Energy Audit Summary Report

Audit No. 09

Food Industry

Production of canned vegetables

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: 2010

Level of confidentiality: anonymous data

2.1. General information of the company

Sector	canned food	
Products	canned vegetables, soups and meat	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- natural gas	10.355	10.355
- local district heating network	152	152
- electricity	1.855	210

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

2.2. Description of the company

a) Productive process

The company receives both fresh and frozen ingredients already prepared for filling into cans. Part of the products is temporarily stored in cooling chambers before further processing.

Vegetables are blanched in hot water, whereas other products are directly mixed and cooked with other ingredients in a mixing vessel.

After mixing and cooking products are filled into cans, and in the subsequent step cans are pasteurized. For this purpose both continuous and batch autoclaves are used.

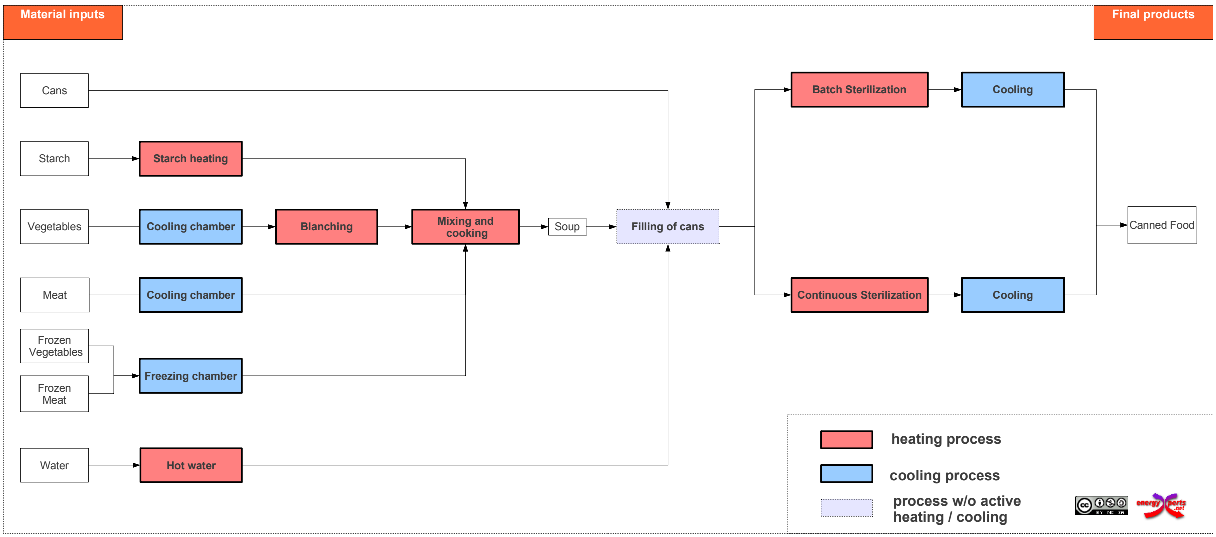

Figure 1. Simplified production flow sheet

The most energy consuming processes in the company are sterilisation (both heating and cooling) and blanching.

b) Energy supply system

The heat used in the company is generated in a gas fired steam boiler. Only space heating in the offices has a separate supply, being connected directly to the local city district heating network.

Cooling at low temperature is provided by electrically driven chillers for the cooling chambers. Cooling of cans after pasteurization is provided by a wet cooling tower and by fresh water from the grid. Fresh water consumption (including additional fee for waste water) is a very relevant cost item for the company.

