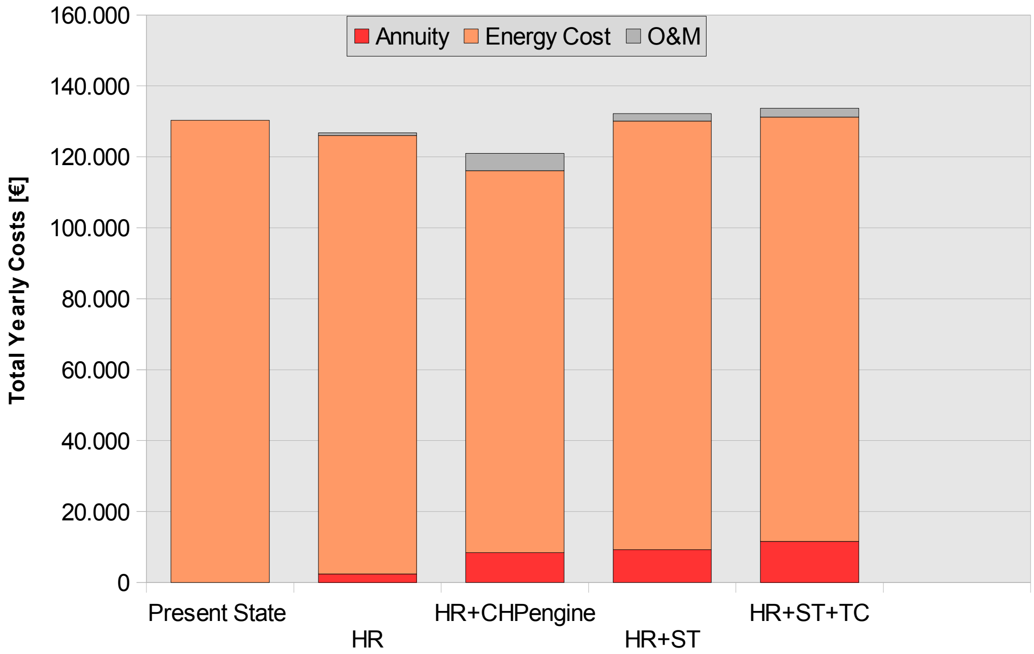

Figure 7. Comparative study: annual costs .

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 "Heat Recovery + Cogenerative engine " (HR+CHPengine) combines a customized heat exchanger network (nominal power: 70 kW_{th}) with the integration in the actual heat supply system of a cogenerative gas fired engine 50 kW_e /93 kW_{th}). It has been considered the best option among those analysed because it shows a significant potential for energy saving and a good economic performance.

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

4.1.1. Process optimisation

Not investigated.

4.1.2. Heat recovery

The proposed heat exchanger network uses:

- the outflow (wasted hot water) of the cookers and of the dishwasher to pre-heat the process water (HX1),
- the smokes and vapours extracted from the kitchen during the cooking processes to pre-heat the outside air (HX2).

Heat recovery would lead to a fuel saving of 14% which in terms of total primary energy consumption (incl. electricity) means a saving of 7%.

Table 5. List of heat exchangers proposed (excl. the existing ones).

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX 1	8	Wasted process hot water	Process hot water	22	14%
HX2	62	Outflow of the vapours and smokes extractor	Inflow of the AHU for the kitchen space heating	134	86%
	70			**156**	**100**

Figure 8. Smoke extractor in the kitchen

4.1.3. Heat and Cold Supply

In the new system proposed a cogeneration plant (gas engine, nominal power: 50 kW_{el}/93 kW_{th}) has been added to the existing heat supply system. The CHP plant delivers the energy content of the o cooling circuit and of the exhaust gases of the engine to the existing heat distribution network in order to cover the base load.

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

Equipment	Type	Nominal capacity [kW]	Contribution to t [MWh]
New CHP	CHP engine	93	370
Condensing boilers	condensing boiler	626	83
Hot water boiler	hot water boiler	110	9
Burners	burner (direct heating)	916	514
Chiller air conditioning	compression chiller (water cooled)	121	22
Chillers cooling chambers	compression chiller (air cooled)	13	23
Chillers freezing chambers	compression chiller (air cooled)	31	54

The technical specifications of the new CHP turbine are given in Table 7.

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

Parameter	Units	Technical data
Type of equipment	-	CHP engine
Nominal power (heat or cold output)	kW	93,00
Fuel type	-	NG
Fuel consumption (nominal)	kg/h	14,40
Electrical power generated (CHP)	kW	50,00
Electrical conversion efficiency (CHP)	-	0,28
Turn-key price	€	62500,00
Annual operational and maintenance fixed costs	€	500,00
Annual operation and maintenance variable costs dependant on usage	€/MWh	10,00

The total and monthly contribution of the new equipments to the total heait supply (975 MWh) is shown respectively in Table 8, Figure 9 and Figure 10.

Table 8. Contribution of the different equipments to the total useful heat supply (USH) in the company.

