Energy Audit Summary Report

Audit No. 26 - ESP04

Transformación Ganadera Leganés S.A.

Leganés (Madrid), Spain

Food Industry

Cattle meat

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: 09-06-2011)

2.1. General information of the company

Company, location	Leganés (Madrid) /Spain	
Sector	Slaughterhouse	
Products	Cattle meat	
Yearly production	73.000 cattle	
Turnover	4,2 M€	
No. of employees	29	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- gas oil B	999	999
- electricity	1.100	990

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

(a)

(b)

Figure 1. (a) Hot water tank (b) Distribution

2.2. Description of the company

a) Productive process

The company receives the cattle. After the slaughtering, different process with hot water demand are carried out (cleaning, skin removal, toenail removal, etc.). There are four recipients to perform these processes, three at 60ºC and one at 120ºC. Afterwards, the cattle are stored in the cooling chambers which are at temperatures between 0 and 10ºC (most of them at 0 and 3ºC). They remain in the chambers for a while ready for its final preparation. Furthermore, there is a significant sanitary hot water demand at 60ºC for cleaning and other purposes.

In the present analysis, the cooling chambers have been simplified in a sole process with a cooling power demand at 0ºC, since the cooling installation is rather new and no optimisation is going to be carried out.

Figure 2. Boilers

