Energy Audit Summary Report

Audit No. 20

VIS S.r.l.

Lovero (Sondrio), Italy

Food industry

Production of jam

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

(Date of the visit on site: 20-05-2011)

2.1. General information of the company

Company, location	Vis Srl, Lovero (Italy)	
Sector	food (fruit conditioning)	
Products	jam	
Yearly production	2.000 t (of jam)	
Turnover	6 M€	
No. of employees	20	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- fuel oil	2.037	2.037
- electricity	488	148

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

Figure 1. (a) Overview of the company's production site

2.2. Description of the company

a) Productive process

The frozen fruit is periodically delivered to the company in tracks at -20ºC and then stored in two refrigeration chambers. The fruit is extracted from the chambers, selected, crushed and placed in vessels.

Then, the fruit is cooked and concentrated. The jam is bottled and the pots are then pasteurized and cooled down.

The storage of the final products is done at ambient temperature.

All the equipments are periodically cleaned up with warm water.

The production halls and the offices are heated in winter time.

Figure 2. Overview of the production hall

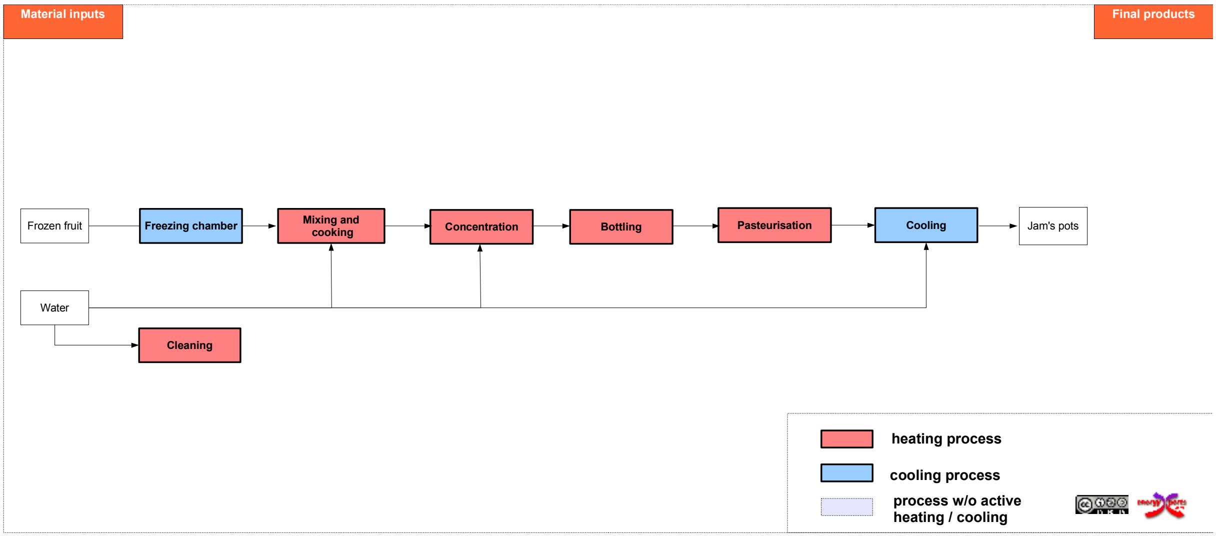

Figure 3. Simplified production flow sheet

The analysis of the data showed that the heat demand is split homogeneously among the main heating processes.

Concerning the cooling processes, cold groundwater at about 13ºC is used to condensate the vapour produced during the fruit concentration process and to cool down the jam pots after pasteurisation (about 50% of the total cooling demand) while the freezing chambers generate a cooling demand at lower temperature (at about – 20ºC).

b) Energy supply system

The heat used in the company is generated in two fuel oil fired steam boilers. The equipments are quite old, not insulated and stop frequently for maintaining. A fuel shift towards natural gas or district was envisaged by the owner of the company, but not implemented due to the distance between the company production site and the local grids.

Figure 4. View of a*ctual boilers and auxiliary systems*

Cooling at low temperature is provided by electrically driven chillers for the freezing chambers while groundwater – very cheap for the company - provides the cooling power for the concentrators and the (post) pasteurisation. The daily water consumption for cooling is quite relevant, but due to its negligible cost, no saving strategy is currently adopted.

