Energy Audit Summary Report

Audit No. 11 - FR01

La Grihète

Nyons, France

Food Industry

Brewery

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: 13-01-2011)

2.1. General information of the company

Company, location	La Grihète, Nyons (France)	
Sector	brewery	
Products	beer	
Yearly production	4000 hl	
Turnover	0,81 M€	
No. of employees	7	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- gas oil	194	194
- electricity	150	72

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

(a) (b)

Figure 1. (a) General view of the company (b) Filling of bottles

2.2. Description of the company

a) Productive process

The productive process is the typical process of beer brewing.

Malt is milled, mixed with warm water, and then gradually heated up in the mashing process. In a subsequent step additional hot water is added and the sweet juice is filtered separating the wort and the malt.

Then the wort is boiled for sterilization and aromatization (hop is added to provide flavours). After the boiling, the wort is passed through a so-called whirlpool for filtering, and then immediately cooled down and stored for some time in the fermentation tanks. Fermentation is an exothermic reaction so that the fermentation tanks have to be cooled.

After the fermentation, the beer has to be maintained at about 1ºC during 2 - 4 weeks for maturation. Finally beer is poured in bottles and kegs and stored in a cool chamber.

Auxiliary processes are cleaning of vessels, pipes and other equipment.

Figure 2. Fermentation tanks

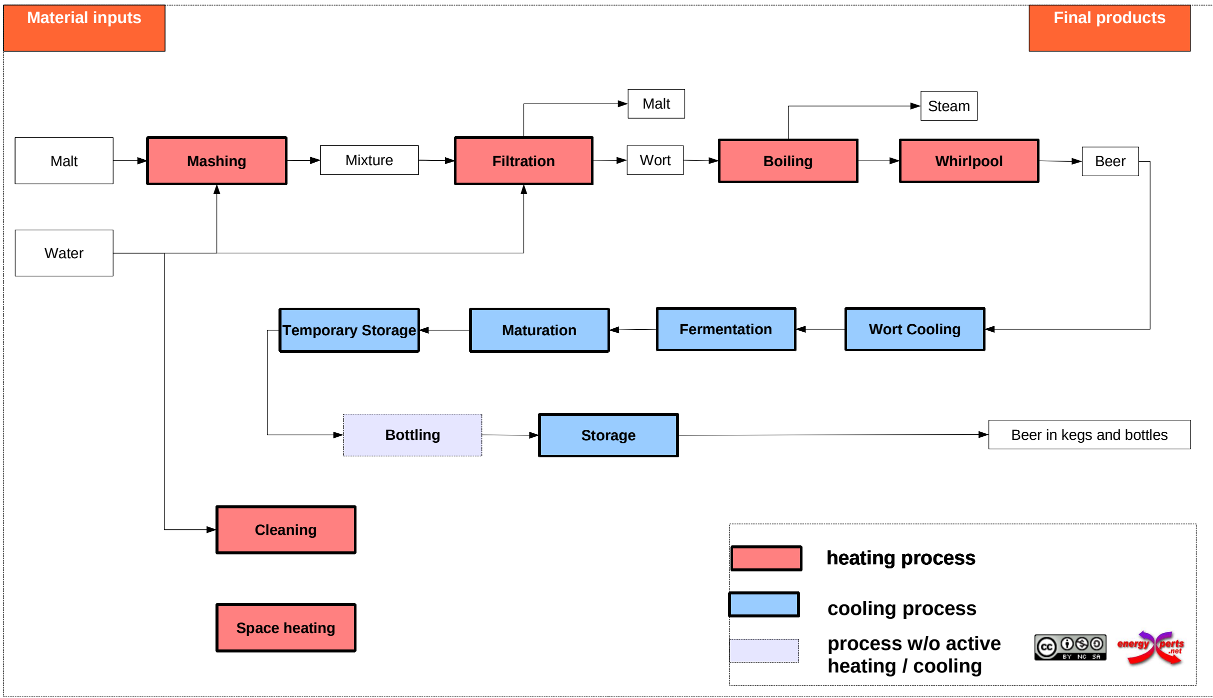

Figure 3. Simplified production flow sheet

The most energy consuming processes in the company are wort boiling, hot water for cleaning, and cooling for maturation.

b) Energy supply system

The heat used in the processes is generated in a gas oil fired steam boiler. Hot water for space heating of production hall and offices is generated in a separate boiler.