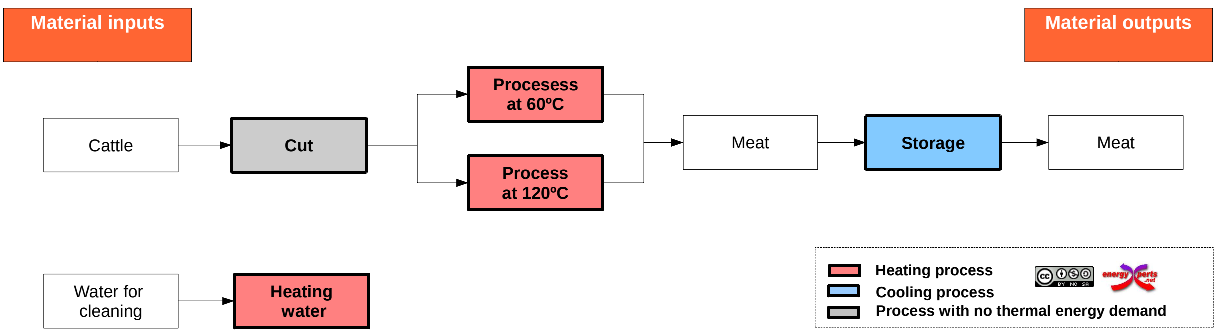


Figure 3. Simplified production flow sheet

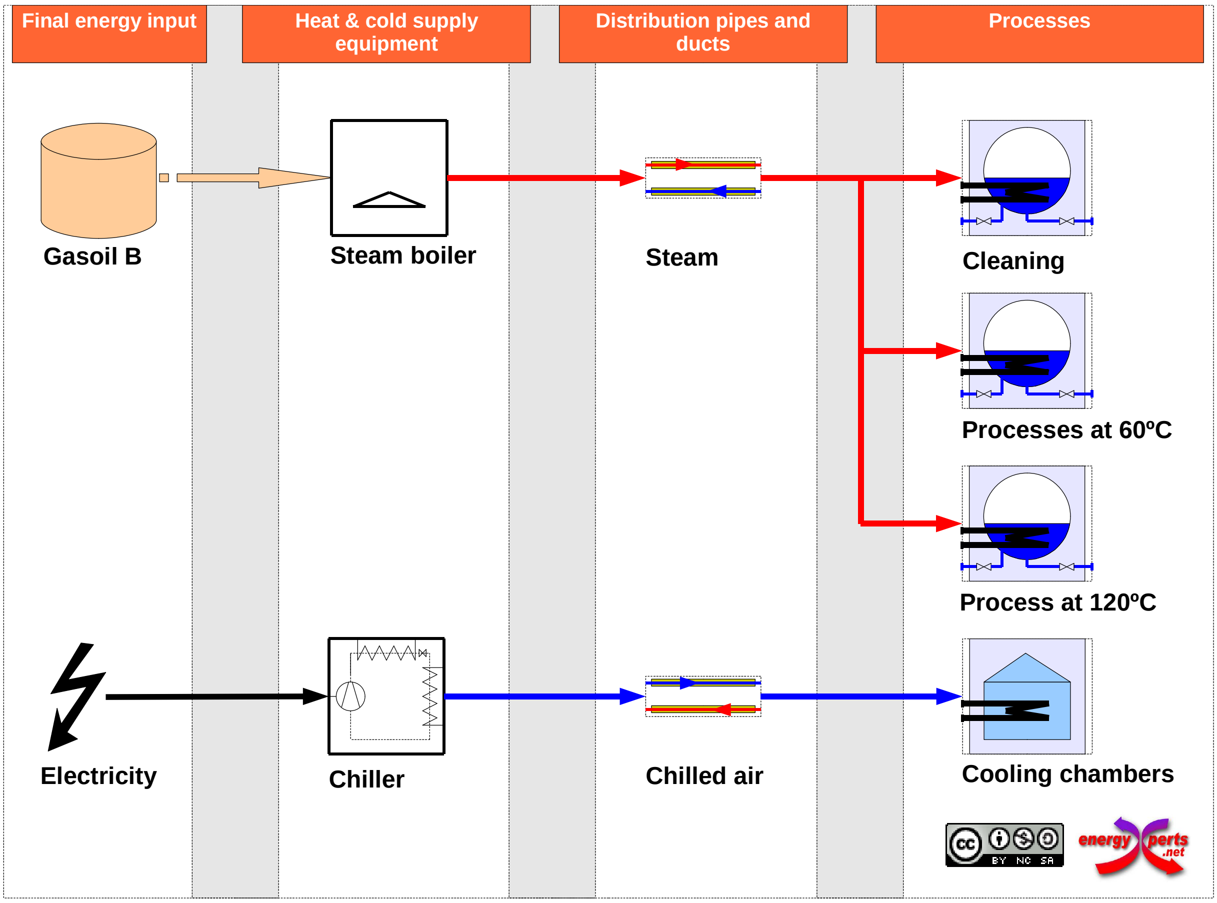
Sanitary hot water corresponds to the half of the total heat demand, while the other half is associated to the hot water for processes.

b) Energy supply system

Two steam boilers generate hot water for sanitary uses, which is stored in a tank in the same boiler room. Furthermore, the steam is distributed to the production hall to generate hot water for the processes.

There are no cooling processes in the plant. The only cooling demand corresponds to the cooling chamber where the product is stored. They are refrigerated by compression chillers (air cooled). Since the compression chillers are very new (year 2010), it is supposed that the plant has been already optimised, so no changes in the generation and distribution of cold are proposed (although electricity corresponds to 75% of the final energy entering the plant).

Figure 4. Overview of the heat and cold supply system



2.3. Additional comments

Specific assumptions

Table 1.List of assumptions

Parmeter description	Value	Justification
Medium temperature of the cooling air of the compression chillers	21ºC	Dependent on the ambient temperature. Estimation needed for the analysis of heat recovery.
COP chillers	3,71	Estimation based on the process power requirement and the total electrical consumption associated to cooling (90% of the total).

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 2.

