Energy Audit Summary Report

Audit No. 39 - Spain

Entertainment Center

Spain

Entertainment Center

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

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With the collaboration of the Chamber of Commerce and Industry of Madrid.

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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: 08-06-2011)

2.1. General information of the company

Company, location	Entertainment Center, Spain	
Sector	Entertainment	
No. of employees	n.a.	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- natural gas	2.153	2.153
- electricity	6.320	1.742

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

2.2. Description of the company

a) Activity

The facility has a useful area of around 10.000 m^2 (excluding gardens) and accommodates certain types of entertainment activities and events and other activities such as catering and parties. Daily visits oscillate between 800 and 1200. In special days, it can increase to 4.000 people. It is designed to attend 5.555 visits.

For the analysis, the area has been divided into different sectors according to its use and also to energy supply equipments. Almost all areas are heated in winter and cooled in summer and are usually often at afternoon and night (from 16h to 6h). Sanitary hot water is needed the whole year.

b) Energy supply system

A natural gas hot water boiler supplies heat for sanitary uses. Another natural gas fired hot water boiler supplies hot water for space heating. Six compression chillers produce cooling for most of the areas. Some smaller areas have an own chiller or a heat pump that supplies heat and cold.

Furthermore, the waste heat of the general chillers is recovered. Hot water is stored in three tanks and used for space heating. See Figure 1.

2.3. Specific assumptions

The results of this study are based on specific assumptions:

Table 1. List of assumptions

	Description	Value	Justification
1	Low calorific value (LCV) of natural gas	12,43 kWh/kg	energyXperts
2	Hot water for sanitary uses	175 m^3/day	Value calculated assuming 24 liters per person and day, and an average number of visits of 1030 people.
3	Repartition of energy demand		The assignation of the heat and cooling demand for each area has been done according to areas, characteristics, use, internal thermal loads and installed handling air units and equipments.
4	EER chillers	2,50	energyXperts
5	Heat recovered from the chillers	441 MWh	It has been calculated that 5000 MWh of residual heat are availiable. According to energy balances, about 10% is used.
6	Tariff of sold energy	145 EUR/MWh	http://www.mityc.es/energia/electricidad /Tarifas/Instalaciones/Documents /categoria_a_abril_2011.pdf