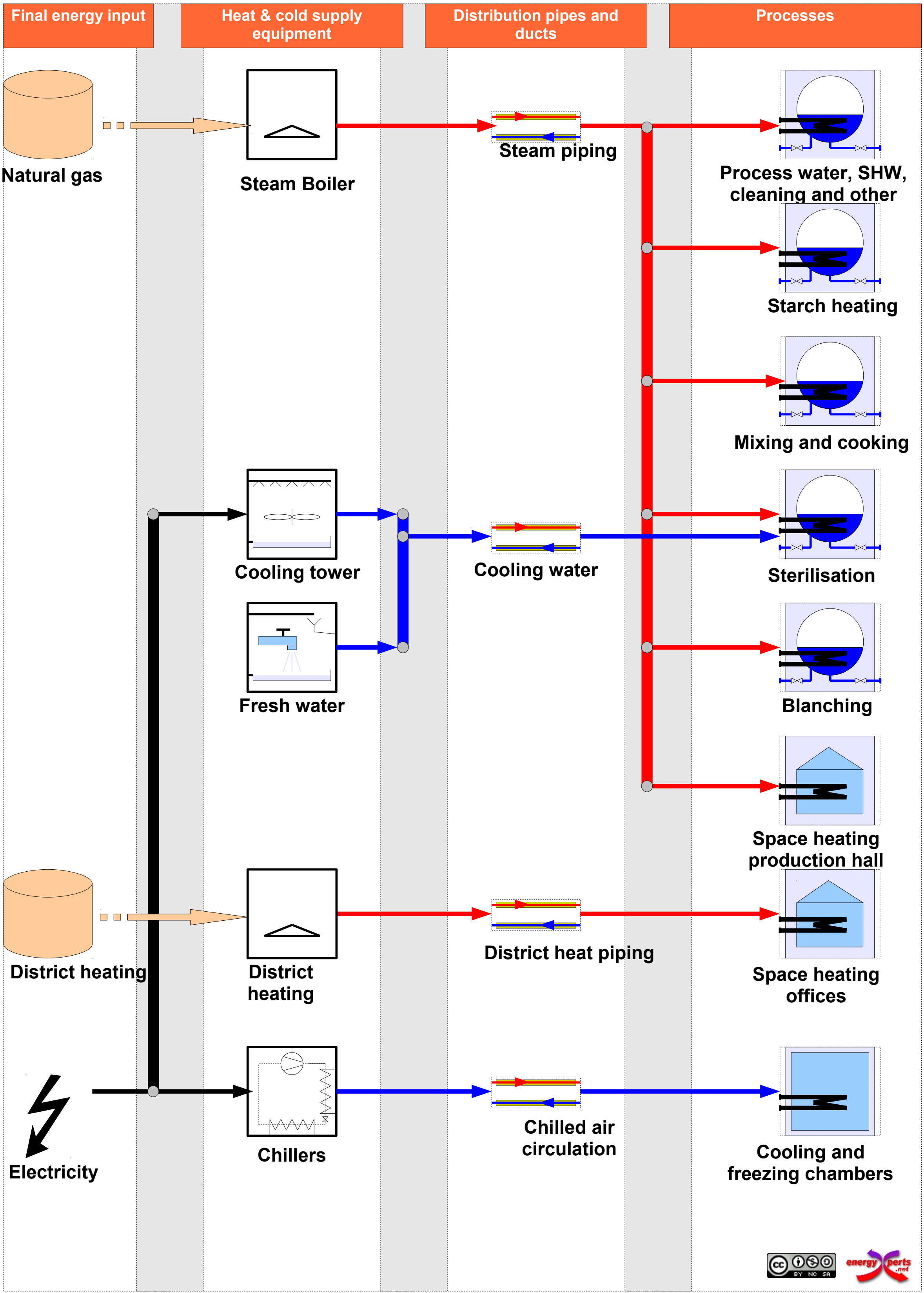

Figure 2. Overview of the heat and cold supply system

2.3. Additional comments

Specific assumptions:

The results of this study are based on specific assumptions on the regulation and control of the batch autoclaves that would have to be checked in more detail in further investigations in the future.

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 possible technical alternatives that have been studied are listed in Table 1.

All alternatives include process optimisation as described below in section 4.1.1.. Furthermore, "present state" in the following refers to the situation (energy consumption) of the company after implementing this process optimisation measure.