Cooling at low temperature is provided by electrically driven chillers for the cooling chambers. For cooling of tanks a water-glycol circuit is available cooled by separate electrically driven chillers.

During the boiling process, part of the steam is recovered and used to hot water up to 52ºC. The hot water is stored in a warm water tank. Furthermore, fresh water is used for wort cooling and, by exchanging heat with the wort, is heated up to 72ºC. This water is also stored in the warm water tank. The tank is maintained at 85ºC and it is used to provide hot water to the mashing, filtration and cleaning processes. Since the temperature of these processes is lower than 85ºC, the hot water is mixed with net water to achieve the desired temperature.

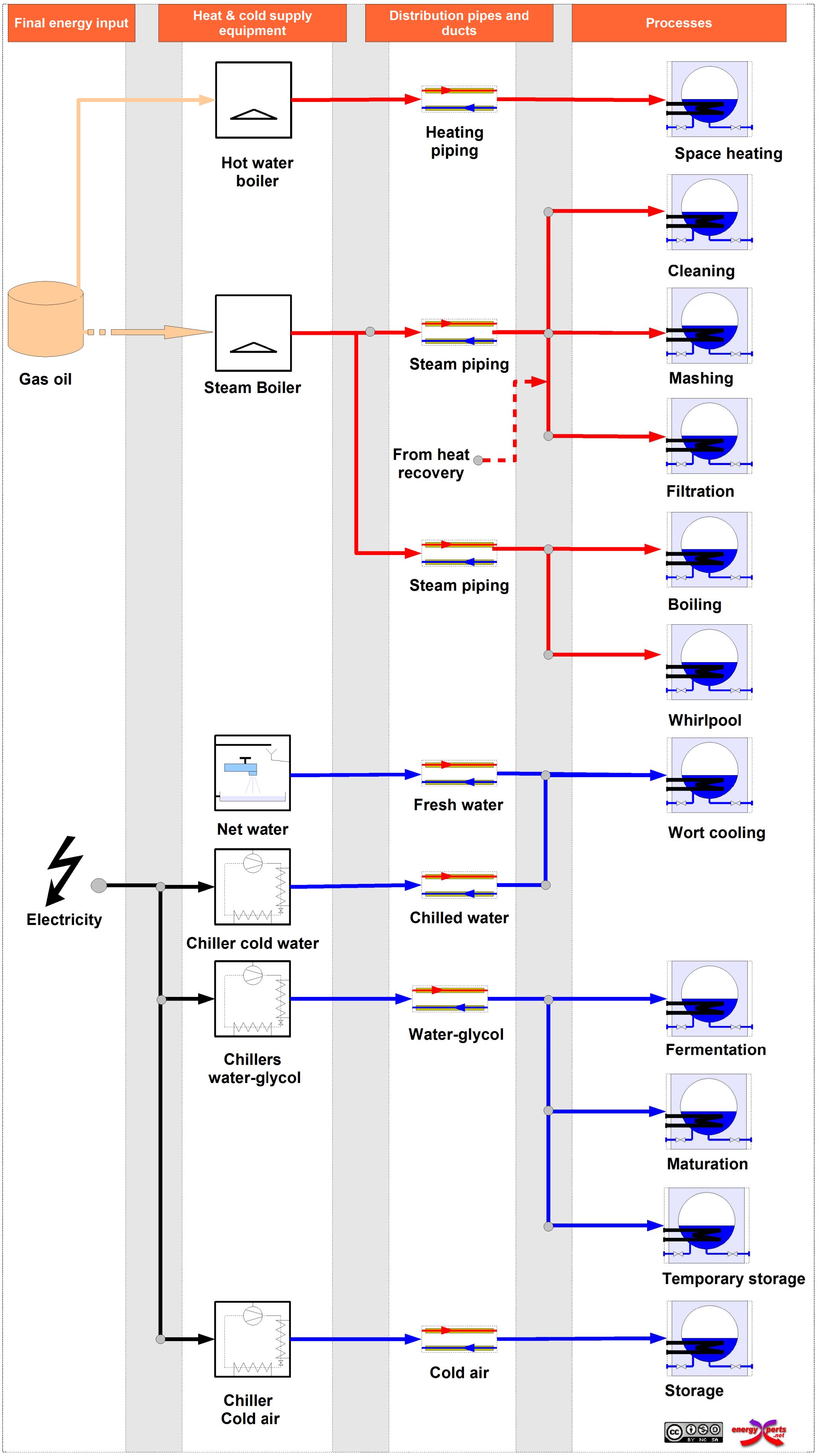
Final energy input
Heat & cold supply equipment
Distribution pipes and ducts
Processes
Hot water boiler
Heating piping
Space heating
Cleaning
Gas oil
Steam Boiler
Steam piping
Mashing
From heat recovery
Filtration
Steam piping
Boiling
Whirlpool
Net water
Fresh water
Wort cooling
Electricity
Chiller cold water
Chilled water
Water-glycol
Fermentation
Chillers water-glycol
Maturation
Temporary storage
Chiller Cold air
Cold air
Storage

