Energy Audit Summary Report

Audit No. 10

Plastic Industry

Production of expanded polystyrene

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

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In collaboration with 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

Level of confidentiality: anonymous data

2.1. General information of the company

Sector	Manufacture of plastics
Products	Expanded polystyrene (EPS)

2.2. Description of the process and supply system

a) Productive process

The manufacturing of the EPS consists of the following stages:

- Pre-expansion
- Stabilisation (drying and storage)
- Expansion (preheating needed)
- Cutting and shape molding

The company receives expandable polystyrene beads, already prepared for the expansion. The raw material has a density of about 600 kg/m^3 and has to be expanded to densities between 12-40 kg/m^3.

In the first stage, the beads are fed into an agitation tank and are expanded to the desired density through the addition of steam. The control of the density depends on some parameters such us the temperature and time of exposition. After the pre-expansion, the EPS beads are dried (inside the pre-expander) and immediately stored for several hours in open air for stabilization. Then, the pearls enter in a closed block chamber where steam is injected again. The chamber has been previously preheated by steam. Since there is no room for expansion, the pearls fuse and form a solid block. The EPS block has to be cooled down before leaving the block chamber. Finally, the blocks can be cut into several shapes for final use, usually as isolating boards.

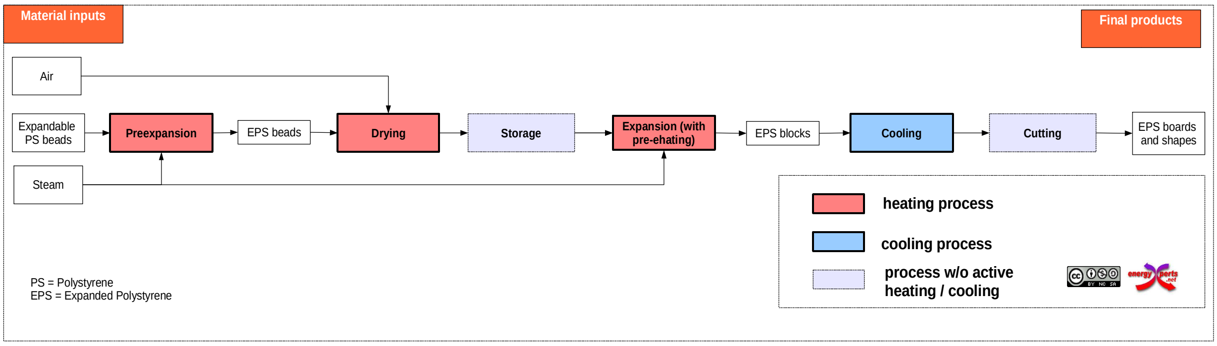

Figure 1. Simplified production flow sheet

The most energy consuming processes in the company are the pre-expansion followed by the preheating of the block chamber of the expansion process.

b) Energy supply system

The heat used in the company is generated in a natural gas fired steam boiler. The steam is distributed to the different processes. In the two expansions the steam is injected together with the process material, so the condensate is not returned to the boiler. This condensate is not recovered. The cooling is provided by fresh water from the net or a well.

