Energy Audit Summary Report

Audit No. 68

Food Industry

Production of snack pellets and pre-cooked lasagna

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

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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

(Date of the visit on site: 15-06-2011)

2.1. General information of the company

Sector	Food	
Products	Snack pellets and pre-cooked lasagna	
Yearly production	7.180 tons	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- natural gas	10.222	10.222
- electricity	4.265	727

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

2.2. Description of the company

a) Productive process

The company produces pellet-based products and pre-cooked pasta for lasagna. Pellets are half- food products mainly used in the snack industry.

During the manufacturing process, flour and water are mixed and fed into an extruder in which the dough is forced to flow through a die, under various conditions of heating and cooling depending on the recipe.

After the extrusion process, the pasta for lasagna is cooked, rinsed and dried while the snack pellets are cooled down, pre-dried and finally dried.

After packaging, the final products are stored at controlled temperature.

Warehouse and offices are equipped with space heating and cooling devices.

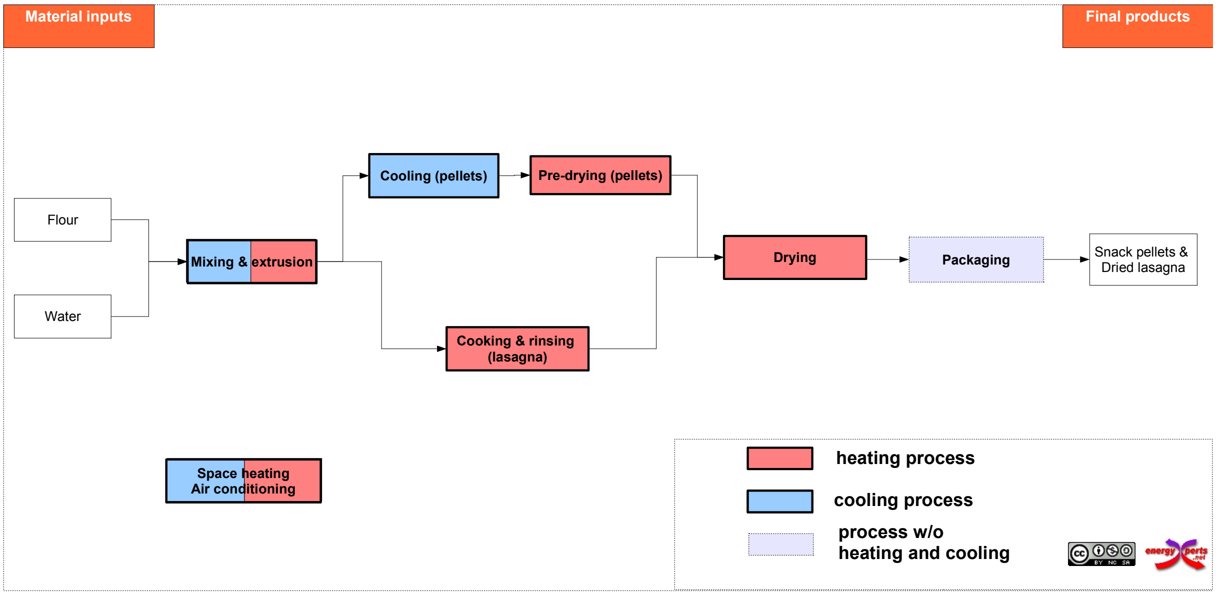

Figure 1. Simplified production flow sheet

The most energy consuming processes in the company are cooking and drying.

b) Energy supply system

The heat used in the production lines is generated in several equipments.

Electrical heaters regulate the temperature during the extrusion processes while the steam necessary for an ingredients vaporization process is generated into a gas fired steam boiler.

Two gas fired hot water boilers supply the required energy to the driers for snacks pellets and for process hot water. Gas burners provide heat to the lasagna cooking process while lasagna dryiers are equipped with catalytic combustors.

The chilled water used in the company mainly to cool down the production equipments temperature during operation is provided by two electrically driven chillers.
Space heating and air conditioning is done via a reversible heat pump.