Figure 4. Overview of the heat and cold supply system

2.3. Additional comments

Specific assumptions:

– energy consumption of fermentation has been estimated supposing a diminution of the plato grade of 10% (necessary to calculate the energy of the exothermic reaction)

– The currently recovered fraction of vapour in the wort boiling process has been estimated from energy balances to 33%. It has been supposed that this fraction can be increased to 80%.

– cleaning process: it has been supposed that the waste water temperature from cleaning of the tanks is 60-65ºC and that part of the heat from this waste water can be recovered.

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.

Possibilities for process optimisation have not been considered in the present study. All alternatives include an improved heat recovery as described below in section 4.1.1..

Table 1. Overview of the alternative proposals studied

Short Name	Description
Improved Heat Recovery	Increased rate of vapour regeneration from wort boiling
Solar Thermal ETC 60 kW_th	Solar system (evac. tubes) 60 kW
Solar Thermal ETC 150 kW_th	Solar system (evac. tubes) 150 kW for hot water and steam generation
Solar HC 150 kW_th	Solar heating and cooling with evacuated tube collectors (150 kW_th) and absorption chiller (10 kW)
CHP Engine 25 kW_th	Generation of heat and power with CHP Engine 25 kW_th

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	664	---	---
Improved Heat Recovery	639	25	3,81
Solar Thermal ETC 60 kW_th	561	103	15,47
Solar Thermal ETC 150 kW_th	501	163	24,51
Solar HC 150 kW_th	493	171	25,72
CHP Engine 25 kW_th	569	94	14,22