Table 2. Overview of the alternative proposals studied

Name	Description
Heat exchanger network	- Heat exchanger of 7 kW to recover heat content of the air used to refrigerate the compression chillers to preheat water at low temperature (processes or sanitary hot water). - Economizer of 17 kW in the boiler to recover heat content of the exhaust gas to preheat water inlet of the boiler.
Solar thermal ETC 200 kW	- Heat exchanger of 7 kW to recover heat content of the air used to refrigerate the compression chillers to preheat water at low temperature (processes or sanitary hot water). - Economizer of 13 kW in the boiler to recover heat content of the exhaust gas to preheat water inlet of the boiler. - Solar thermal system ETC (evacuated tube collector) of 200 kW.
Solar thermal ETC 100 kW	- Heat exchanger of 7 kW to recover heat content of the air used to refrigerate the compression chillers to preheat water at low temperature (processes or sanitary hot water). - Economizer of 15 kW in the boiler to recover heat content of the exhaust gas to preheat water inlet of the boiler. - Solar thermal system ETC (evacuated tube collector) of 100 kW.
Cogeneration 75 kW	- Heat exchanger of 7 kW to recover heat content of the air used to refrigerate the compression chillers to preheat water at low temperature (processes or sanitary hot water). - Cogeneration system (engine) of 75 kW thermal / 43 kW electrical.
Cogeneration 110 kW	- Heat exchanger of 7 kW to recover heat content of the air used to refrigerate the compression chillers to preheat water at low temperature (processes or sanitary hot water). - Cogeneration system (engine) of 110 kW thermal / 60 kW electrical.

3.2. Energy performance[1]

Table 3. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present state	4.289	---	---
Heat exchanger network	4.220	69	1,60
Solar thermal ETC 200 kW	3.886	403	9,39
Solar thermal ETC 100 kW	4.041	247	5,77
Cogeneration 75 kW	3.834	455	10,60
Cogeneration 110 kW	3.769	520	12,12

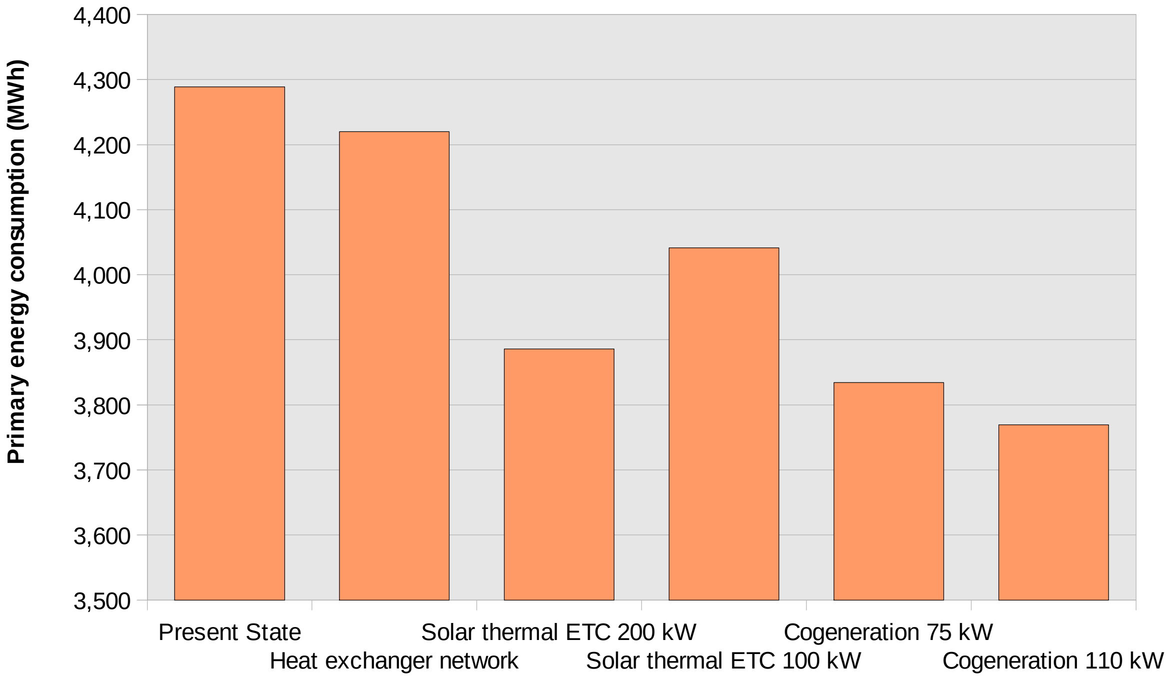


Figure 5. Comparative study: yearly primary energy consumption.