Table 1. Overview of the alternative proposals studied

Short Name	Description
Heat recovery- HX network	Customized heat exchangers (HX) network (total power: 584 kW)
Heat recovery + CHP engine	HX network 584 kW and cogenerative gas engine 600 kWe / 686 kWth
Heat recovery + CHP turbine	HX network 584 kW and cogenerative gas turbine 500 kWe / 938 kWth
Heat recovery and solar thermal ETC	HX network 584 kW and solar thermal system with evcuated tube collectors (1550 kW)
Heat recovery and solar thermal FPC	HX network and solar thermal system with flat plate collectors (2000 kW)

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption. "Present state (checked)" refers to present state after implementation of process optimisation measure.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	15.457	---	---
Heat recovery- HX network	11.439	4.018	26,00
Heat recovery + CHP engine	7.901	7.557	48,89
Heat recovery + CHP turbine	7.513	7.944	51,39
Heat recovery and solar thermal ETC	10.253	5.204	33,67
Heat recovery and solar thermal FPC	10.576	4.881	31,58

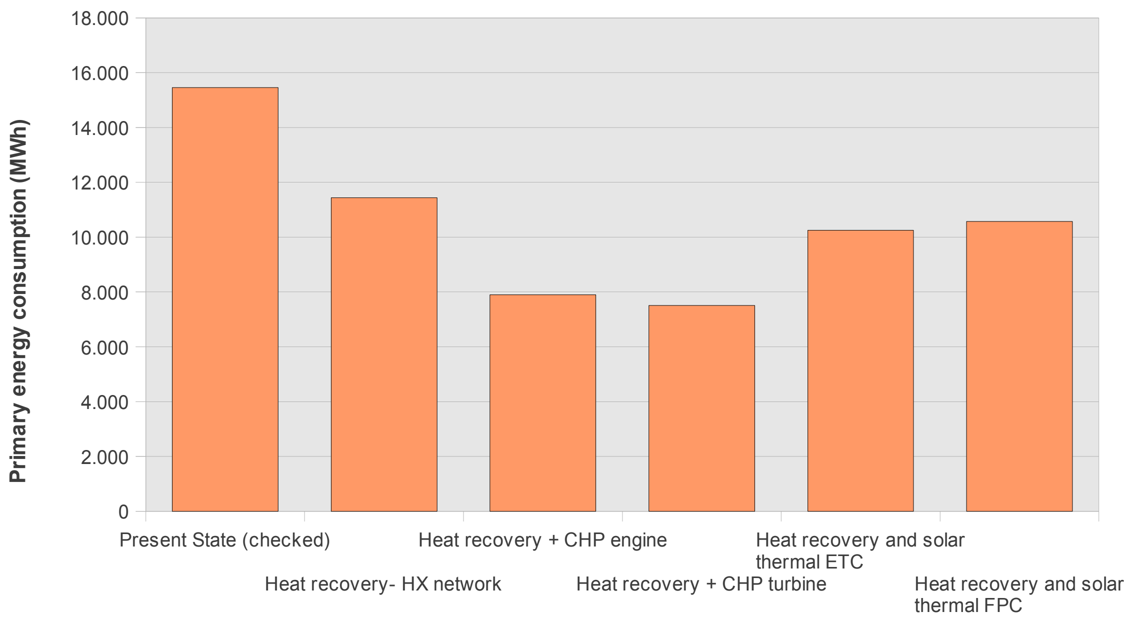

Figure 3. Comparative study: yearly primary energy consumption. "Present state (checked)" refers to present state after implementation of process optimisation measure.

1 The factors for conversion of final energy (for fuels in terms of LCV) to primary energy used in this study are 3 for electricity and 1,1 for natural gas.

3.3. Economic performance

Table 3. Comparative study: investment costs. Estimated co-funding: 20 % for investment in heat recovery, 30 % for solar thermal systems.