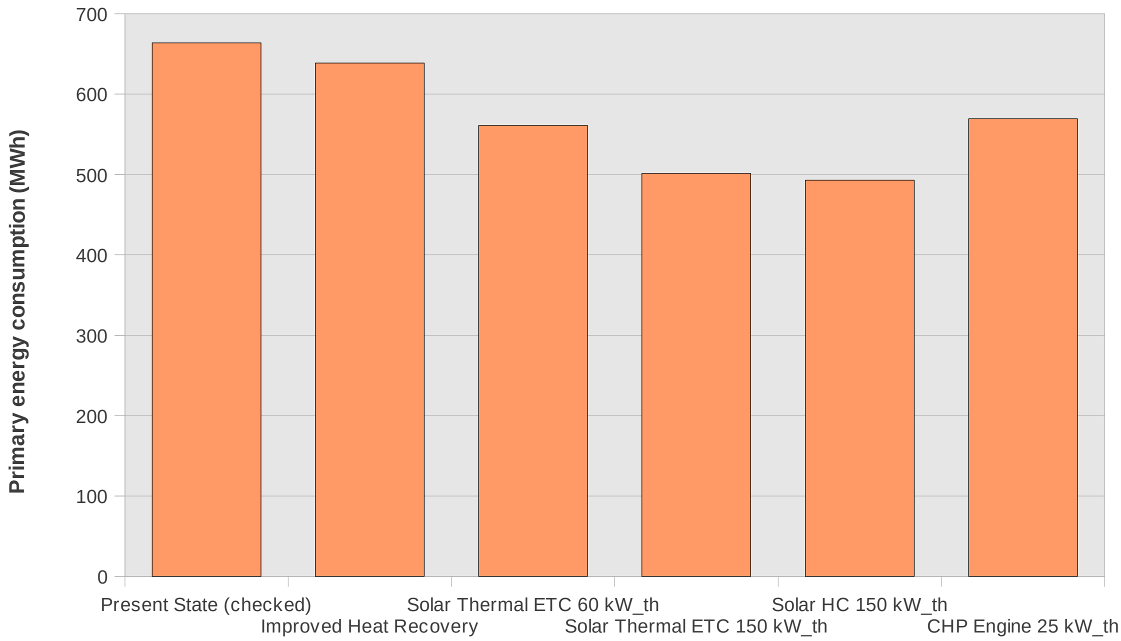

Figure 5. Comparative study: yearly primary energy consumption.

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

3.3. Economic performance

Table 3. Comparative study: investment costs. Estimated co-funding: 10 % for investment in heat recovery and CHP, 30 % for solar thermal systems and solar cooling.

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State (checked)	---	---	---
Improved Heat Recovery	2.000	1.800	200
Solar Thermal ETC 60 kW_th	52.451	37.116	15.335
Solar Thermal ETC 150 kW_th	130.248	91.574	38.674
Solar HC 150 kW_th	135.248	95.074	40.174
CHP Engine 25 kW_th	29.500	26.550	2.950

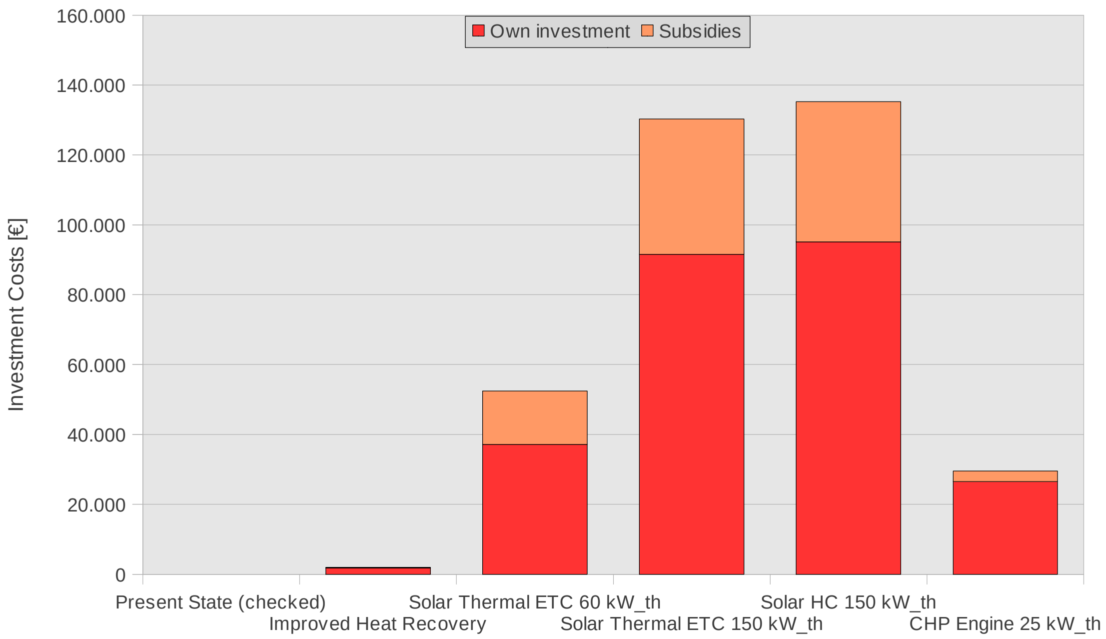

Figure 6. Comparative study: investment costs. Estimated co-funding: 10 % for investment in heat recovery and CHP, 30 % for solar thermal systems and solar cooling.