1 The factors for conversion of final energy (for fuels in terms of LCV) to primary energy used in this study are 2,9 for electricity and 1,1 for natural gas.

3.3. Economic performance

Table 4. Comparative study: investment costs. Estimated co-funding: 30 % for solar thermal systems and 10% for the rest of technologies. The electricity generated in the CHP is consumed in the plant (for refrigeration).

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State	---	---	---
Heat exchanger network	2.400	2.160	240
Solar thermal ETC 200 kW	164.400	115.560	48.840
Solar thermal ETC 100 kW	85.899	60.610	25.290
Cogeneration 75 kW	57.300	51.570	5.730
Cogeneration 110 kW	72.900	65.610	7.290

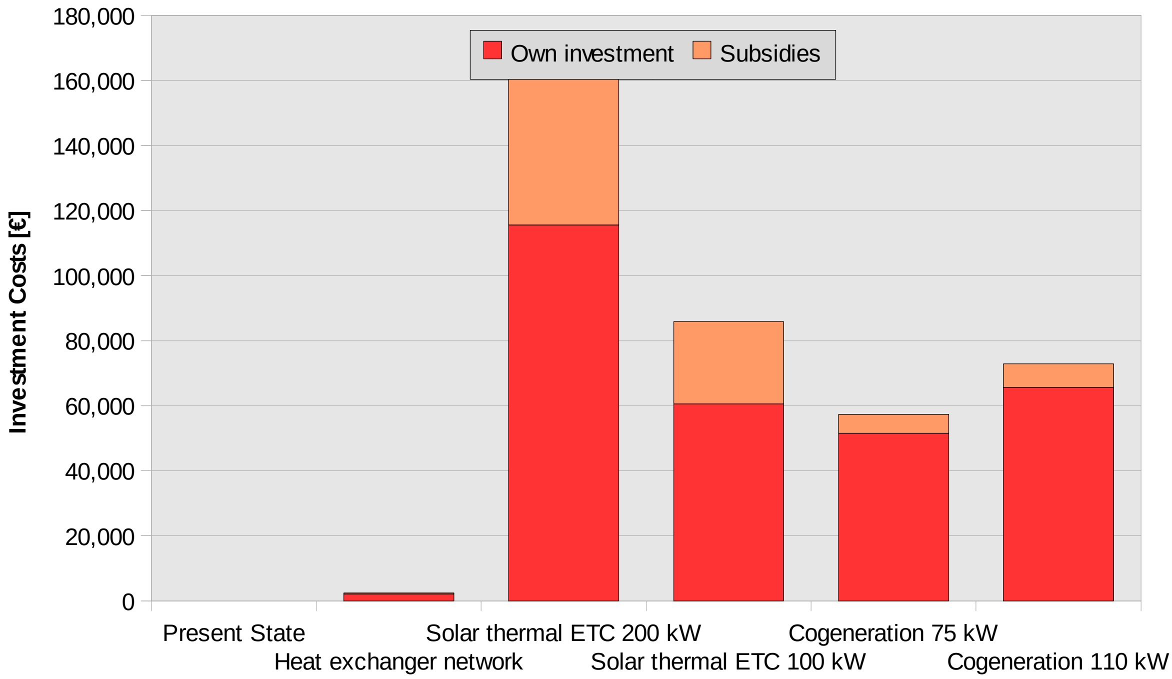


Figure 6. Comparative study: investment costs (Estimated co-funding: 30 % for solar thermal systems and 10% for the rest of technologies).