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State (checked)	---	---	---
Heat recovery- HX network	46.465	37.172	9.293
Heat recovery + CHP engine	421.465	412.172	9.293
Heat recovery + CHP turbine	596.465	587.172	9.293
Heat recovery and solar thermal ETC	826.605	583.270	243.335
Heat recovery and solar thermal FPC	947.855	668.145	279.710

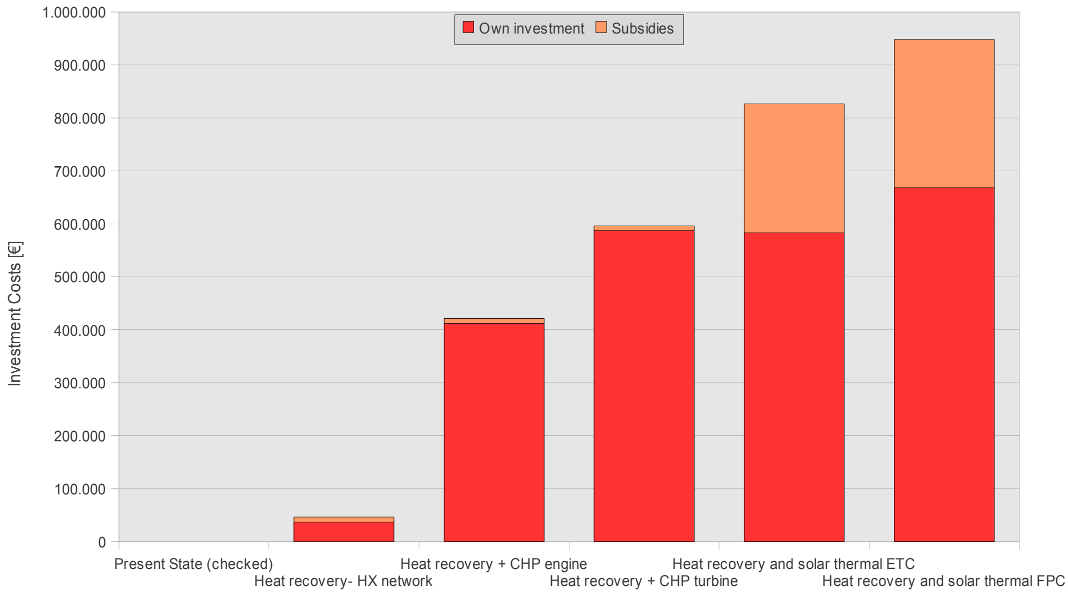

Figure 4. Comparative study: investment costs. Estimated co-funding: 20 % for investment in heat recovery, 30 % for solar thermal systems.

Table 4. Comparative study: annual costs including annuity of initial investment[2]. "Present state (checked)" refers to present state after implementation of process optimisation measure. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity. O&M costs include the O&M equipments costs and the annual costs for cooling water.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]
Present State (checked)	---	541.487	213.307
Heat recovery- HX network	4.477	411.936	33.271
Heat recovery + CHP engine	40.605	172.652	53.771
Heat recovery + CHP turbine	57.465	162.333	53.771
Heat recovery and solar thermal ETC	79.637	374.789	38.851
Heat recovery and solar thermal FPC	91.319	384.949	40.470