Table 4. Comparative study: annual costs including annuity of initial investment[2]. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity. O&M costs include only additional O&M costs compared to present state.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]
Present State (checked)	---	30.333	1.433
Improved Heat Recovery	206	28.437	170
Solar Thermal ETC 60 kW_th	5.400	24.180	920
Solar Thermal ETC 150 kW_th	13.411	20.617	2.245
Solar HC 150 kW_th	13.926	21.381	2.545
CHP Engine 25 kW_th	3.037	26.519	1.394

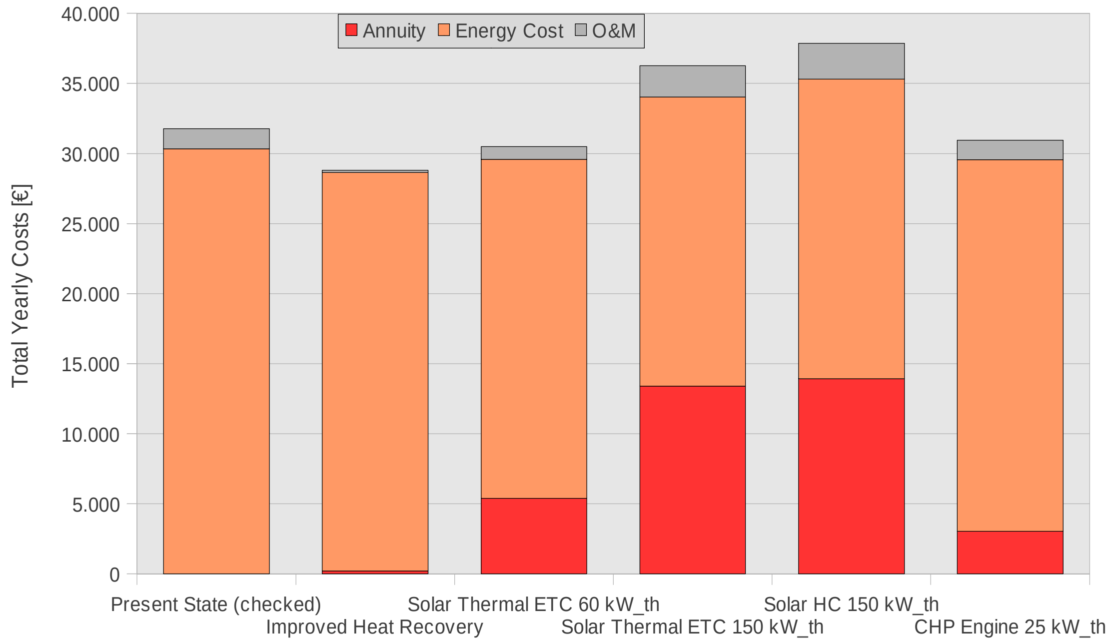

Figure 7. Comparative study: annual costs including annuity of initial investment[2]. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity (0,007 EUR/MWh). O&M costs include only additional O&M costs compared to present state.

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 "solar thermal ETC 60 kW_{th}" that combines an improved heat recovery system and a solar thermal system of 60 kW_{th} (86 m^2) of evacuated tube collectors (or alternatively other medium temperature collectors) has been considered the best option among the previously analysed as it allows a maximum amount of primary energy saving within the economic constraint of reasonable pay-back times.

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

4.1.1. Improved heat recovery

Currently there is already an existing heat recovery for hot water preparation, using vapour from wort boiling and hot juice leaving the whirlpool as heat sources.

The proposed improvements consist mainly in the increase of the fraction of vapour from wort boiling that is used in heat recovery (from now about 1/3 to 80 %). In addition heat recovery from waste water from washing is proposed. A conservative estimate has been used for this latter contribution, supposing that only 10 % of the water consumed for cleaning can be recovered. The proposed heat exchangers are shown in Table 5. As can be seen from Table 2, improved heat recovery leads to an additional saving of 3,8 % of the primary energy consumption.

Table 5. List of heat exchangers proposed.