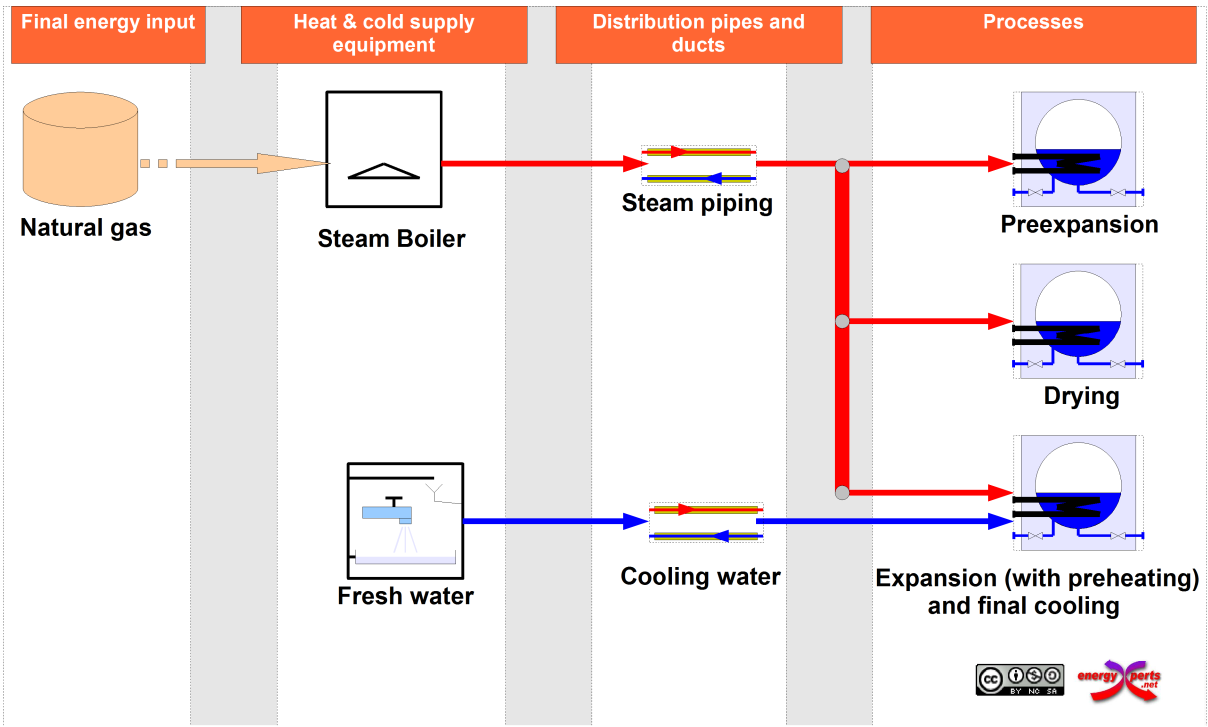

Figure 2. Overview of the heat and cold supply system

2.3. Additional comments

Specific assumptions

It has been assumed that the preheating of the block chamber for the expansion can be carried out using hot water instead of steam injection, thereby lowering the temperature level of the required heat.

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.

All alternatives include process optimisation as described below in section 4.1.1. The second alternative consists in a heat recovery. The solar thermal and the cogeneration system include the process optimization and heat recovery.

Table 1. Overview of the alternative proposals studied

Short name	Description
Process Optimization	Reduction of the energy demand of the preheating of the expansion pro
Heat recovery	Process optimization + Economiser (*) 66 kW
Solar thermal system (ETC)	Process optimization + Economiser (*) 59 kW +Solar thermal system Evacuated Tube Collectors 300 kW
CHP (Gas turbine)	Process optimization + Economiser (*) 26 kW + Cogeneration system turbine) 200 kWe / 375 kWt

(*) Economiser for recovery of boiler exhaust gas

3.2. Energy performance[1]

Table 2. Comparative study: yearly primary energy consumption.

Alternative	Primary Energy Consumption [MWh]	Savings [MWh]	[%]
Present State	2.537	---	---
Process Optimization	2.285	255	9,93
Heat recovery	2.007	533	20,89
Solar thermal system (ETC)	1.748	792	31,10
CHP (Gas turbine)	1.132	1.408	55,38