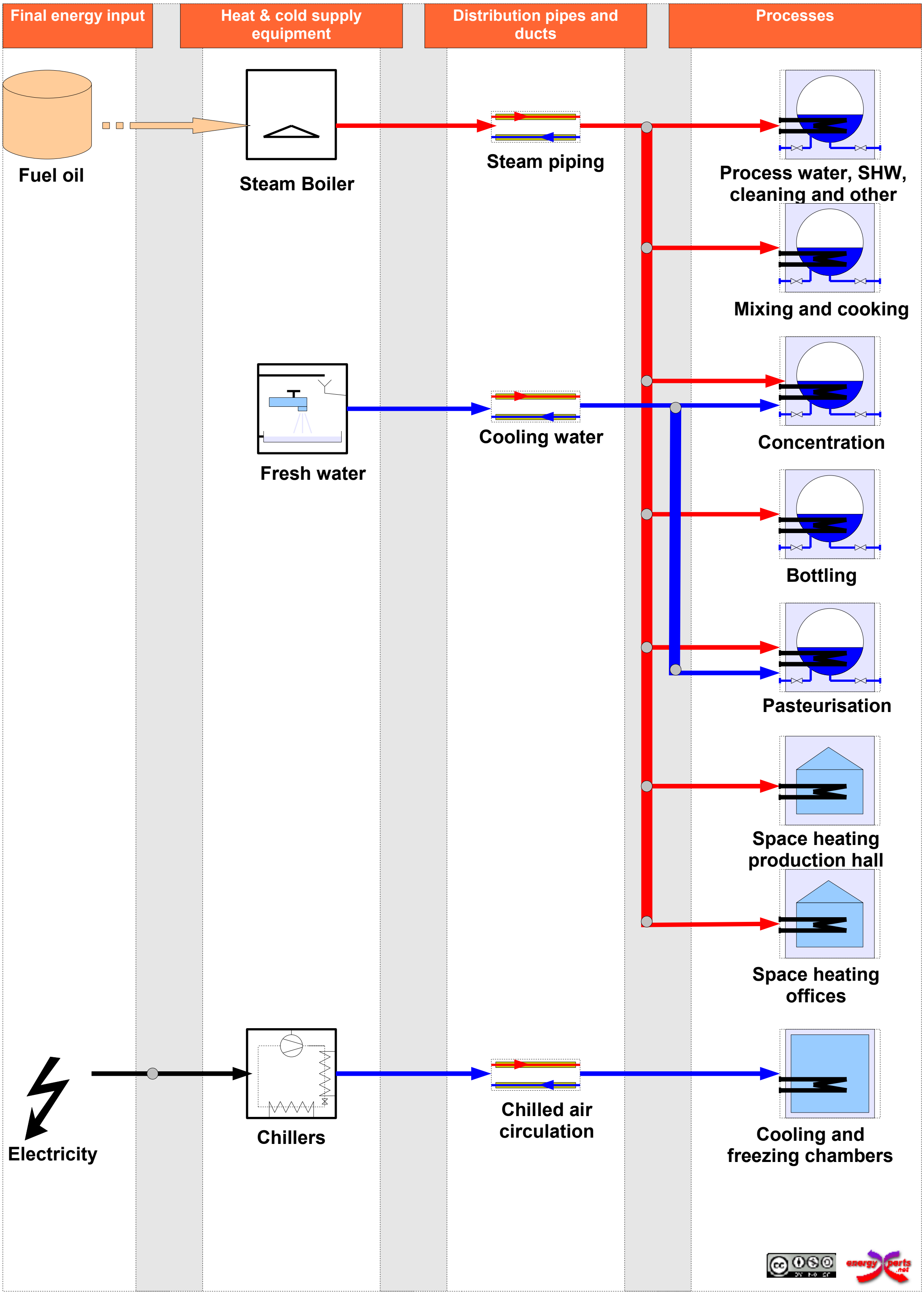

Figure 5. Overview of the heat and cold supply system

2.3. Additional comments

Specific assumptions

The results presented in this study are based on specific assumptions among which the estimation of:

- the energetic behaviour of the pasteuriser
- the energy and water consumption of concentrators
- the thermal losses of the steam generators and distribution pipes

which should be further assessed in the framework of the follow-up actions for the implementation of the proposed measures.