Table 5. Comparative study: annual costs including annuity of initial investment[2]. The electricity generated in the CHP is totally consumed in the plant (for refrigeration, lighting, machinery, etc.), since tariff of sold electricity is cheaper than the purchased electricity tariff.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]
Present State	---	227.183	0
Heat exchanger network	247	223.566	200
Solar thermal ETC 200 kW	16.927	206.002	2.700
Solar thermal ETC 100 kW	8.844	214.171	1.450
Cogeneration 75 kW	5.900	203.090	2.778
Cogeneration 110 kW	7.506	199.399	3.426

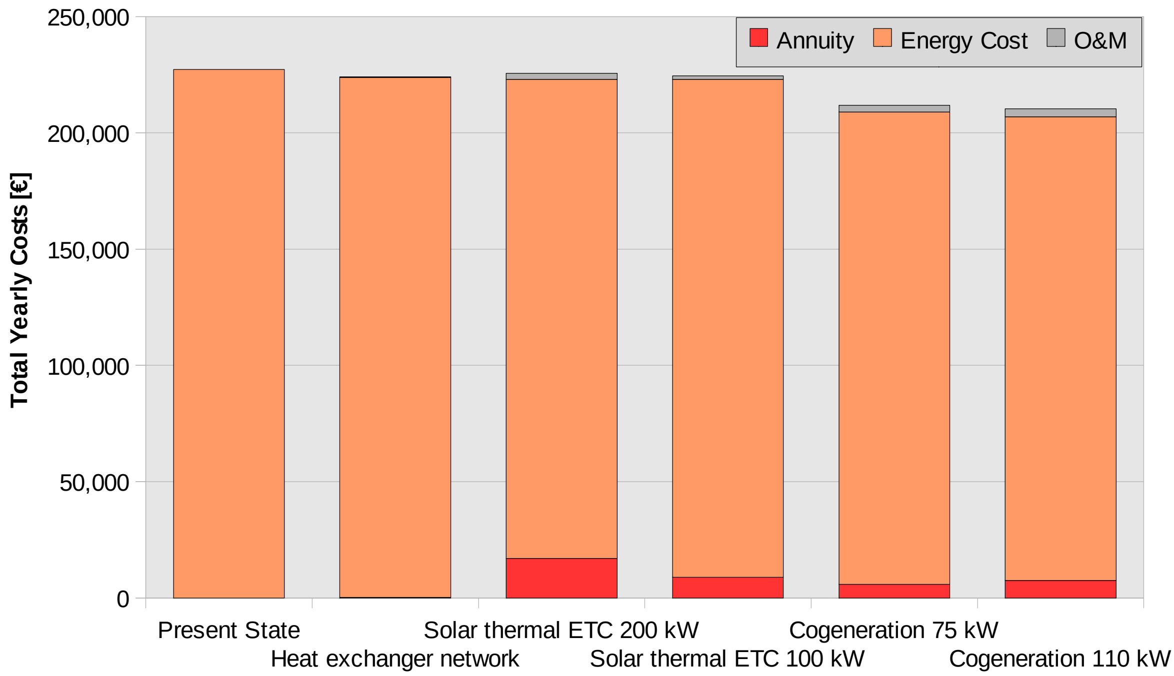


Figure 7. Comparative study: annual costs including annuity of initial investment. The electricity generated in the CHP is totally consumed in the plant (for refrigeration, lighting, machinery, etc.), since tariff of sold electricity is cheaper than the purchased electricity tariff. This electricity is counted as negative in the economic balance.

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 "Cogeneration 110 kW" that combines a customized heat exchanger network and a cogenerative engine of 60 kW_e /110 kW_{th} has been considered the best option among the previously analysed due to the following facts:

- high potential of primary energy savings
- high potential of energy cost savings
- solar systems have been discarded due to a longer payback period in comparison with the cogeneration system

The solar thermal system is a second interesting option to take into consideration. A possible combination of cogeneration and solar thermal could be studied more in detail.

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

4.1.1. Process optimisation

No process optimisation hast been studied, due to the lack of information of the processes and its normative. During the visit, it was seen that the recipients where the processes are carried out did not have any covers, so the heat losses are high. It is recommended to study the possibility of covering the recipients.