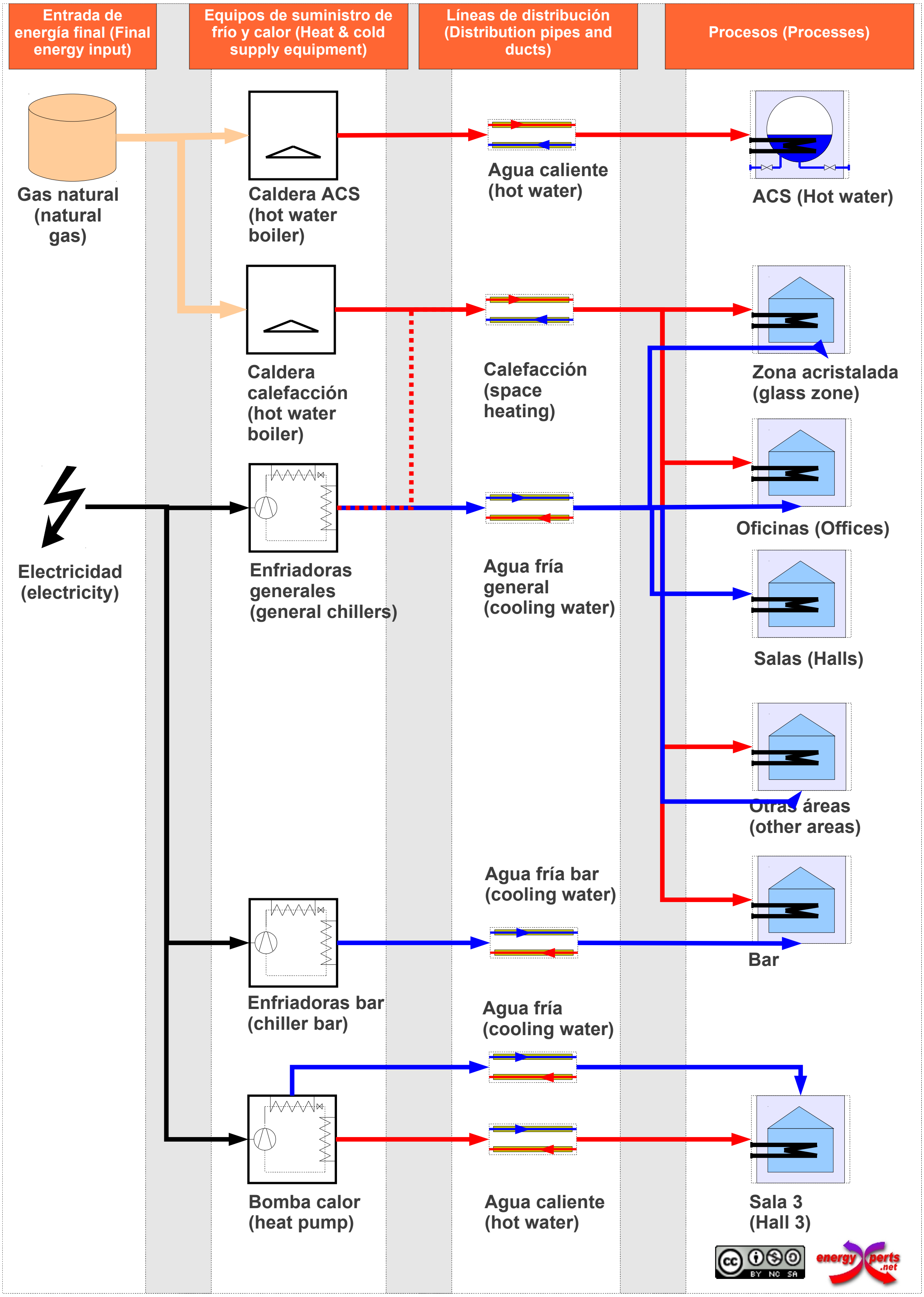

Figure 1. Overview of the heat and cold supply system

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.

The scope of the EINSTEIN audit is focussed exclusively on the analysis and optimisation of the supply system of heating and cooling. Building optimisation is not included. It is strongly recommended to carry out a study on potential demand reductions in the building itself (building envelope, lighting, reduction of internal gains) and – in case of modifications – adapt the measures proposed in this study to the then reduced heating and cooling demands.

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

Heat recovery	**Heat recovery** - Use of waste heat of the compression chilelrs to generate hot water for sanitary uses during the summer period, when space heating is not required.
Cogeneration	**Heat recovery and cogeneration** - Idem to heat recovery - Installation of a cogenerative engine (686 kW thermal / 500 kW electric)
Trigeneration	**Heat recovery and trigeneration system (cogenerative engine + absorption chiller)** - Idem to heat recovery - Installation of a cogenerative engine (686 kW thermal / 500 kW electric) - Installation of an absorption chiller (350 kW) coupled to the cogenerative engine
Solar ETC	**Heat recovery and solar sytem ETC** - Idem to heat recovery - Installation of a solar system ETC (Evacuated Tube Collector) of 100 kW
Trigeneration and solar thermal ETC	**Heat recovery and trigeneration system (cogenerative engine + absorption chiller) + solar system ETC** - Idem to heat recovery - Installation of a cogenerative engine (686 kW thermal / 500 kW electric) - Installation of an absorption chiller (350 kW) coupled to the cogenerative engine - Installation of a solar system ETC (Evacuated Tube Collector) of 100 kW

3.2. Energy performance[1]

Table 3. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present state	20.698	---	---
Heat recovery	20.506	192	0,93
Cogeneration	18.575	2.123	10,26
Trigeneration	18.005	2.693	13,01
Solar thermal ETC	20.345	353	1,70
Trigeneration and solar thermal ETC	17.962	2.735	13,22