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

All the alternatives include the optimisation of the pasteuriser as described in section 4.1.1..

Table 1. Overview of the alternative proposals studied

Short Name	Description
POpast + HX	Optimisation of pasteurisation and heat exchangers network for heat recovery
POpast + HX + ST + Bio	Optimisation of pasteurisation, heat exchangers network, solar thermal plant for hot water (50 kW) and biomass for steam generation (1 MW)
PO past. & concentr + HX	Process optimisation of pasteurisation and concentration (incl. MVR system 182 kW) , and heat exchangers network for heat recovery
PO past. & concentr + HX +Bio	Process optimisation of pasteurisation and concentration (incl. MVR system 182 kW), heat exchangers network and biomass for steam generation (1 MW)
PO past. & concentr + HX +ST + Bio	Process optimisation of pasteurisation and concentration (incl. MVR system 182 kW), heat exchangers network, solar thermal plant for hot water (60 kW) and biomass for steam generation (1 MW)

** MVR: Mechanical vapour re-compression*

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	3.675	---	---
POpast + HX	3.164	512	13,92
POpast + HX + ST + Bio	1.529	2.146	58,40
PO past. & concentr + HX	2.922	754	20,51
PO past. & concentr + HX +Bio	1.590	2.085	56,74
PO past. & concentr + HX +ST + Bio	1.588	2.088	56,80

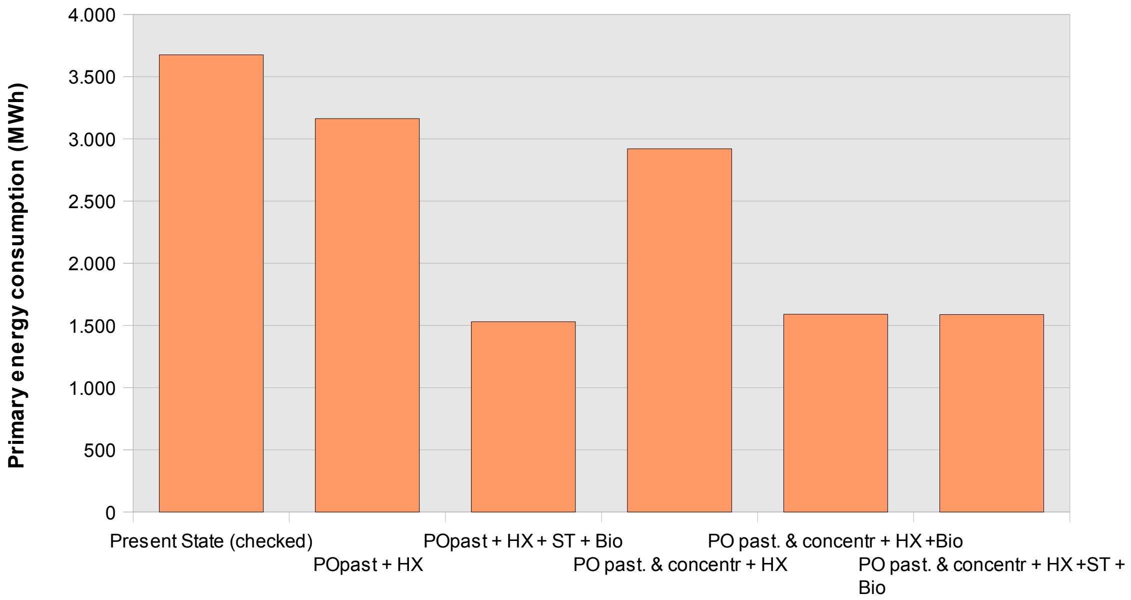

Figure 6. Comparative study: yearly primary energy consumption.

1 The factors for conversion of final energy (for fuels in terms of LCV) to primary energy used in this study are 3 for electricity, 1,1 for fuel oil and 0,06 for solid biomass.