4.1.2. Heat recovery

The proposed heat exchanger network uses waste heat of the chiller to preheat process and sanitary hot water (Table 6). As can be seen from Table 3, heat recovery leads to a saving of 1,6 % of the primary energy consumption (2,3% of gas oil consumption).

Table 6. List of heat exchangers proposed.

Heat exchanger	Power	Source	Sink	Transferred energy	
	[kW]			[MWh]	[%]
HX 1	7	Compression chillers (refrigerant)	Process and sanitary hot water	21	100,00
Total	7			**21**	**100**

4.1.3. Heat and Cold Supply

In the new system proposed a cogeneration plant (engine) is added to supply heat into the existing hot water network using the exhaust gas and the cooling water. It also produces electricity, which is used consumed for the own industry needs (chillers, machinery, lighting, etc.). There is no excess electricity that can be sold to the grid.

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

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

Parameter	Units	Technical data
Type of equipment	-	CHP engine
Nominal power (heat or cold output)	kW	110.00
Fuel type	-	Gasoil
Fuel consumption (nominal)	kg/h	15.81
Electrical power generated (CHP)	kW	65.00
Electrical conversion efficiency (CHP)	-	0.33

The contribution of the new equipments to the total heat supply (878 MWh) is shown in Table 8. The distribution of heat supply by months is shown in Error: Reference source not found.

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
Boilers	347	39,52
New CHP	531	60,48
Total	**878**	**100**

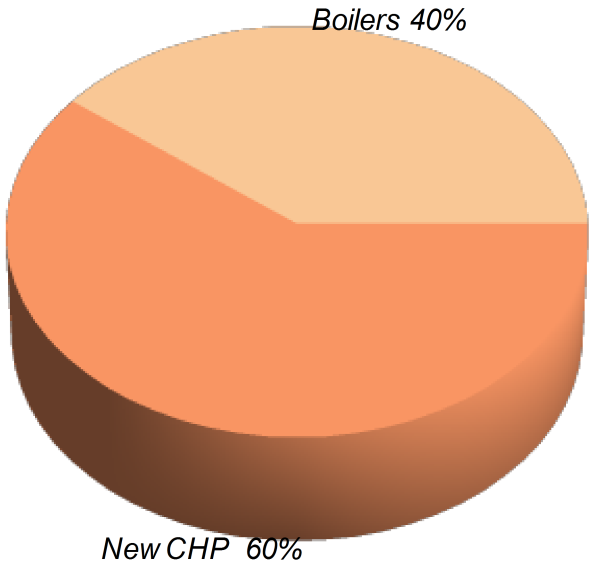


Figure 8. Contribution of the different equipments to the total useful heat supply (USH) in the company.

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

The following measures are proposed:

- heat recovery: use of cooling air of the compression chillers to preheat water (for processes or sanitary purposes)
- cogeneration (engine) to cover the base load of the remaining heat demand

These measures allow to save 12,1 % of the current primary energy consumption and 7,4% of current energy system cost. The required investment is about 72.900 € with a short pay-back time of 2,9 year (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
Primary energy consumption (1)				
- total	*[MWh]*	*4.289*	*3.769*	*12,1%*
- fuels	*[MWh]*	*1.099*	*1.616*	*-47,0%*
- electricity	*[MWh]*	*3.190*	*2.153*	*32,5%*
Primary energy saving due to renewable energy	*[MWh]*	*0*	*0*	*-*
CO_2 emissions	*[tons/a]*	*800*	*739*	*7,7%*
Annual energy system cost (2)	*[EUR]*	*227.183*	*210.332*	*7,4%*
Total investment costs (3)	*[EUR]*	*0*	*72.900*	*-*
Payback period(4)	*[years]*	*0*	*2,9*	*-*

(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. It also includes the feed-in-tariff revenue for the electricity produced by the CHP plant and sold to the net.

(3) total investment excluding subsidies.

(4) supposing 10% of funding of total investment (subsidies or equivalent other support mechanisms)