Energy Audit Summary Report

Audit No. 45 - ESP07

Arturo Soria (OHL) Building

Offices

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: 14-03-2011)

2.1. General information of the company

Company, location	Madrid (Spain)	
Sector	Offices	
Occupation	390 persons	
Current final energy consumption [MWh] (*)	total	for heating and cooling
- electricity	644	322

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

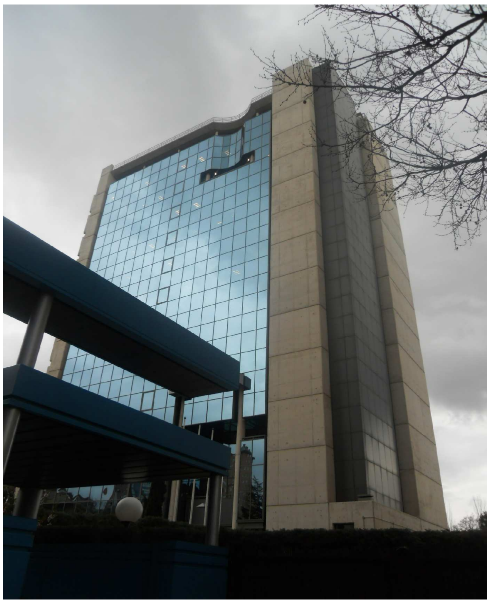

Figure 1. General view of the company

2.2. Description of the company

a) Activity

The building has a surface of 6802 m^2 used for offices. There are 12 floors and a parking. Each floor is divided into north and south part. Windows correspond to 50% of the facade.
The offices are heated in winter and refrigerated in summer. The basements and parking are just ventilated, but not conditioned.
Sanitary hot water demand is needed during the whole year.
The building opens from 7 to 22h except in summer (June to September), when it operates from 7 to 15h.

Figure 2. Empty floor

The most energy consuming process in the building is the refrigeration of the building in summer.

b) Energy supply system

Space heating and cooling is supplied by a VRV (variable refrigerant volume) electrically driven heat pump. The equipment is a large multiple split system. The system comprises several indoor evaporator/condensing units, matched to one or more outdoor condensing/evaporating units (its function depends on the mode: heating or cooling), which work with autonomy. There are 14 terminals in each plant, 7 for the north face and 7 for the south one.
The outdoor units are in the roof together with the AHU (air handling unit). Part of the

extracted air is recirculated into the AHU to preheat/precool the inlet air (heat recovery). Heating of sanitary hot water is carried out with 16 electrical boilers.