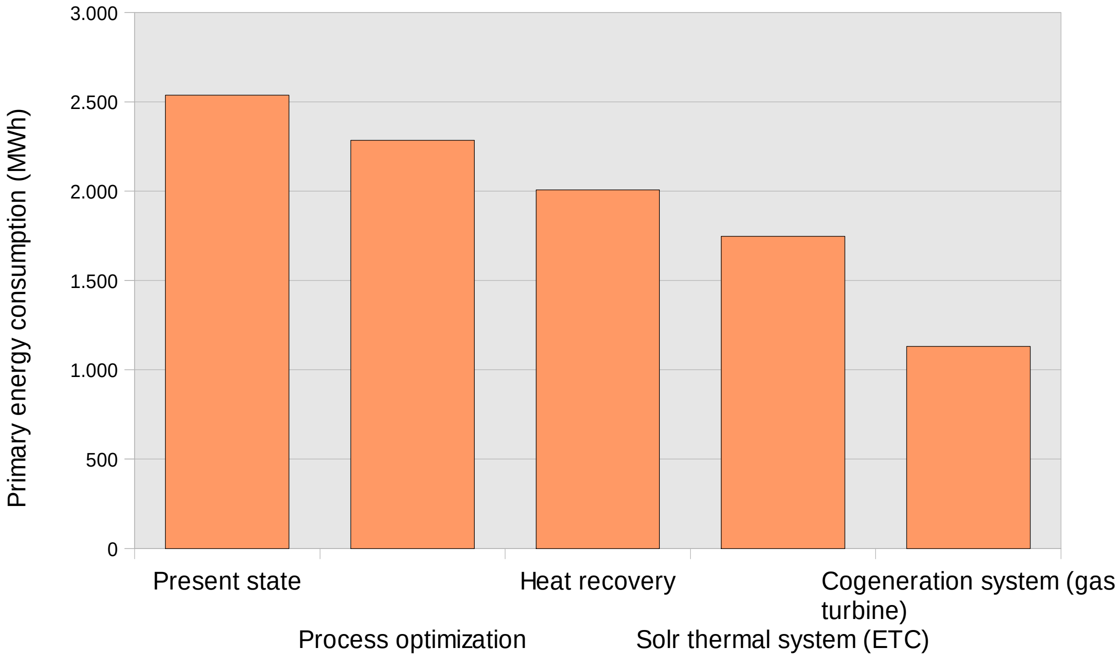

Figure 3. Comparative study: yearly primary energy consumption.

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 natural gas.

3.3. Economic performance

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

Alternative	Total Investment [€]	Own Investment [€]	Subsidies [€]
Present State	---	---	---
Process Optimization	4.000	3.600	400
Heat Recovery	11.000	9.900	1.100
Solar Thermal (ETC)	248.287	176.001	72.286
CHP (gas turbine)	266.000	239.400	26.600

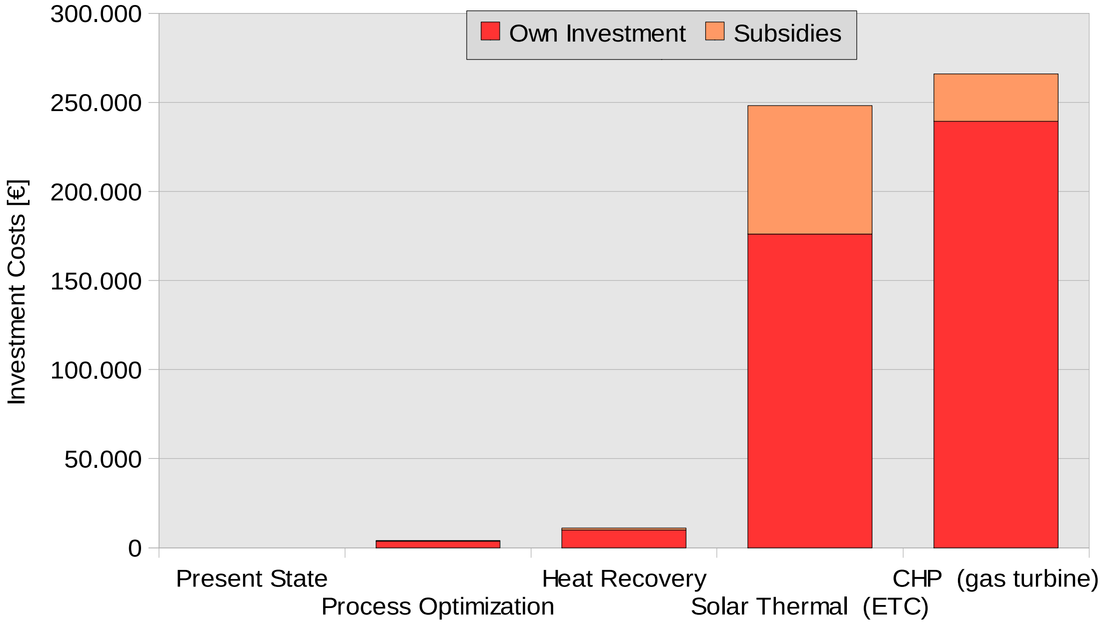

Figure 4. Comparative study: investment costs. Estimated co-funding: 10 % for investment in heat recovery, 30% for solar thermal systems.