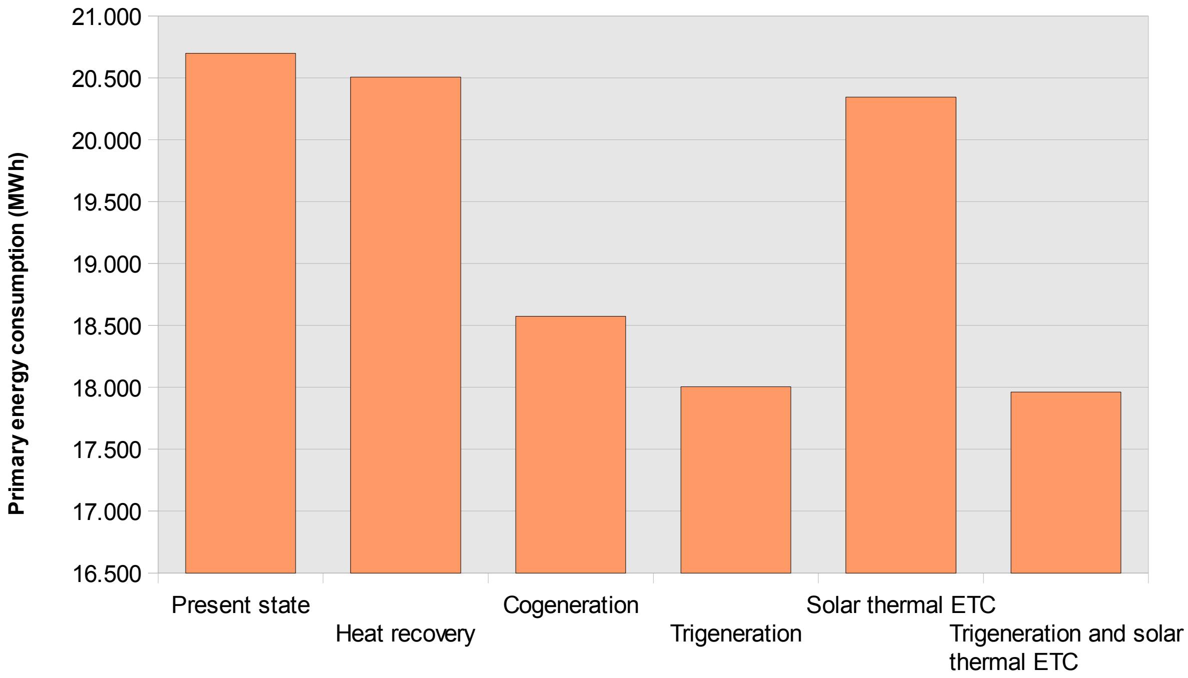

Figure 2. Comparative study: yearly primary energy consumption.

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.

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present state	---	---	---
Heat recovery	0	0	0
Cogeneration	375.000	337.500	37.500
Trigeneration	480.000	432.000	48.000
Solar thermal ETC	83.499	58.450	25.050
Trigeneration and solar thermal ETC	563.499	490.450	73.050