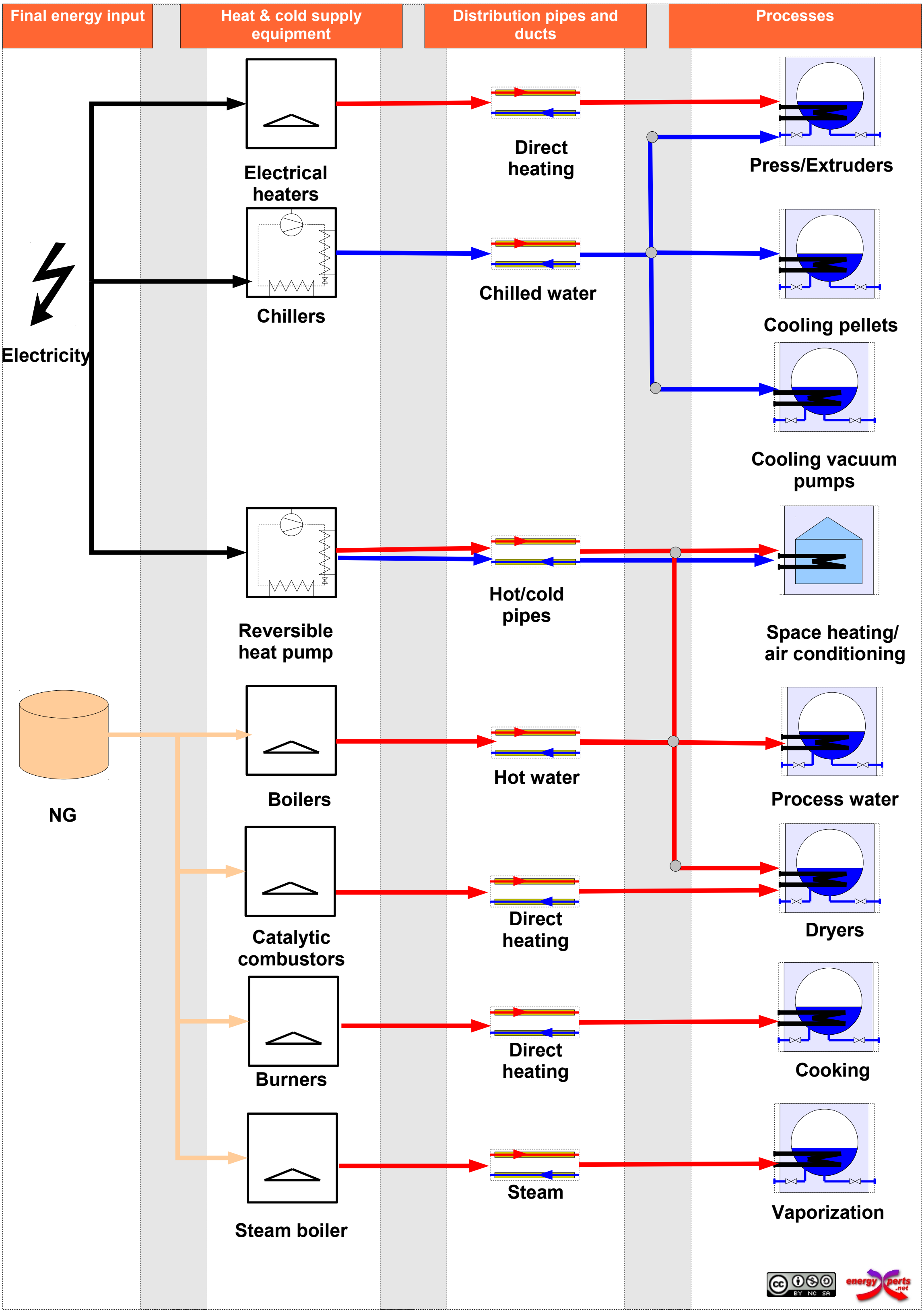

Figure 2. Overview of the heat and cold supply system

2.3. Additional comments

Peculiarities of the company

- Various food products drying methodologies in use.

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

Table 1. Overview of the alternative proposals studied. The HR measure is the same in all alternatives.