Table 4. Comparative study: annual costs[2] including annuity of initial investment[3]. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity.

Alternative	Annuity [€]	Energy costs [€]	O&M [€]
Present State	---	77.377	0
Process Optimization	385	70.510	0
Heat Recovery	1.060	62.922	600
Solar Thermal (ETC)	23.921	55.933	4.350
CHP (gas turbine)	25.627	-13	7.115

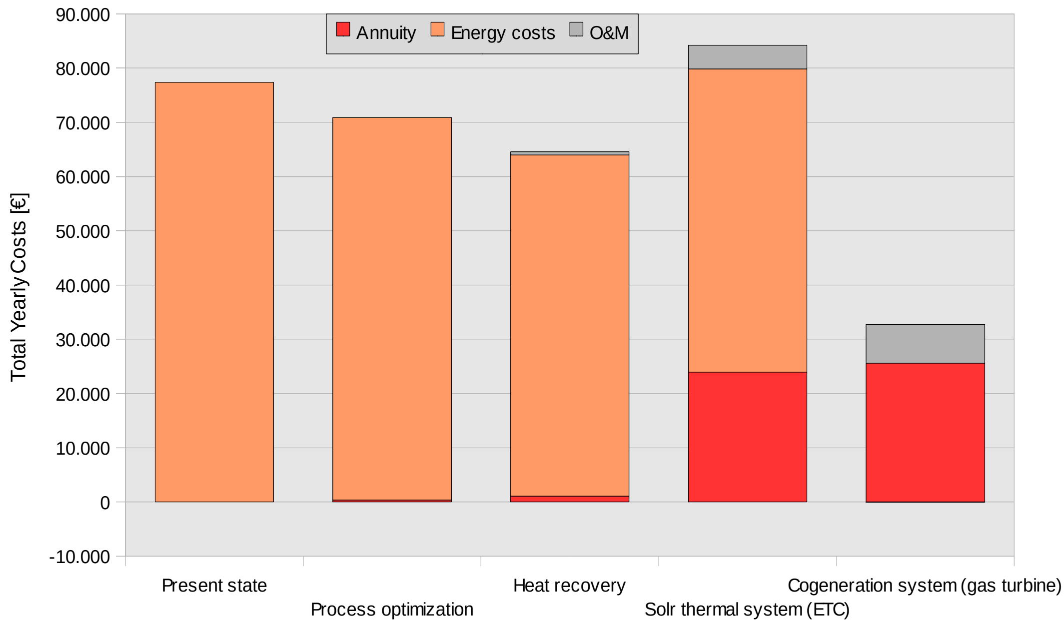

Figure 5. Comparative study: annual costs including annuity of initial investment. The energy cost for CHP includes also the feed-in-tariff revenue for the CHP electricity. O&M costs include the O&M equipments costs.

2 The tariffs used are 30 €/MWh (based on lower calorific value – LCV) for natural gas, 120 €/MWh for electricity consumed and 145 €/MWh for electricity exported to the grid.
3 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 "CHP gas turbine" that combines a process optimization, a customized heat exchanger and a cogenerative gas turbine of 200 kWe / 375 kWth has been considered the best option among the previously analysed due to the high potential of both primary energy and energy cost savings.

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

4.1.1. Process optimisation

The expansion process requires an initial preheating of the block chamber. The internal temperature of the chamber must achieve a temperature of 70ºC before the EPS beads enter. Currently, the pre-heating is achieved through the injection of steam at 1,5 bars and 112ºC. The preheating must be done for each cycle since the chamber is always cooled down after the expansion.

During the visit it was seen that every time the doors were opened, large quantities of steam escaped. Therefore, it is suggested to find another mechanism for the preheating. A possibility consists of heating the walls of the chamber using hot water generated in a heat exchanger instead of steam.