Equipment	USH by equipment	
	[MWh]	[% of Total]
Condensing boilers	83	8,50
Hot water boiler	9	0,91
Burners	514	52,67
New CHP	370	37,91
Total	**975**	**100**

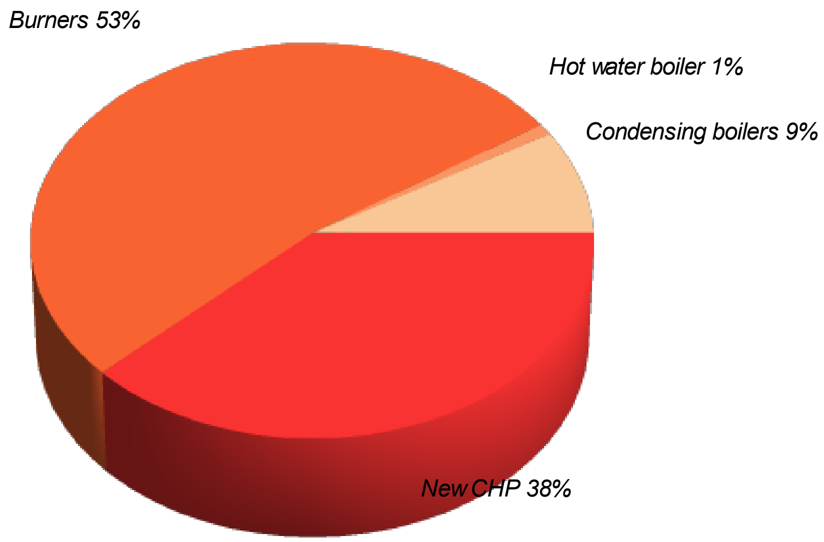

Figure 9. Contribution of the different equipments to the total useful heat supply (USH) in the company.

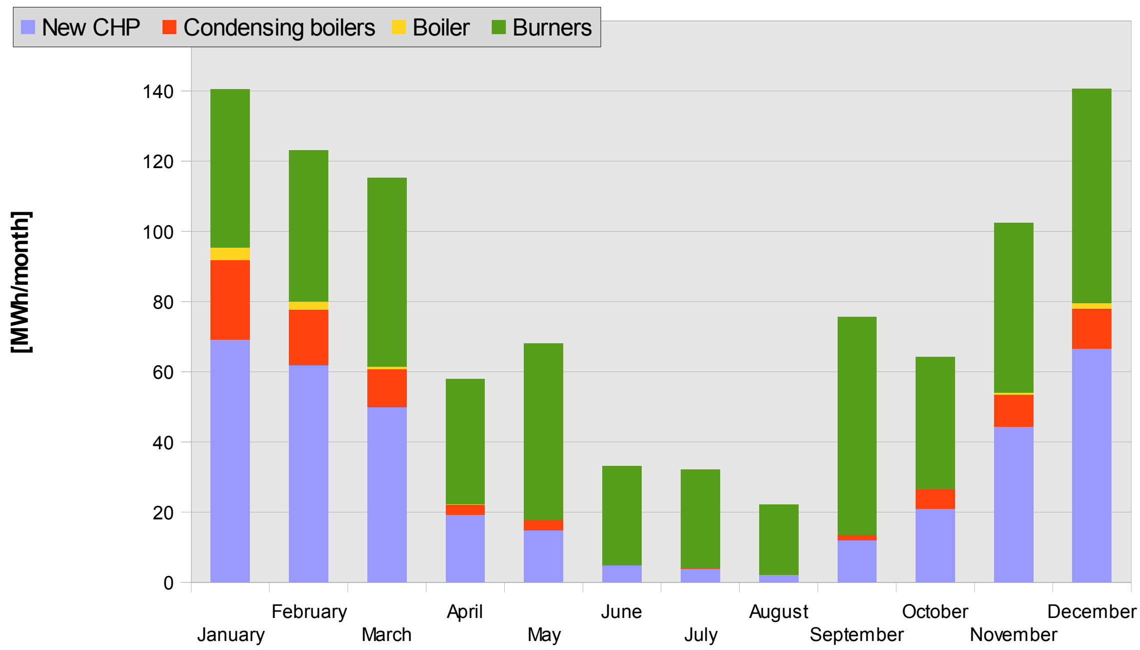

Figure 10. Contribution of the different equipments to the total useful cooling supply (USH) per month.

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

The following measures are proposed:

- heat recovery: to re - use the energy content of the wasted process water and of the smokes and vapours extracted from the kitchen during the cooking processes to pre-heat respectively the fresh water and the outside air;
- improvement of the energy supply system: to integrate a new CHP gas engine to cover the base demand load.

These measures together allow to save 9,5% of the current total primary energy consumption and more than 17% of the current energy cost. The estimated investment is 87.300 € and the expected pay-back time, taking into account a revenue for the white certificates, is around 4 years.

Table 9. 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*	*2.506*	*2.268*	*9,49%*
- fuels	*MWh*	*1.284*	*1.491*	*-16,06%*
- electricity	*MWh*	*1.222*	*778*	*36,35%*
Primary energy saving due to renewable energy	*MWh*	*0*	*0*	-
CO_2 emissions	t/a	*540*	*496*	*8,00%*
Annual energy system cost (2)	*EUR*	*130.335*	*121.024*	*7,14%*
Total investment costs	*EUR*	-	*87.300*	-
Payback period (3)	*years*	-	*4,15*	-

(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) *the simple pay back time calculation includes the annual total non - recurring revenue for the white certificates (estimated in approx. 4.700 € at year 1)*