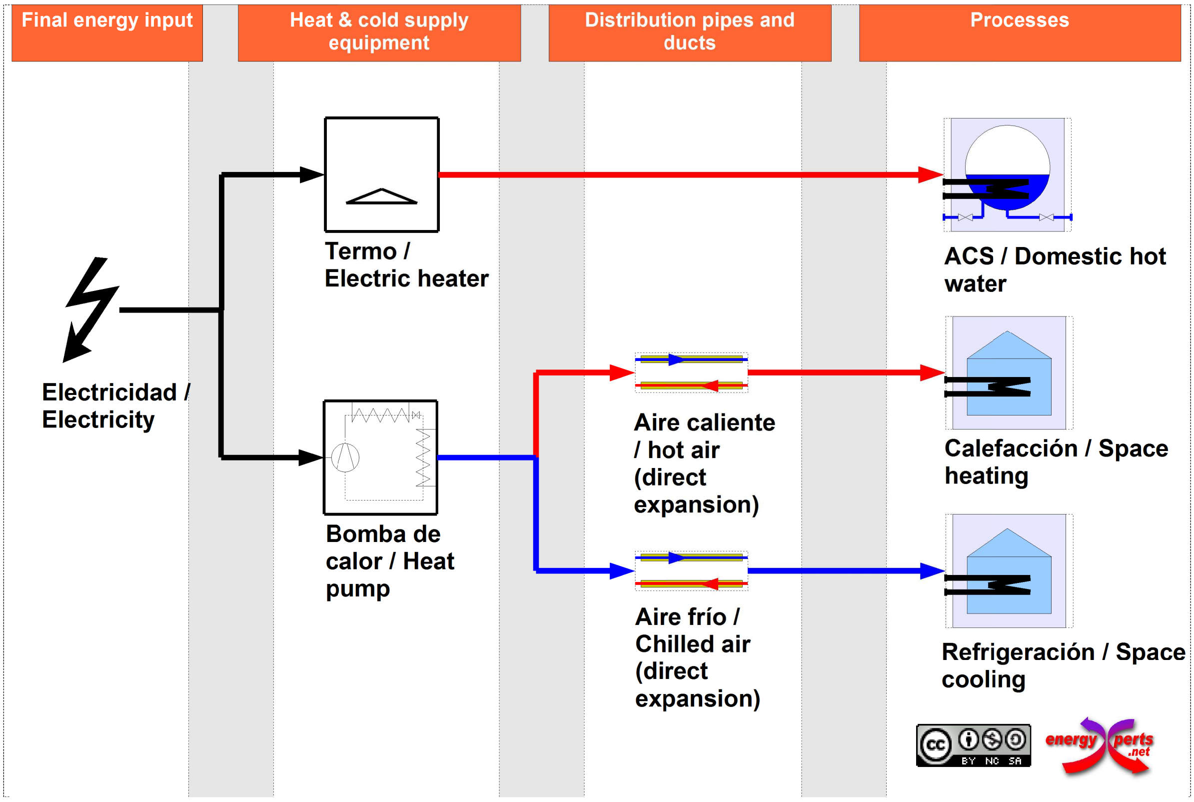

Figure 3. Overview of the heat and cold supply system

2.3. Additional comments

Specific assumptions

Table 1. List of assumptions

1	Repartition of electricity for heating and cooling	40% heating 60% cooling	300 MWh are anually consumed in the heat pump, but the division between heat and cooling supply is unkwnown. It has been supposed that 60% of the electrical consumption corresponds to the cooling demand.
2	Annual sanitary hot water consumption	546 m^3	It has been estimated based on the Spanish building regulation (CTE): 5 liters/person·day
3	Sold electricity tariff	145 €/MWh	Spanish regulation regarding feed-in tariff for electricity from CHP: http://www.mityc.es/energia/electricidad/Tarifas/Instalaciones/Documents/categoria_a_abril_2011.pdf

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 for buildings 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

Name	Description
Solar thermal	Solar thermal system FPC (Flat Plate Collector) of 15 kW to generate sanitary hot water
Cogeneration	Cogenerative engine (75 kW thermal / 43 kW electric) for sanitary hot water and space heating
Trigeneration	Coupling of: - Cogenerative engine (75 kW thermal / 43 kW electric) for sanitary hot water, space heating and driving of the thermal chiller - Thermal chiller (absorption) of 45 kW for cooling production The system generates heat, cold and electricity.
Solar cooling	Coupling of: - Solar thermal system ETC (Evacuated tube collector) of 80 kW for generation of sanitary hot water, space heating and driving of the thermal chiller. - Thermal chiller (absorption) of 20 kW for cooling production

3.2. Energy performance[1]

Table 3. Comparative study: yearly primary energy consumption.

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present state	1.868	---	---
Solar thermal	1.822	46	2,49
Cogeneration	1.669	199	10,67
Trigeneration	1.682	186	9,98
Solar cooling	1.777	91	4,89

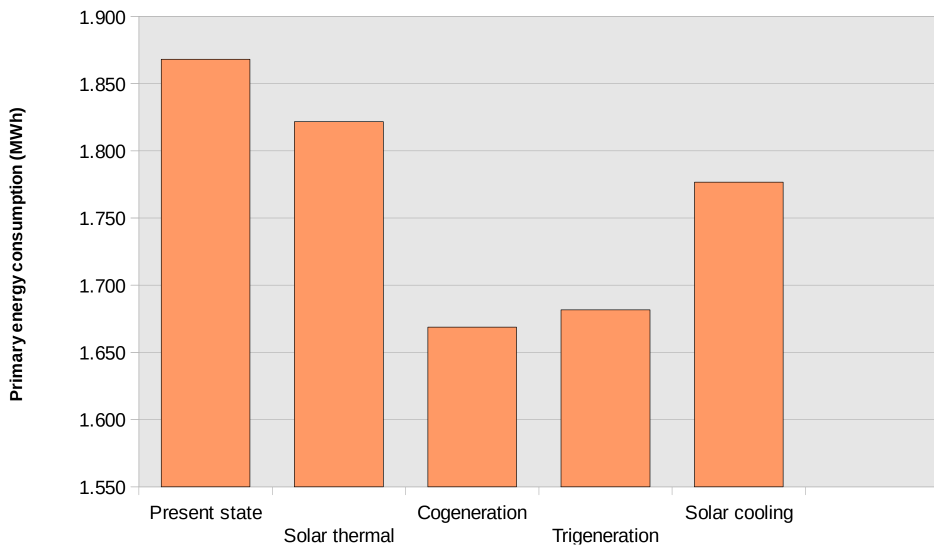

Figure 4. Comparative study: yearly primary energy consumption.