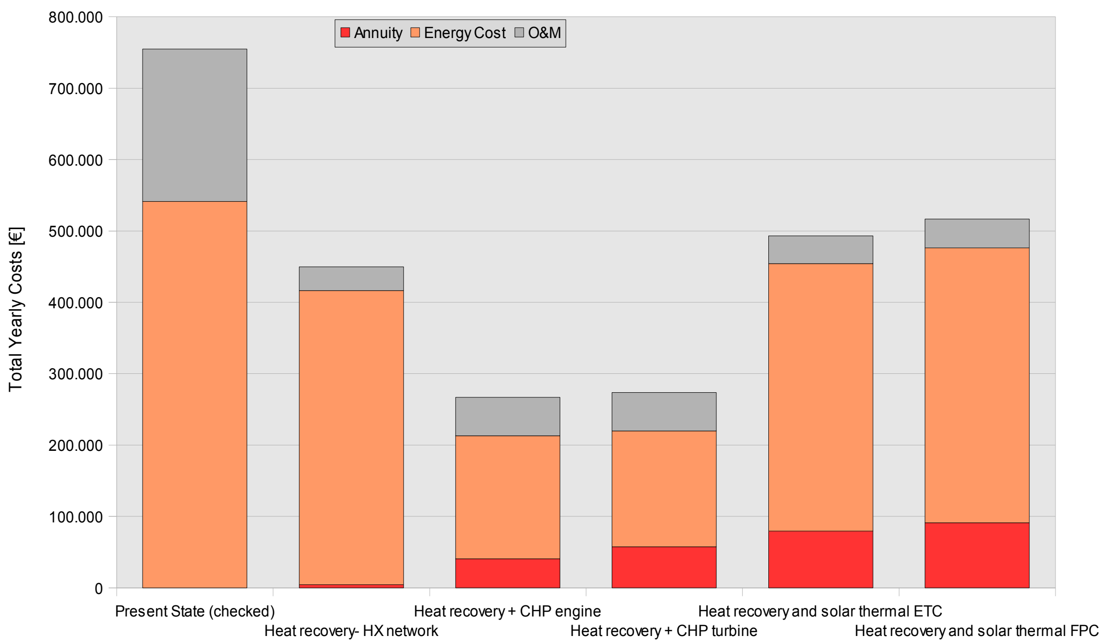

Figure 5. Comparative study: annual costs including annuity of initial investment. ""Present state (checked)" refers to present state after implementation of process optimisation measure. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity. O&M costs include the O&M equipments costs and the annual costs for cooling water.

2 Annuity of initial investment: 10,3 % of yearly payments, calculated based on 8 % nominal interest for external financing, 2 % 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 among the previously analysed due to the following facts:

- high potential of both primary energy and energy cost savings
- easier technical implementation of a CHP turbine then the comparable alternative based on a CHP engine.

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

4.1.1. Process optimisation

Currently cooling of cans within batch autoclaves is done expelling hot superheated water by means of an inflow of cold cooling water. This leads to a high degree of mixing of the hot water inside the autoclave and the cold water and, therefore, to high correlated exergy losses. It is proposed to change the current regulation in order to use hot water from an appropriate storage tank for the first phase of cool-down. It is supposed that, by means of a simple change of regulation, the temperature of the residual hot water can be increased from 70 °C to 90 °C.

By process optimization, the potential energy demand reduction of the pasteurisation process is estimated to around 32%.

4.1.2. Heat recovery

The proposed heat exchanger network uses heat from the cooling water of both continuous and batch sterilisation processes for preheating of process water (Table 5). As can be seen from Table 2, heat recovery leads to a saving of 26 % of the primary energy consumption after process optimisation.

Table 5. List of heat exchangers proposed.

Heat Exchanger	Power	Heat Source	Heat Sink	Contribution to total heat transferred	
	[kW]			[MWh]	[%]
HX1	176	Cooling water Sterilisation Batch	Warm water for blanching at medium temp.	788	30,14%
HX2	35	Cooling water Sterilisation Batch	Warm water for starch preparation	150	5,75%
HX3	23	Cooling water Sterilisation Batch	Warm water for mixing and cooking of vegetables	104	3,97%
HX4	68	Cooling water Sterilisation Batch	Water for cans filling at medium temp.	310	11,87%
HX5	110	Cooling water Sterilisation Batch	Warm water for cleaning	500	19,10%
HX6	97	Cooling water Sterilisation continous	Warm water for cleaning	443	16,94%
HX7	71	Cooling water Sterilisation continous	Warm water for blanching at low temp.	306	11,68%
HX8	1	Cooling water Sterilisation continous	Sanitary hot water	6	0,23%
HX9	2	Cooling water Sterilisation continous	Water for cans filling at low temp.	8	0,31%
	584			**2615,72**	**100,00%**

4.1.3. Heat and Cold Supply

In the new system proposed a cogeneration plant (gas turbine) is added to the heat supply system. The CHP plant can feed heat into the existing steam network via a steam generator using the exhaust gas of the turbine, or alternatively by an additional pressurized water circuit.

Table 6. Heat and cooling supply equipments and contribution to total supply. Selected alternative.