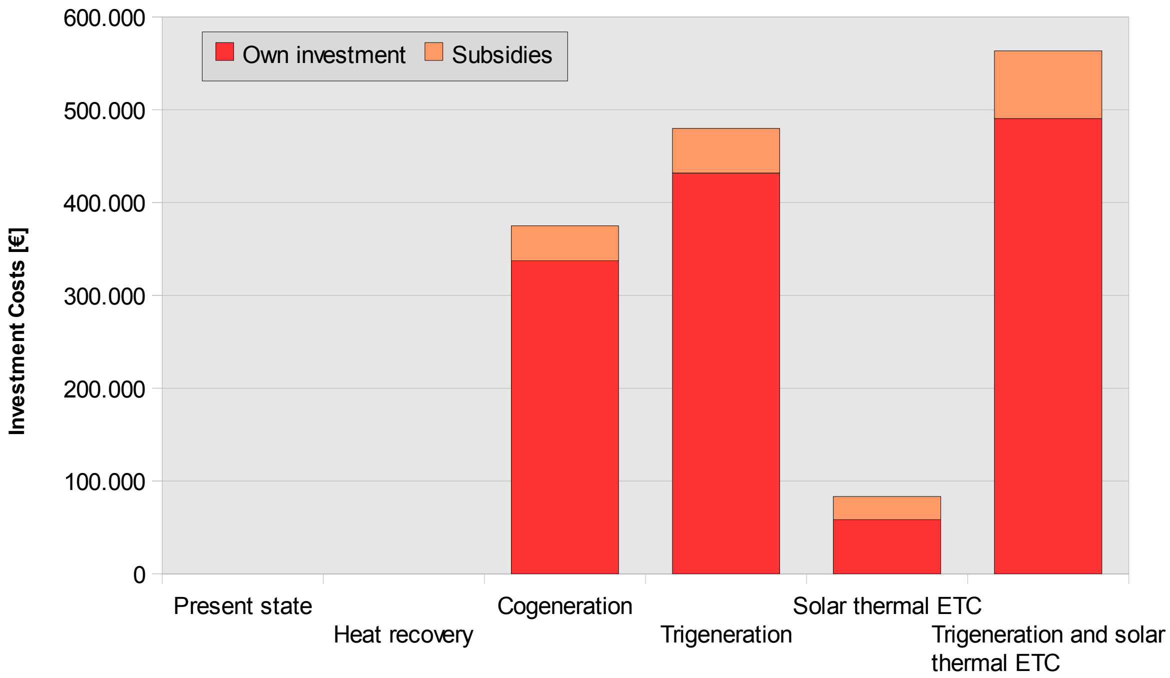

Figure 3. Comparative study: investment costs. Estimated co-funding: 30% for solar thermal systems and 10% for the rest of technologies.

Table 5. Comparative study: annual costs including annuity of initial investment[2]. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity.

Alternative	Annuity [€]	Energy Cost [€]	O&M [€]
Present state	---	691.581	0
Heat recovery	0	683.595	0
Cogeneration	38.611	563.781	12.872
Trigeneration	49.422	526.184	21.813
Solar thermal ETC	8.597	676.914	1.250
Trigeneration and solar thermal ETC	58.019	527.510	22.521

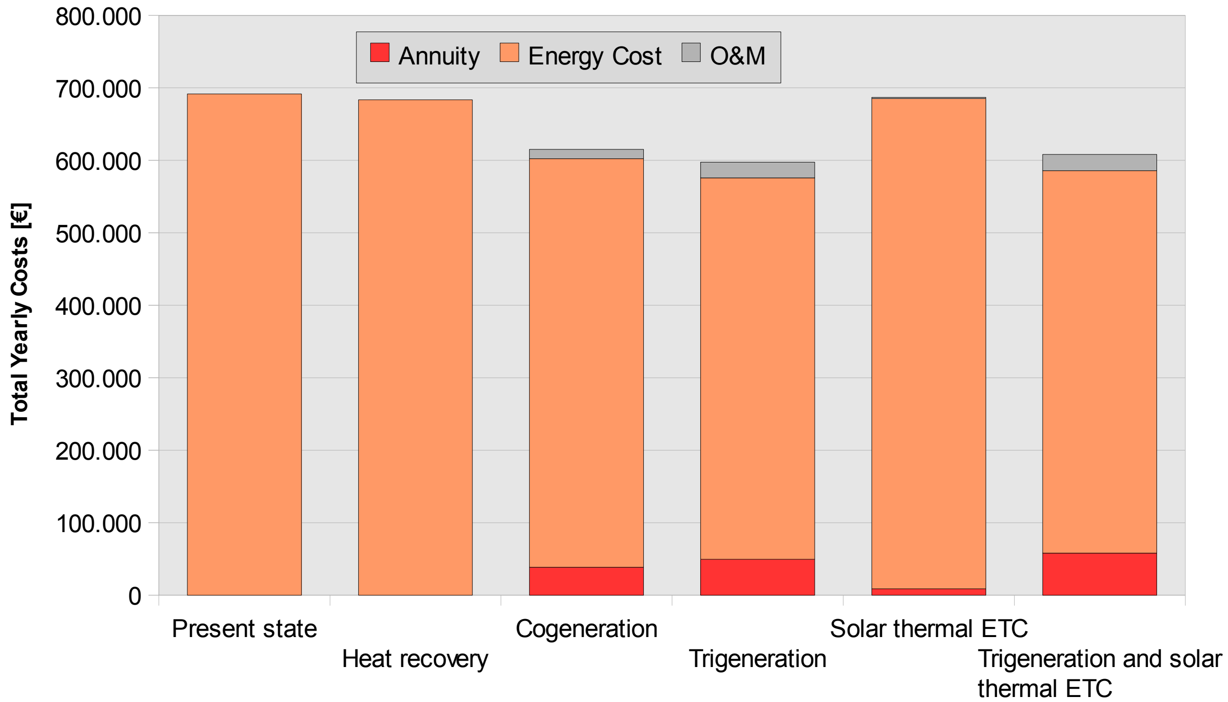

Figure 4. Comparative study: annual costs including annuity of initial investment. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity.

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 "Trigeneration" that combines a cogenerative engine of 500 kWe / 686 kWth coupled to an absorption chiller of 350 kW has been considered the best option among the previously analysed due to the high potential of both primary energy and energy cost savings. The alternatives with a solar thermal system have been discarded due to a longer pay-back period. However, it is a second interesting option that could be taken into account.

