C.C.E.

Centro para a Conservação de Energia

THE COGENERATION IN PORTUGAL

by

Engº João de Jesus Ferreira

Engº João Paulo Calau

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THE COGENERATION IN PORTUGAL

1- INTRODUCTION

Even though there was a considerable interest from the economic agents, within the period of 1975-1980, the implantation of cogeneration technology in Portugal has been slow. This fact cannot be blamed alone on the low energy prices practiced in the international market since 1986. Other elements such as the lack of technical knowledge and information, high financial costs associated to the initial investment and the lack of legislative orientation can be blamed for the small headway.

If the mentioned barriers, namely the low costs of energy, are on their own (and in the present conjuncture) sufficient to prevent a higher rhythm in the penetration of the cogeneration, the same can not be true if restrictions to environmental atmospheric emissions are considered. Those restrictions can contribute to the development and higher use of more efficient energetic technologies, namely cogeneration.

In this context, it is the aim of this paper to present a short analysis of the cogeneration systems in Portugal, according to the guidelines of the Portuguese energy policy. This analysis follows the existing legislation which has implications within the promotion and support for the development of the cogeneration systems in Portugal.

COGENERATION SYSTEMS IN PORTUGAL

(Evolution of the installed power)

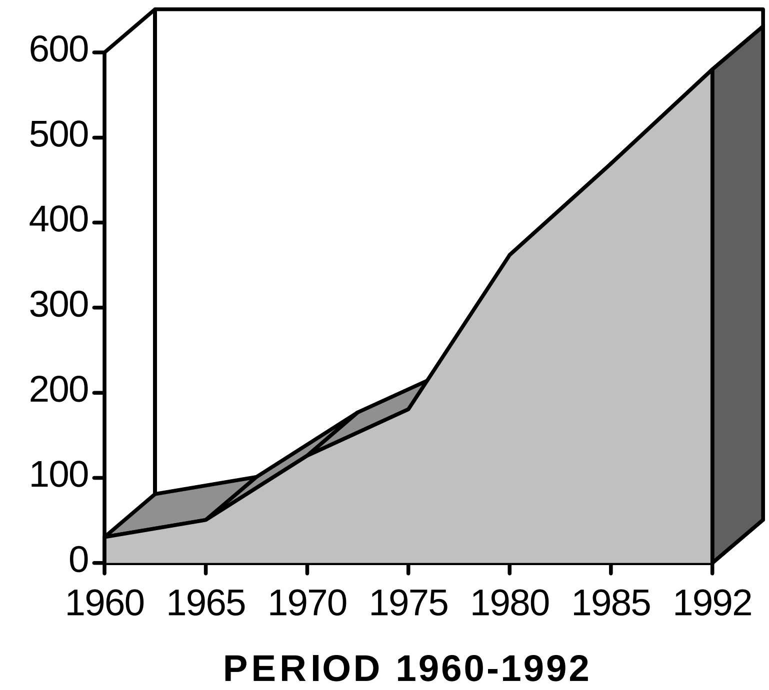

Figure 1- Evolution of the installed power

2 - THE COGENERATION IN PORTUGAL (PRESENT SITUATION)

The Portuguese energetic situation is characterised by a high external dependency (90% of the primary energy consumed is imported), strong oil dependency (70% of the total consumption of primary energy) and also by a high energetic intensity of the productive sector (energy intensity of the Gross Domestic Product = 600 TOE/MECU(85).

Taking into consideration the estated facts, it becomes obvious that the promotion and development of efficient energy technologies, in wich cogeneration has an important role to play, is the way.

In Portugal, in the last 15 years the evolution of the cogeneration installed power has registered an important increase (figure 1), and in 1992 about **580 MW** of installed power **(7,5% of total installed power)** is responsible for the production of approximately **1750 GWh/year**. This production represents **7% of the total consumed electrical energy in Portugal**.

It is safe to say that the penetration of cogeneration technology started in 1923, basically in textile industry, using technology systems with condensation turbines. With the evolution of this process, other technologies started to be used, according to the specific characteristics of each consumer. In 1992 the installed power, in Portugal, was distributed through different technologies as can be seen in figure 2.