Equipment	Type	Nominal capacity	Contribution to total heat / cooling supply	
		[kW]	[MWh]	[%]
New CHP 1	**CHP gas turbine**	**938**	**3.991**	**71,11**
Steam generator	steam boiler	6.173	830	14,79
District heating	steam boiler	147	44	0,79
Cooling tower	cooling tower (wet)	407	224	4,00
Cold water network	fresh or ground water	489	151	2,70
Chiller_cooling chamber	compression chiller (air cooled)	37	38	0,68
Chiller_intermediate cooling chamber	compression chiller (air cooled)	18	67	1,20
Chiller_freezing chamber	compression chiller (air cooled)	94	266	4,74
Total		**8.303**	**5.613**	**100**

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

Table 7. Technical specification of the new CHP gas turbine.

Parameter	Units	Technical 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	125,82
Electrical power generated (CHP)	kW	500,00
Electrical conversion efficiency (CHP)	-	0,32

The contribution of the CHP plant to the total heat and cold supply is shown in Table 8 and Figure 6.

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
District heating	44	0,91
Steam generation	830	17,06
New CHP 1	3.991	82,03
Total	**4.865**	**100**

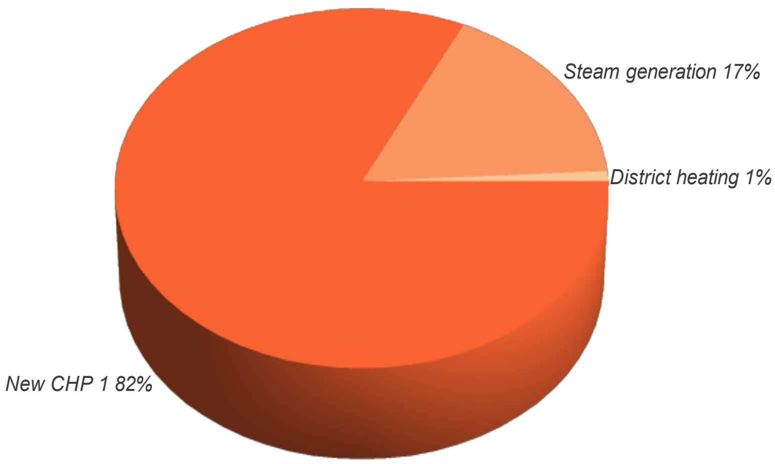

Figure 6. Contribution of the different equipments to the total useful heat supply (USH) in the company.

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

The following measures are proposed:

- optimisation of the regulation of batch autoclaves (cooling stage): avoid mixture of hot and cold water at very different temperatures
- heat recovery: use of pre-cooling of autoclaves cooling water for preheating of process water
- cogeneration (gas turbine) for covering the base load of the remaining heat demand

These measures allow for saving of 56 % of the current primary energy consumption and 73 % of saving of current energy cost (about 63% excluding the revenue from the feed-in tariff for the CHP electricity). The required investment is about 600.000 € with a very short pay-back time of about 1 year.

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*	*17.123*	*7.513*	*56,12%*
- fuels	*MWh*	*11.558*	*9.310*	*19,45%*
- electricity	*MWh*	*5.565*	*-1.797*	*132,29%*
Primary energy saving due to renewable energy	*MWh*	*0,00%*	*0,00%*	*0,00%*
CO_2 emissions	t/a	*3.562*	*1.819*	*48,93%*
Annual energy system cost (2)	EUR	*809.848*	*273.569*	*66,22%*
Total investment costs (3)	*EUR*	-	*596.465*	-
Payback period (4)	*years*	-	*0,99*	-

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

(2) Including energy cost (fuel and electricity bills) and operation and maintenance costs (inlc. cooling and wasted water). In the alternative proposal the energy system cost includes also the annuity of total investment and the feed-in-tariff revenue for the electricity produced by the CHP plant and sold to the net. Estimated revenue: about 60.000 €/a

(3) Total investment excluding subsidies.I nvestments cost for the process optimisation not estimated (approx. Negligible)

(4) Supposing 20% of funding of the heat exchangers investment cost.