Short Name	Description
HR (Heat recovery via HX network)	* Heat exchanger network for heat recovery from the pellets pre-dryers and dryers air-outflows and from the lasagna cooking hot water-outflow for pre-heating of the drying air-inflows and of the process water (Nom. Power: 115 kW)
HR + HP (Heat recovery via HX network and Heat Pump)	* Heat exchanger network for heat recovery from the pellets pre-dryers and dryers air-outflows and from the lasagna cooking hot water-outflow for pre-heating of the drying air-inflows and of the process water (Nom. Power: 115 kW) * Heat pump recovering the latent heat from the pellets pre-dryers humid air-outflows for the pellets drying heating process (Nom. Power: 200 kW)
HR + CHP (Heat recovery via HX network + CHP turbine)	* Heat exchanger network for heat recovery from the pellets pre-dryers and dryers air-outflows and from the lasagna cooking hot water-outflow for pre-heating of the drying air-inflows and of the process water (Nom. Power: 115 kW) * Cogenerative turbine (Nom. Power: 500 kWe /938 kWt)
HR + HP+CHP (Heat recovery via HX network and Heat Pump + CHP turbine)	* Heat exchanger network for heat recovery from the pellets pre-dryers and dryers air-outflows and from the lasagna cooking hot water-outflow for pre-heating of the drying air-inflows and of the process water (Nom. Power: 115 kW) * Heat pump recovering the latent heat from the pellets pre-dryers humid air-outflows for the pellets drying heating process (Nom. Power: 200 kW) * Cogenerative turbine (Nom. Power: 500 kWe /938 kWt)
HR + ST + CHP (Heat recovery via HX network + Solar Thermal plant + CHP turbine)	* Heat exchanger network for heat recovery from the pellets pre-dryers and dryers air-outflows and from the lasagna cooking hot water-outflow for pre-heating of the drying air-inflows and of the process water (Nom. Power: 115 kW) * Solar thermal evacuated tubes collectors for process hot water preparation and space heating (Nom. Power: 350 kW) * Cogenerative turbine (Nom. Power: 500 kWe /938 kWt)

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State	20.500	---	---
Heat Recovery	19.329	1.171	5,71
Heat Recovery + Heat Pump	18.757	1.742	8,50
Heat recovery + CHP turbine	16.207	4.293	20,94
Heat Recovery + Heat Pump + CHP turbine	16.137	4.362	21,28
Heat recovery + Solar thermal + CHP turbine	16.033	4.467	21,79

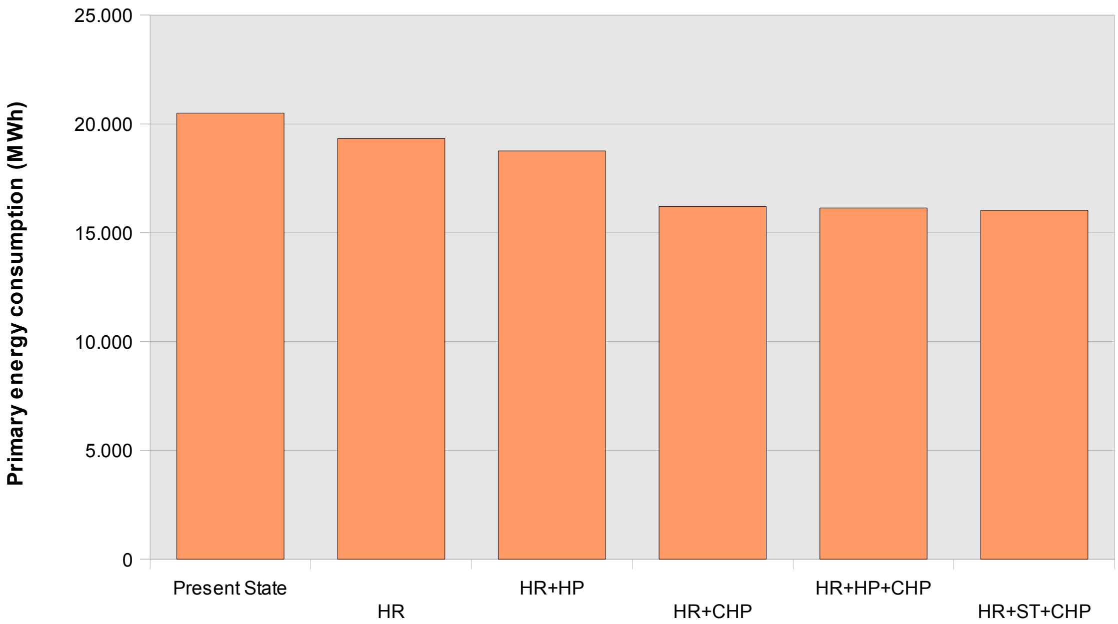

Figure 3. Comparative study: yearly primary energy consumption.