4.1.1. Heat recovery

In the proposed alternative, the heat recovery module is optimised: the waste heat of the chillers can be also used to generate sanitary hot water during the summer period (it is currently used just for space heating). The savings achieved by the measure are listed in Table 6. As it can be seen from Table 3, heat recovery leads to a saving of 1% of total primary energy consumption.

This measures do not required any structural change, since the heat exchangers and the tanks already exist.

Table 6. List of heat exchangers proposed.

Heat exchanger	Power	Source	Sink	Transferred energy	
	[kW]			[MWh]	[%]
HX space heating	160	Chillers	Space heating	441	72,2
HX hot water	29	Chillers	Hot water sanitary uses	170	27,8
	188			**611**	**100**

4.1.2. Heat and Cold Supply

In the new system proposed a cogeneration plant (engine) is added to the heat supply system. The CHP plant can feed heat into the existing hot water network.

Furthermore, an absorption chiller is added to supply cooling to the glass area, hall 3 and the bar. The absorption chiller is driven with heat generated in the cogenerative engine.

The technical specifications of the new CHP engine and the absorption chiller are given in Table 7. and Table 8 respectively.

Table 7. Technical specifications and economics of the new CHP engine.

Parameter	Units	Technical data
Type of equipment	-	CHP engine
Nominal power (heat or cold output)	kW	686
Fuel type	-	Natural gas
Fuel consumption (nominal)	kg/h	115
Electrical power generated (CHP)	kW	500

Table 8. Technical specifications and economics of the new absorption chiller.

Parameter	Units	Technical data
Type of equipment	-	thermal chiller (water cooled)
Nominal power (heat or cold output)	kW	350
Electricity power input	kW	500

The total and monthly contribution of the new equipments to the total heat supply (3.133 MWh) is shown respectively in Table 9, Figure 5 and Figure 6 while the contribution to the cooling supply (3.663 MWh) is shown in Table 10, Figure 7 and Figure 8.

Table 9. Contribution of the different equipments to the total useful heat supply (USH) in the company.

Equipment	USH by equipment	
	[MWh]	[% of Total]
HW boiler	10	0,3
Space heating boiler	99	3,2
Heat pump	20	0,7
CHP	3.003	95,9
Total	**3.133**	**100**

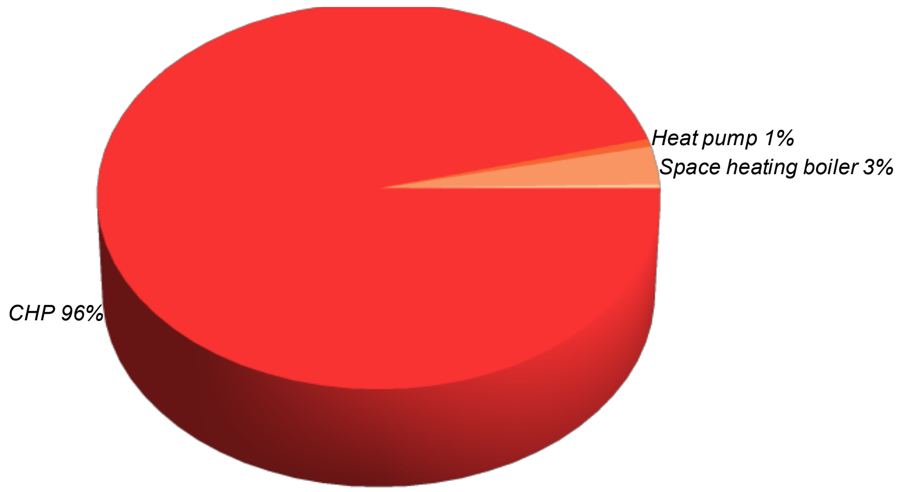

Figure 5. Contribution of the different equipments to the total useful heat supply (USH) in the company.