By process optimization, the potential reduction of the overall primary energy consumption of the plant is estimated to around 10%, as seen in the first alternative of Table 2.

4.1.2. Heat recovery

Currently the exhaust gas of combustion in the boiler is lost to the ambient at a high temperature. Installing a heat exchanger that uses the energy content of the exhaust gas to heat up the boiler feed water, 37 MWh would be recovered in one year, which corresponds to the 10% of the total consumption of the plant.

Table 5. List of heat exchangers proposed.

HX1	26	Exhaust gas from boiler	Water inlet of the boielr	**36**

4.1.3. Heat and Cold Supply

In the new system proposed, a cogeneration plant (gas turbine) is added to the heat supply system. The CHP plant can feed heat into the existing steam network via a steam generator using the exhaust gas of the turbine.

Table 6. Heat and cooling supply equipments and contribution to total supply (USH and USC). Selected alternative. The new equipment is marked in bold.

Equipment	Type	Nominal capacity [kW]
CHP	**CHP gas turbine**	**375**
Boiler	Steam boiler	2.372
Net water	Net water	700
Total		**3.447**

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

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

Prameter	Units	Technical data
Equipment type	-	CHP turbina de gas
Nominal power (heat output)	kW	375,00
Thermal conversion efficiency		0,60
Fuel Type	-	Natural gas
Fuel consumption (nominal)	kg/h	50,30
Electrical power generated	kW	200,00
Electrical conversion efficiency	-	0,32

The contribution of the CHP plant to the total heat and cold supply is shown in Table 8 and Figure 6.

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

Equipment	Type	Nominal capacity	Contribution to total heat/cooling supply (USH)	
		[kW]	[MWh]	[%]
CHP	CHP gas turbine	375	1.031	86,00
Boiler	Steam boiler	2.372	169	14,00
Total		**2.747**	**1.200**	**100**

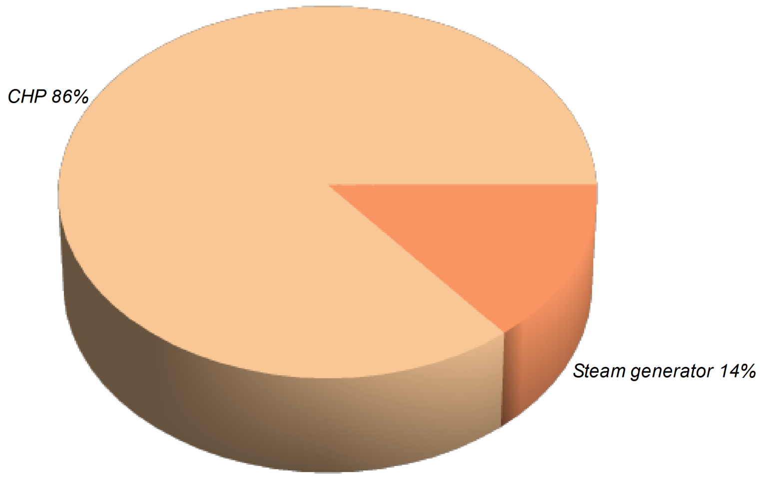

Figure 6. Contribution of the different equipments to the total useful heat supply (USH) in the company.

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

The following measures are proposed:

- optimisation of preheating of the expansion chamber: preheat the chamber by use of hot water instead the direct injection of steam
- heat recovery: use of exhaust gas of the boiler for preheating of the boiler feed water
- cogeneration (gas turbine) for covering the base load of the remaining heat demand

These measures allow for saving of 55 % of the current primary energy consumption and 57,7 % of saving of current energy system cost. The required investment is about 266.000 € with a pay-back time of 3,6 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*	*2.537*	*1.132*	*55,38%*
- fuels	*MWh*	-	-	*-16,00%*
- electricity	*MWh*	-	-	*295,70%*
Primary energy saving due to renewable energy	*MWh*	-	*0*	-
CO_2 emissions	t/a	*540*	*320*	*40,74%*
Annual energy system cost (2)	*EUR*	*77.377*	*32.729*	*57,70%*
Total investment costs (3)	*EUR*	-	*266.000*	-
Payback period (4)	*years*	-	*3,6*	-

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