3.3. Economic performance

Table 3. Comparative study: investment costs. No subsidies: the tax reduction for solar thermal has been included in the economic evaluation as annual revenue. Revenues for white certificates not considered. The extra cost for a wood warehouse not included in the investment cost: it has been considered as non-recurring cost at year 0

Alternative	Total investment [€]
Present State (checked)	---
POpast + HX	29.800
POpast + HX + ST + Bio	203.035
PO past. & concentr + HX	49.400
PO past. & concentr + HX +Bio	189.400
PO past. & concentr + HX +ST + Bio	229.130

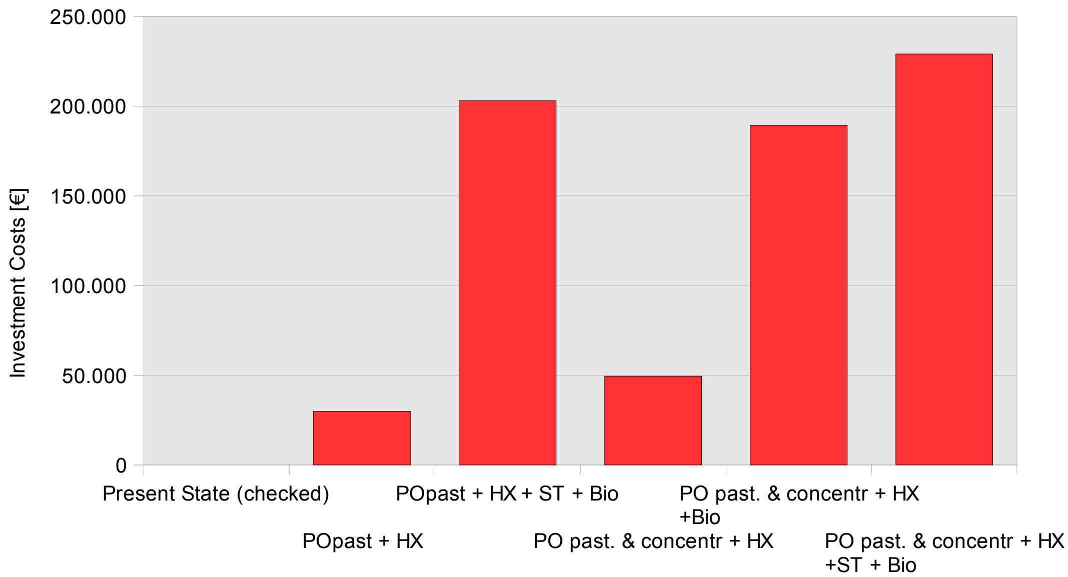

Figure 7. Comparative study: investment costs.

Table 4. Comparative study: annual costs including annuity of initial investment[2].

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]
Present State (checked)	---	189.066	8.000
POpast + HX	2.871	162.681	9.750
POpast + HX + ST + Bio	19.561	86.459	6.375
PO past. & concentr + HX	4.759	150.164	9.755
PO past. & concentr + HX +Bio	18.247	88.255	5.755
PO past. & concentr + HX +ST + Bio	22.075	87.890	6.505