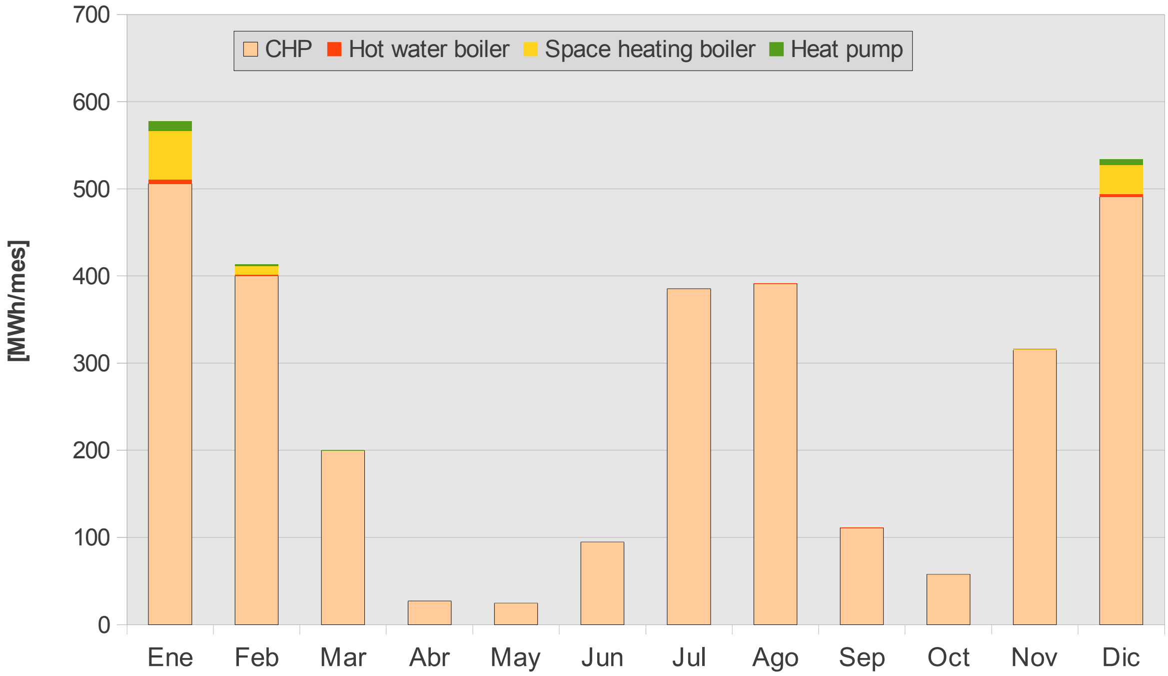

Figure 6. Contribution of the different equipments to the total useful cooling supply (USH) per month.

Table 10. Contribution of the different equipments to the total useful cooling supply (USC) in the company.

Equipment	USC by equipment	
	[MWh]	[% of Total]
General chillers	3.044	83,10
Heat pump	0	0,00
Chiller bar	0	0,00
New absorption chiller	619	16,90
Total	**3.663**	**100**

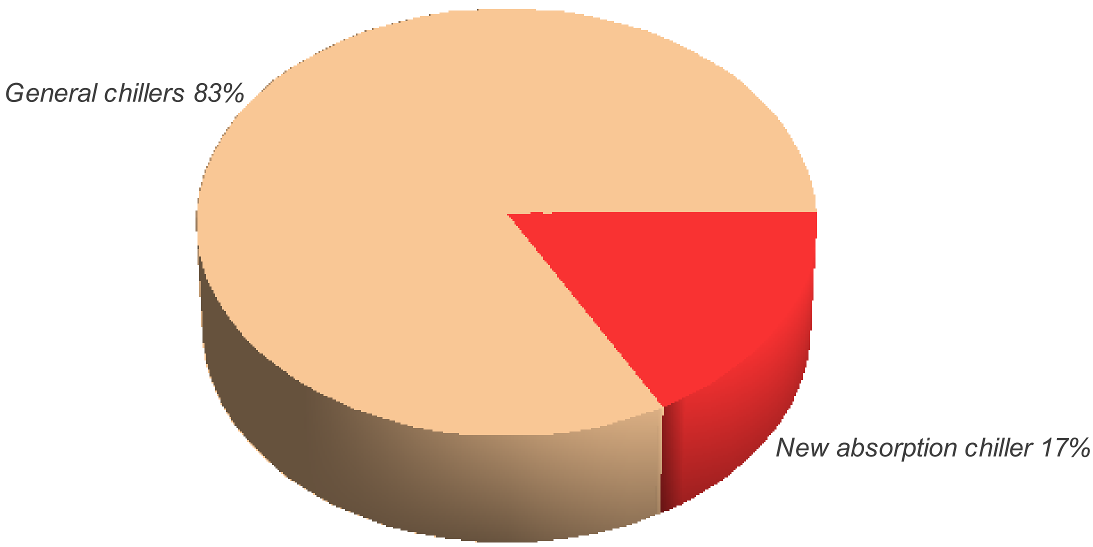

Figure 7. Contribution of the different equipments to the total useful cooling supply (USC)in the company.