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX1	86	Boiling	Hot water demands of several processes	25	46,08
HX2	90	Whirlpool	Hot water demands of several processes	26	47,50
HX3	1	Cleaning	Hot water demands of several processes	4	6,41

4.1.2. Heat and Cold Supply

In the new system proposed a solar thermal system with evacuated tube collectors, or alternatively other medium temperature collectors such as parabolic trough, linear Fresnel, etc., is added to the heat supply system. The solar heat is stored in an additional hot water tank and covers a major part of the heat demand below 100 °C.

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

Equipment	Type	Heat / cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat / cooling supply	
			[kW]	[MWh]	[%]
Solar thermal system	solar thermal (evacuated tubes)	pipe_steam pipe_hot water	60	52	16,86
steam boiler	steam boiler	pipe_steam	150	72	23,22
chiller_water	compression chiller (water cooled)	pipe_chilled_water	31	2	0,64
chiller_wg	compression chiller (water cooled)	pipe_chilled_water_glycol	60	137	44,45
chiller_wg2	compression chiller (water cooled)	pipe_chilled_water_glycol2	750	8	2,51
chiller_air	compression chiller (air cooled)	pipe_chilled_air	18	25	8,19
net water	fresh or ground water	pipe_fresh_water	3.000	9	2,95
old boiler	hot water boiler	pipe_hot water	5	4	1,18
Total			**4.074**	**309**	**100**

The technical specifications of the solar thermal system are given in Table 7.

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

Parameter	Units	Technical data
Type of equipment	-	solar thermal (evacuated tubes)
Manufacturer	-	not specified
Model	-	evacuated tube collector or other medium temperature collector
Nominal power (heat or cold output)	kW	60,00
Solar collector size (aperture area)	m2	85,71
Storage volume	m3	4,29
Electricity power input	kW	0,60

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

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
steam boiler	72	56,27
old boiler	4	2,87
Solar thermal system	52	40,86
Total	**128**	**100**

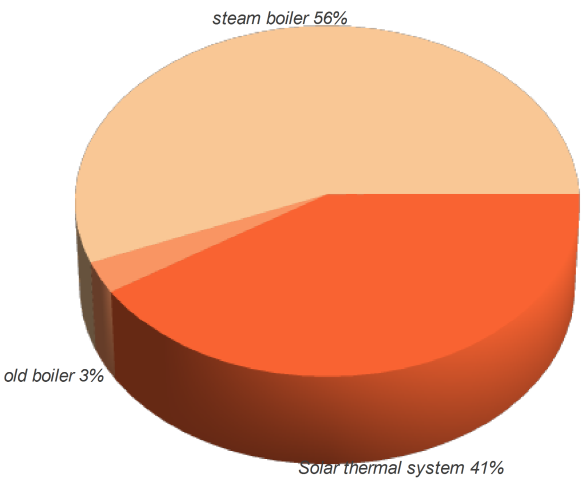

Figure 8.

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:

- heat recovery: increased rate of heat recovery from wort boiling (vapours)
- solar thermal system (60 kW_{th}) with evacuated tube or other medium temperature collectors for heating up to 100 °C.

These measures allow for saving of 15,5% of the current primary energy consumption. It also saves 20,3% of current energy cost (cost of fuel and electricity, including auto-generated electricity) and leads to a reduction of 4,0 % of the total energy system cost (fuel and electricity, operation and maintenance, amortisation). The total required investment is about 52.451 € and the expected pay-back time is 8,2 years (taking into account the subsidies).

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*	*664*	*561*	*15,5*
- fuels	*MWh*	*214*	*107*	*50,0*
- electricity	*MWh*	*450*	*454*	*-0,9*
Primary energy saving due to renewable energy	*MWh*	*0*	*78*	-
CO_2 emissions	t/a	*124*	*100*	*19,1*
Annual energy system cost (2)	*EUR*	*31.766*	*30.501*	*4,0*
Total investment costs (3)	*EUR*	*0*	*52.451*	-
Payback period (4)	*years*	*0*	8,2	-

(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) total investment excluding subsidies.

(4) Supposing funding of total investment (subsidies or equivalent other support mechanisms): 30% for solar technologies, 10% for the rest of technologies.