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. 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 [€]	Own investment [€]	Subsidies [€]
Present State	---	---	---
Heat Recovery	44.900	44.900	0
Heat Recovery + Heat Pump	100.900	100.900	0
Heat recovery + CHP turbine	594.900	594.900	0
Heat Recovery + Heat Pump + CHP turbine	650.900	650.900	0
Heat recovery + Solar thermal + CHP turbine	869.022	869.022	0

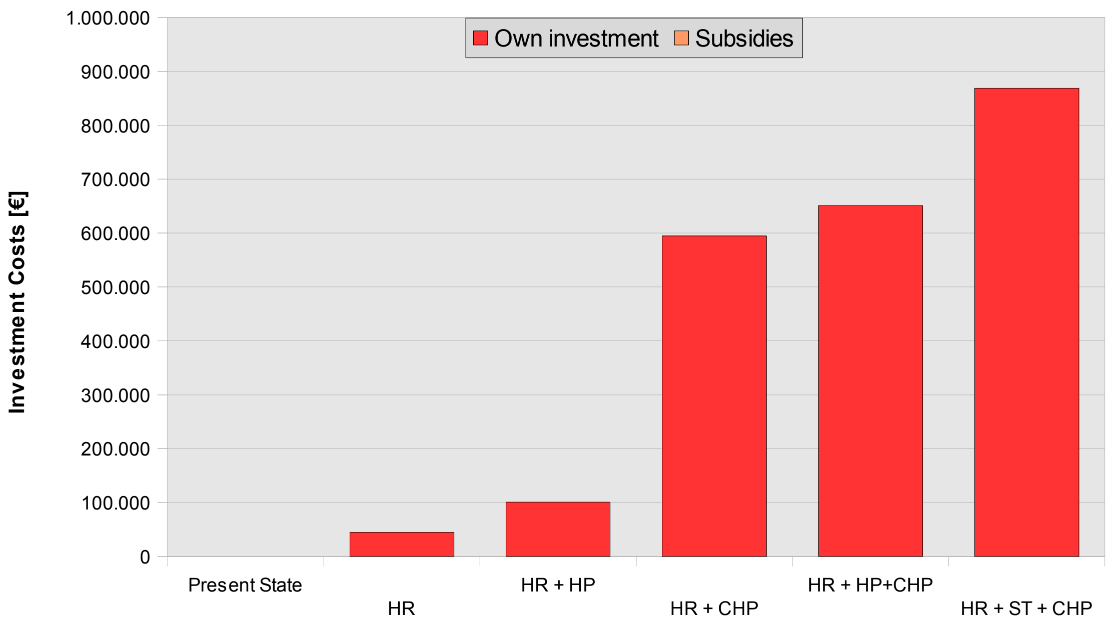

Figure 4. Comparative study: investment costs.

Table 4. Comparative study: annual costs including annuity of initial investment[2]. O&M costs are the additional costs associated to the new equipment. The annual energy costs reported in the table include 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	---	908.259	0	908.259
Heat Recovery	4.326	867.473	3.600	875.398
Heat Recovery + Heat Pump	9.721	857.955	4.400	872.076
Heat recovery + CHP turbine	57.314	577.072	33.566	667.951
Heat Recovery + Heat Pump + CHP turbine	62.709	584.889	31.921	679.519
Heat recovery + Solar thermal + CHP turbine	83.724	572.854	36.908	693.486