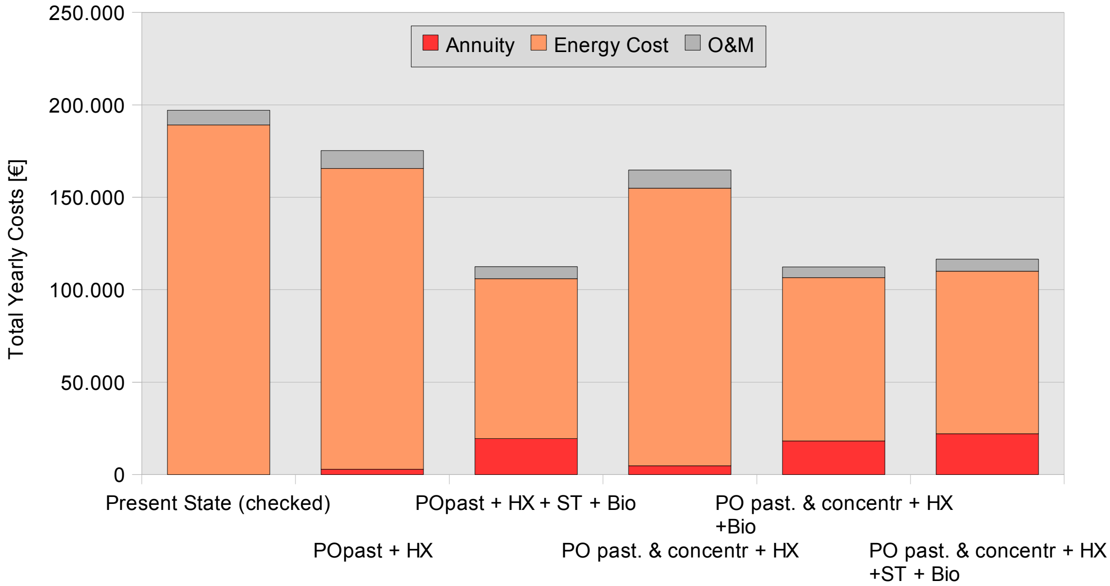

Figure 8. Comparative study: annual costs including annuity of initial investment.

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 "PO pasteurisation & concentration + HX + ST + Bio" combines the optimisation of the pasteurisation and concentration processes with a customized heat exchangers network and with a new heat supply system including a solar thermal plant for the process hot water preparation (60 kW) integrated to a new steam generation fed by wood chips (1 MW).

And it has been considered the best option among all those analysed due to the following reasons:

- highest saving potential of primary resources (fuel, biomass and water)
- significant energy cost reduction and pay - back time below 3 years
- possibility of internal heat recovery and shift to a cleaner energy supply system using local resources (chips wood locally available) and solar energy

in spite of a small increase of the electricity bill.

Without the heat pump (alternative: "PO pasteurisation + HX + ST + Bio") , the primary energy consumption and the economic performance result to be more attractive, but the biomass and water consumption would be higher than in the selected alternative.

4.1.1. Process optimisation

Two interventions are proposed which affect respectively the pasteurisation and the concentration processes.

a) Pasteurisation process

Currently the pasteurisation and the gradual cooling down of the jam pots are done in a tunnel, continuously, by (hot and cold) water injection. Hot and cold sections of the pasteuriser are not (thermally) separated and this causes an increase of the heating and cooling demand due to uncontrolled convection. Dividing the different chambers may lead to a reduction of 88 % of the process heat demand (11% of the total demand) and of 65% of the cooling process demand (15% of the total demand) and of the cooling water consumption. The potential primary energy saving with respect to the total actual consumption results to be around 8,5%.

Figure 9. Equipment for pasteurisation and cooling down of the jam pots.

b) Concentration process

Jam is concentrated via vacuum evaporation, at low process temperature. However, heat is currently supplied to the evaporator by steam at 145ºC.

Running the process at a lower supplied temperature would be feasible coupling the concentrators to a vapour re-compression system via appropriate heat exchangers. This intervention would reduce the heat losses and lead to a reduction of 90% of the cooling (groundwater) demand which is currently required to condensate the vapour and to cool down the condensate (currently not recovered). In spite of this benefit, this measure leads to an increase of electricity consumption to run the heat pump.

4.1.2. Heat recovery

The proposed heat exchangers use as sources the waste heat available from the daily cleaning processes and from the outflow of the concentration process, after the new heat pump (MVR) installation, to pre-heat the process water and the boiler feed-up water (Table 5).

Table 5. List of heat exchangers proposed.

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX01	203	Cleaning	Process water and boiler feed-up water	102	87,21
HX02	12	MVR system	Process water and boiler feed-up water	15	12,79
	215			**116,69**	**100**

4.1.3. Heat and Cold Supply

The new heat supply system includes a new boiler (capacity: 1 MW; efficiency: 0,85) fed by wood chips for steam generation at 170ºC and a solar thermal plant (85 m^2 selective flat plate collectors) for process water pre-heating.

Furthermore, as described in section 4.1.1, for the optimisation of the concentration it is foreseen the installation of a mechanical vapour re-compression equipment (capacity: 182 kW; expected COP: 8,4) to recover the vapour outflow and to feed it into the process at higher pressure/temperature. This measure would lead to a potential reduction of 19% of the biomass consumption in spite of an expected increase of the total annual electricity consumption of 5,5%.

Table 6. Heat and cooling supply equipments and contribution to total supply. Selected alternative. In bold, the new heating equipments.