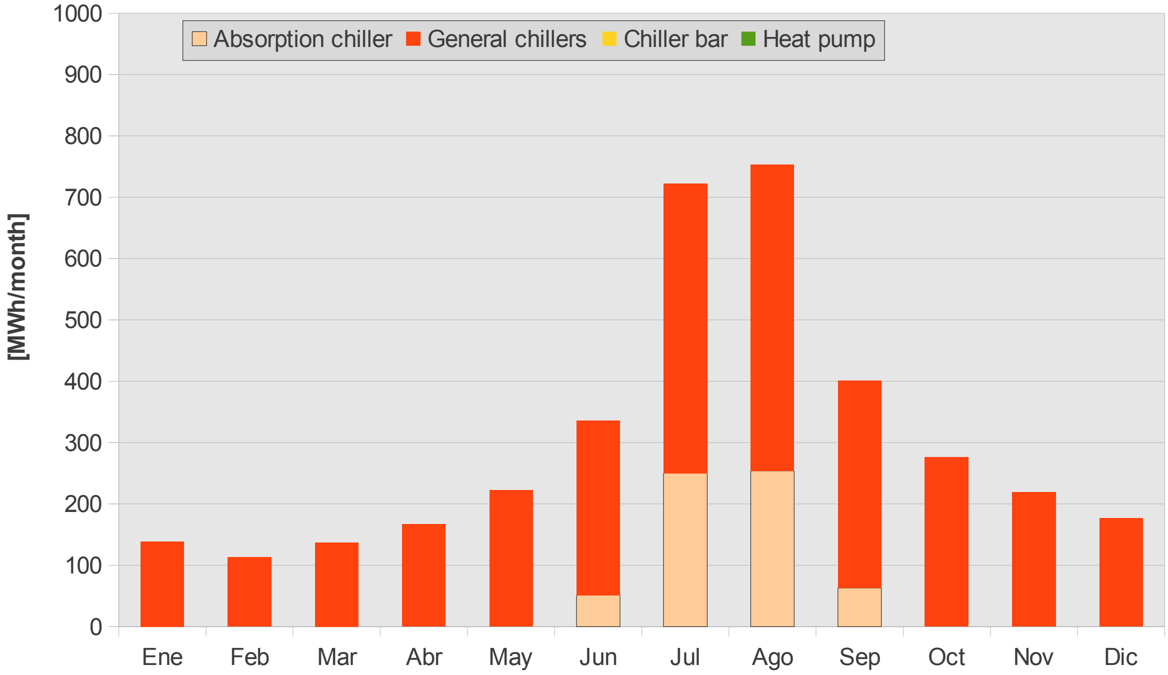

Figure 8. Contribution of the different equipments to the total useful cooling supply (USC) per month.

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

The following measures are proposed:

- heat recovery: use of waste heat of the chiller to generate hot water during summer period.
- cogeneration (engine) for covering the base load of the remaining heat demand
- absorption chiller to produce cooling in summer period

These measures allow to save 13 % of the current primary energy consumption (including primary energy for non-thermal purposes. For thermal purposes, the savings are 36%). It also saves 24 % of current energy cost (cost of fuel and electricity, including auto-generated electricity) and leads to a reduction of 14% of the total energy system cost (fuel and electricity, operation and maintenance, amortisation). The total required investment is about 597.419 € and the expected pay-back time is 3,3 years (taking into account the subsidies).

Table 11. 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*	*20.698*	*18.005*	*13,01%*
- fuels	*MWh*	*2.369*	*8.088*	*-241,41%*
- electricity	*MWh*	*18.329*	*9.917*	*45,89%*
Primary energy saving due to renewable energy	*MWh*	*0*	*0*	-
CO_2 emissions	*tons/year*	*3.699*	*3.548*	*4,08%*
Annual energy system cost (2)	*EUR*	*691.581*	*597.419*	*13,62%*
Total investment costs (3)	*EUR*	-	*480.000*	-
Payback period (4)	*years*	-	*3,3*	-

(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)