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	---	---	---
Solar thermal	15.113	11.579	3.534
Cogeneration	60.900	54.810	6.090
Trigeneration	74.400	66.960	7.440
Solar cooling	78.269	56.988	21.281

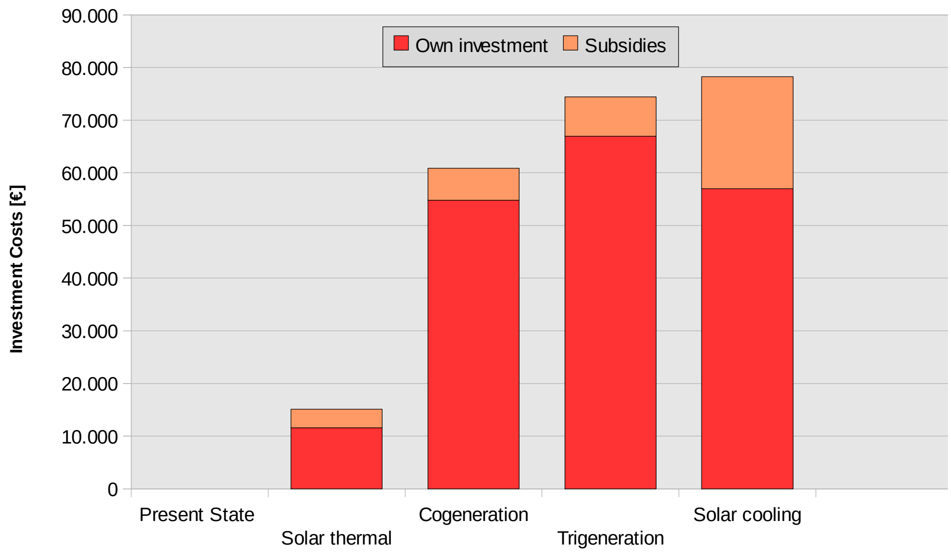

Figure 5. Comparative study: investment costs. Estimated co-funding: 30% for solar thermal systems and 10% for the rest of technologies.

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	---	57.973	0
Solar thermal	1.556	56.532	188
Cogeneration	6.270	48.365	1.675
Trigeneration	7.660	48.123	2.454
Solar cooling	8.059	55.113	1.300

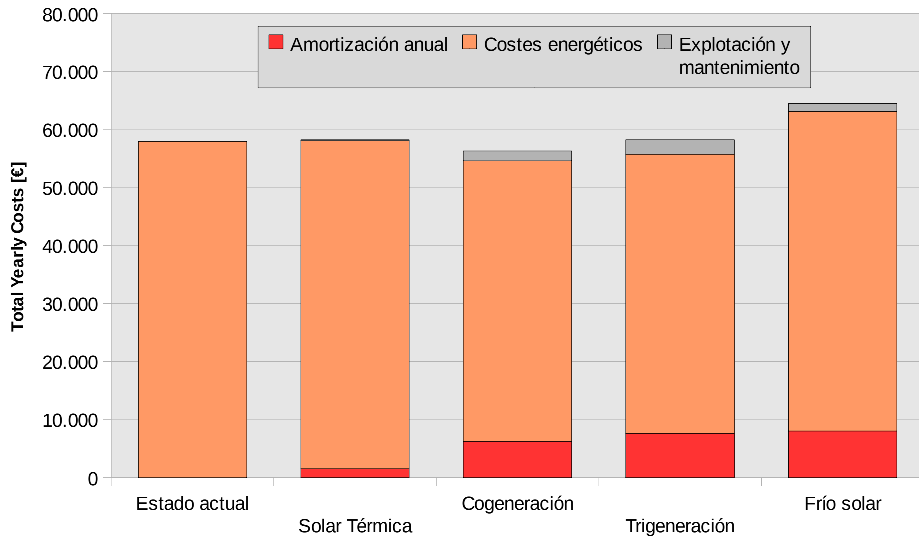

Figure 6. Comparative study: annual costs including annuity of initial investment. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity.

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. Tariffs: 45€/MWh for natural gas, 90 €/MWh for bought electricity, 145 €/MWh for sold electricity.

4. Selected alternative and conclusions

4.1. Selected alternative

The alternative proposal “Cogeneration” which consists in a cogenerative engine of 75 kW_e / 43 kW_{th} has been considered the best option among the previously analysed due to the following reasons:

- high potential of both primary energy and energy cost savings
- shorter pay back period
- trigeneration and solar cooling are energetically and economically worse than cooling with the heat pump

A combination of a solar thermal system and a cogeneration is possible, and might be analysed in a future detail analysis.

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

4.1.1. Building optimisation and heat recovery

In the present study, neither building optimisation (read section 3) nor heat recovery have been carried out. It has been supposed that the existing heat recovery in the air handling units is already optimum. This maybe should be confirmed in a more detailed analysis.

Figure 7. Evaporators / condensers on the roof

4.1.1. Heat and Cold Supply

In the new system proposed a cogenerative engine is added to the heat supply system. The CHP plant generated sanitary hot water, for space heating and to drive the thermal chiller. Since the electrical boilers are replaced by the cogeneration system, a new hot water distribution pipe has to be added.