Equipment	Type	Nominal capacity [kW]	Contribution to total heat / cooling supply [MWh]
New heat pump 1	**mechanical vapour recompression**	**182**	**205**
Solar thermal system	**solar thermal (flat-plate)**	**60**	**32**
New boiler 1	**steam boiler (biomass)**	**1.000**	**876**
Chillers	compression chiller (water cooled)	172	457
Groundwater	groundwater	500	70

The contribution of the new equipments to the total heat supply (1.113 MWh) is shown in Figure 10 while the contribution to the cooling supply (527 MWh) is shown in Figure 11. The related share of fuel and electricity consumption is given in Figure 12.

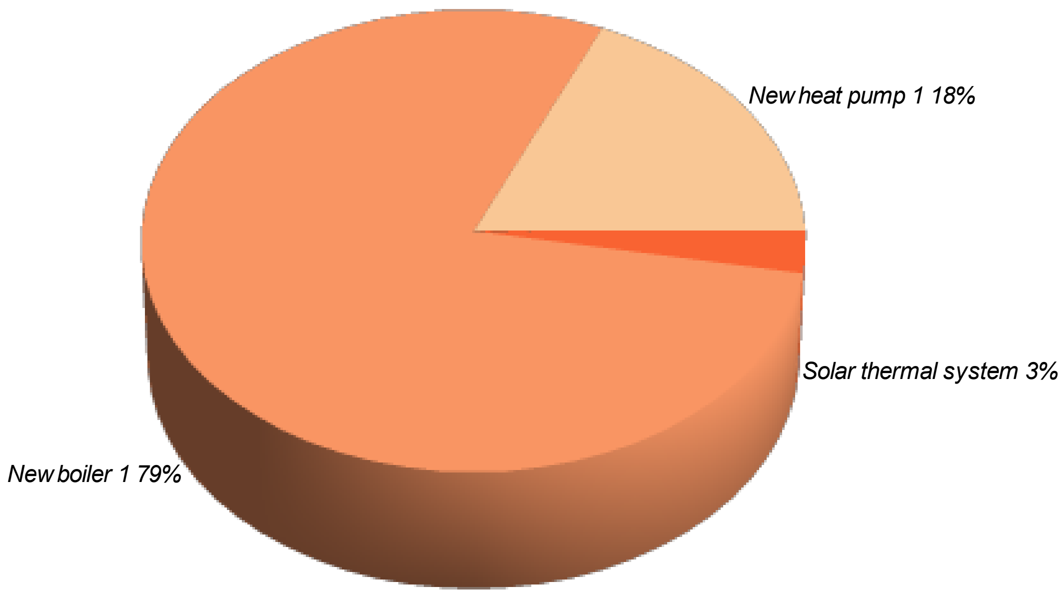

Figure 10. Contribution of the different equipments to the total useful heat supply (USH) in the company.

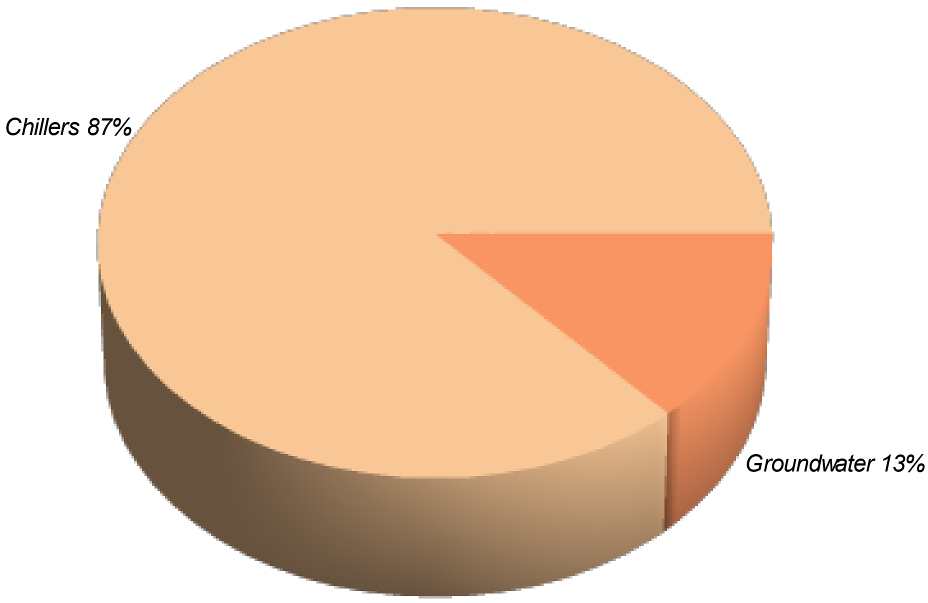

Figure 11. Contribution of the different equipments to the total useful supply cooling ((USC) in the company.