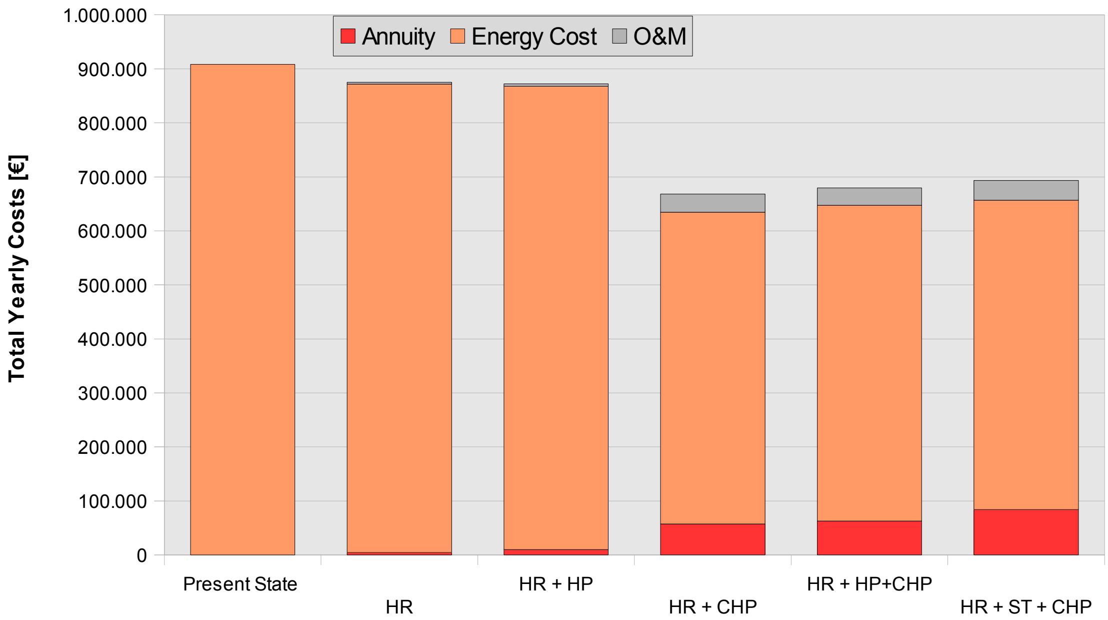

Figure 5. Comparative study: annual costs including annuity of initial investment.

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 Recovery + CHP turbine" that combines a customized heat exchanger network and a cogenerative gas turbine of 500 kW_e /938 kW_{th} has been considered the best option because it shows the best energy saving potential in relation to the economic performance although the energy saving alternatives including either a heat pump or a solar thermal plant might be further investigated being also valuable saving alternatives.

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 alternative includes two types of intervention for waste heat recovery via heat exchangers (see Table 5):

- the use of the cooking waste water for process water pre-heating;
- the use of the air-outflows for the air-inflows pre-heating within the drying processes.

As can be seen from Table 2, this heat recovery measure leads alone to a primary energy saving of 5,7%.

Table 5. List of heat exchangers proposed.

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX network_process water	61	Waste heat cooking lasagna	Process water	448	53,18%
HX network_dryers	54	Drying air-outflows	Drying air-inflows	395	46,82%
	115			**842,67**	**100,00%**

4.1.3. Heat and Cooling Supply

In the new system proposed a cogeneration plant (gas turbine, nominal power: 500 kWe/ 938 kWt) is added to the heat supply system. The energy content of the turbine`s exhaust gas is supplied to the processes either directly or by means of (existing) steam and hot water distribution circuits.

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

Equipment	Type	Nominal capacity	Contribution to total heat / cooling supply
		[kW]	[MWh]
New CHP	CHP gas turbine	938	6.363
Boiler	hot water boiler	1.395	456
Steam generator	steam boiler	209	81
Burners	burner (direct heating)	477	143
Catalytic combustors	burner (direct heating)	790	1.286
Electric heaters (press)	electric heaters (direct heating)	25	183
Electric heaters (extruders)	electric heaters (direct heating)	60	329
Reversible heat pump (heating mode)	compression heat pump	200	24
Reversible heat pump (cooling mode)	compression heat pump	200	124
Chillers	compression chiller (air cooled)	145	726

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

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

Parameter	Units	Data
Type of equipment	-	CHP gas turbine
Nominal power (heat or cold output)	kW	938,00
Fuel type	-	Natural gas
Fuel consumption (nominal)	kg/h	125,80
Electrical power generated (CHP)	kW	500,00
Electrical conversion efficiency (CHP)	-	0,32
Turn-key price	€	550.000
Annual operational and maintenance fixed costs	€	4.500
Annual operation and maintenance variable costs	€/MWh	4

The total and monthly contribution of the new equipment to the total heat supply (8.866 MWh) is shown respectively in Table 8, Figure 6 and Figure 7 .

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
Boiler	456	5,15
Steam generator	81	0,91
Burners	143	1,61
Catalytic combustors	1.286	14,50
Electric heaters (press)	183	2,06
Electric heaters (extruders)	329	3,71
Reversible heat pump (heating mode)	24	0,28
New CHP	6.363	71,77
Total	**8.866**	**100**