The technical specifications of the new CHP engine is given in Table 6.

Table 6. 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	75,00
Fuel type	-	Natural gas
Fuel consumption (nominal)	kg/h	10,40
Electrical power generated (CHP)	kW	43,00
Electrical conversion efficiency (CHP)	-	0,33

The total and monthly contribution of the new equipments to the total heat supply (446 MWh) is shown respectively in Table 7, Figure 8 and Figure 9.

Table 7. Contribution of the different equipments to the total useful heat supply (USH) in the company.

Equipment	USH by equipment	
	[MWh]	[% of Total]
Electrical boilers	6	1,43
Heat pump heating	154	34,64
New CHP	285	63,92
Total	**446**	**100**

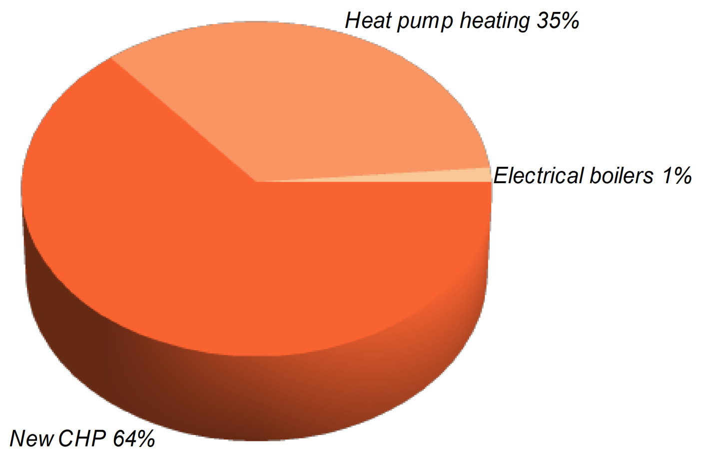

Figure 8.Contribution of the different equipments to the total useful heat supply (USH) in the company.

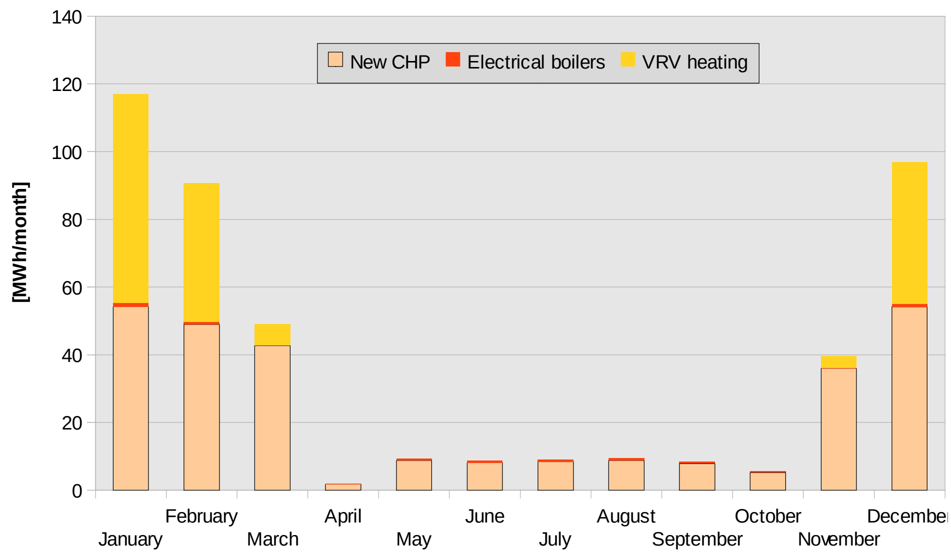

Figure 9. Contribution of the different equipments to the total useful cooling supply (USH) per month.

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

The following measures are proposed:

- cogeneration (engine) for covering the base load for heat generation

These measures allow to save 10,7 % of the current primary energy consumption (including primary energy for non-thermal purposes. For thermal purposes only, the savings are 21,3%). It also saves 16,6 % of current energy cost (cost of fuel and electricity, including auto-generated electricity) and leads to a reduction of 2,9 % of the total energy system cost (fuel and electricity, operation and maintenance, amortisation). The total required investment is about 60.900 € and the expected pay-back time is 7,9 years (taking into account the subsidies).

Table 8. 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*	*1.868*	*1.669*	*10,67%*
- fuels	*MWh*	*0*	*516*	-
- electricity	*MWh*	*1.868*	*1.152*	*38,31%*
Primary energy saving due to renewable energy	*MWh*	*0*	*0*	-
CO_2 emissions	t/a	*322*	*316*	*1,88%*
Annual energy system cost (2)	*EUR*	*57.973*	*56.310*	*2,87%*
Total investment costs (3)	*EUR*	-	*60.900*	-
Payback period (4)	*years*	-	*7,9*	-

(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)