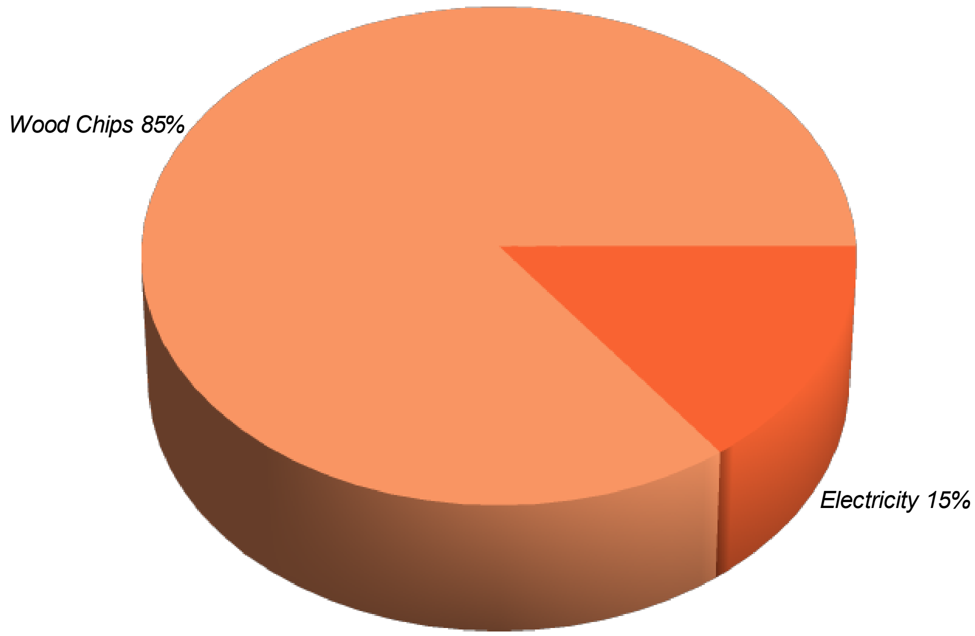

Figure 12. Total final energy consumption for final thermal uses by type of fuel.

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

The following measures are proposed:

- optimisation of the pasteurisation and post-pasteurisation (cooling) processes reducing thermal losses due to undesired ventilation
- optimisation of the concentration process and internal heat recovery via a MVR heat pump
- heat recovery: use of waste water from cleaning processes and concentration to pre-heat the process and boiler feed-up water
- new heat supply system and fuel oil substitution: a new biomass steam generator, a solar thermal FPC plant for process water pre-heating and a heat pump for vapour re-compression.

These measures allow to save 57 % of the current primary energy consumption and 53 % of the current energy bill. The required investment is about 230.000 € with a pay-back time of 2,5 years.

Moreover, these measures would contribute to reduce significantly the actual use of the groundwater for process cooling (saving estimated: 78%).

Table 7. 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*	*3.675*	*1.588*	*56,80%*
- fuels (2)	*MWh*	*2.240*	*62*	*97,23%*
- electricity	*MWh*	*1.435*	*1.526*	*-6,34%*
Primary energy saving due to renewable energy (3)	*MWh*	*0*	*1.427*	-
CO_2 emissions	*t/a*	*804*	*267*	*66,83%*
Annual energy system cost (4)	*EUR*	*197.066*	*116.470*	*40,90%*
Total investment costs	*EUR*	*0*	*229.130*	-
Payback period (5)	*years*	-	*2,47*	-

(1) Including primary energy consumption for non-thermal uses.
(2) Current fuel used: fuel oil. In the proposed alternative fuel oil is substituted by wood chips.
(3) Heat pump not included.

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

(5) The calculation takes into consideration the tax discount foreseen for solar thermal at the first operating year.