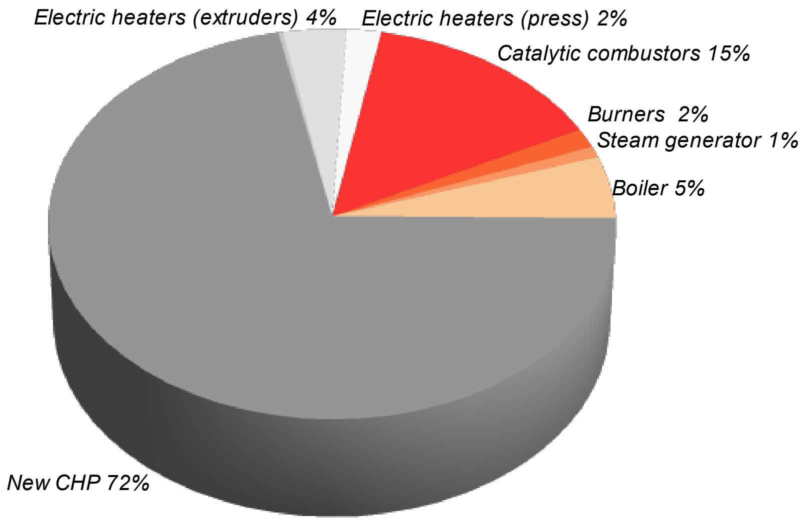

Figure 6. Contribution of the different equipments to the total useful heat supply (USH) in the company.

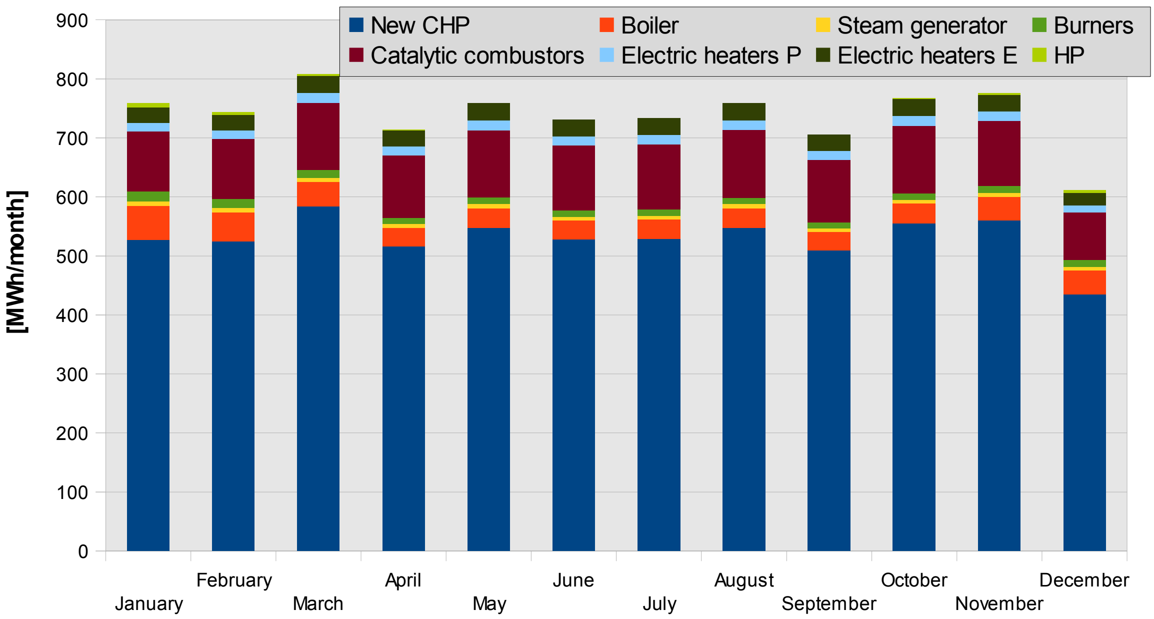

Figure 7. Contribution of the different equipments to the total useful heat supply (USH) per month.

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

The following measures are proposed:

- heat recovery: use of the waste heat from the cooking and drying processes for process water and dryers air-inflows pre-heating
- cogeneration (gas turbine) for covering the base load of the remaining heat demand

These measures allow to save 21 % of the current primary energy consumption and 36 % of the current energy costs. The total estimated investment is 595.000 € and the expected pay-back time, taking into account a revenue for the white certificates, is less than 2 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*	*20.500*	*16.207*	*20,94%*
- fuels	*MWh*	*11.244*	*15.139*	*-34,64%*
- electricity	*MWh*	*9.256*	*1.068*	*88,46%*
Primary energy saving due to renewable energy	*MWh*	*0*	*0*	*-*
CO_2 emissions	t/a	*4.432*	*3.657*	*17,49%*
Annual energy system cost (2)	EUR	*908.259*	*667.951*	*26,46%*
Total investment costs	EUR	*0*	*594.900*	*-*
Payback period (3)	*years*	*-*	*1,8*	*-*

(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. 56.550 € at year 1)