COGENERATION TECHNOLOGIES

(Installed Power)

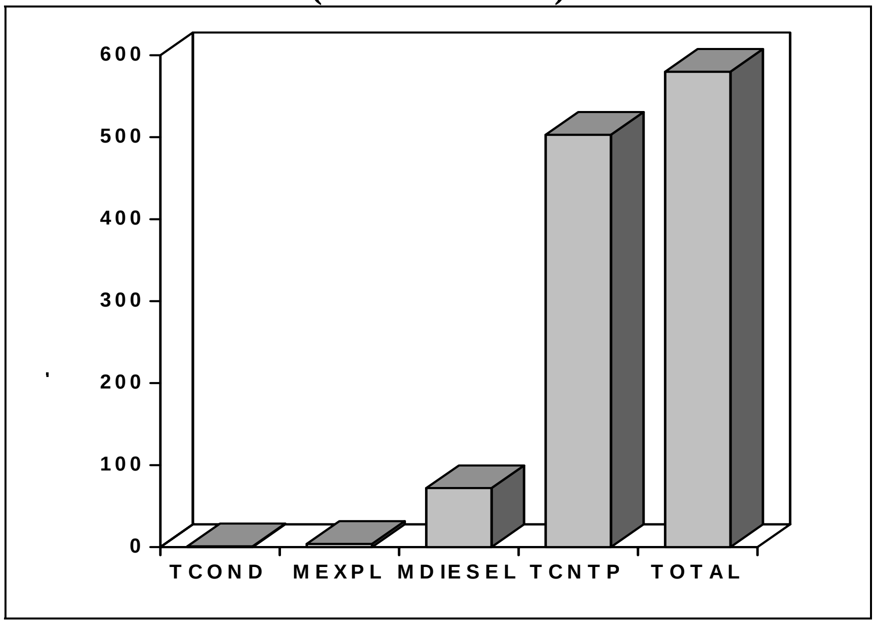

Figure 2: Installed power VS technologies

Backpressure turbines **(503 MW)** and the Diesel engines **(72 MW)** have a considerable lead. The use of explosion engine **(2.6 MW)** can be seen specially with biogas produced in cattle exploration.

Presently, 85 cogeneration plants are distributed among the different economic sectors as can be observed on table I.

As you can see, the higher values for installed power are in Paper and Chimical industries

TABLE I

Activity sector Vs Technologies

ACTIVITY	M.DIESEL	M.EXPLOS	T.CNTP	T.COND	T.GAS	TOTAL
AGRICULTURE	-	14	-	-	-	**14**
FOOD	1	4	2	-	-	**7**
TEXTILE	4	-	5	1	-	**10**
WOOD AND CORK	1	-	1	-	-	**2**
PAPER	5	-	23	-	-	**28**
CHIMIC	1	-	15	1	-	**17**
CERAMIC AND GLASS	2	-	-	-	-	**2**
ELECTRICITY, GAS AND STEAM	-	1	-	-	-	**1**
METALLURGY	-	-	1	-	-	**1**
HOTELS	-	2	-	-	-	**2**
SERVICES	-	1	-	-	-	**1**
TOTAL	**14**	**22**	**47**	**2**	**-**	**85**

Source: General Directorate for Energy (DGE)

Fuel-oil, biogas, LPG and some industrial waste are the most common combustibles utilised in these 85 systems. Table II shows the distribution of fuel used by the different technologies.

It is safe to say that the introduction of natural gas is likely to have a greater impact in the new cogeneration systems and possibily substituting fuel-oil in existing plants.

No references were made to the cogeneration plants using gas turbines or the principle of the combined cycle. These technologies might be considered with the introduction of natural gas.

TABLE II

Fuel vs Technology

FUEL	M.DIESEL	M.EXPLOS	T.CNTP	T.COND	T.GAS	TOTAL
HEAVY FUEL	14	-	24	1	-	**39**
BIOGAS	-	17	-	-	-	**17**
IND.RESID.	-	-	17	1	-	**18**
SOLID.COMB.	-	-	2	-	-	**2**
WOOD RESID.	-	-	4	-	-	**4**
LPG	-	5	-	-	-	**5**
TOTAL	**14**	**22**	**47**	**2**	**-**	**85**

Source: General Directorate for Energy (DGE)

2.1 - Legal framework

One of the objectives of the Portuguese Government's energy policy is the encouragement of cogeneration plants in order to use energy in a rational and efficient way. So, legislation has been made to support and promote cogeneration.

The EDICT nº 189/88 - May 27 guarantees the electric energy auto-producer that EDP will buy the energy and settle the technical conditions and the convenient prices. All this is very convenient to the independent producer, specially to those utilising cogeneration, because, in this cases there is no limit to installed power.

2.2 - Technico-economic framework

The interest of the economic agents to invest or not in cogeneration projects depends on the good returns on the investment.

In this chapter, we try to present a picture of the Portuguese cogeneration projects, from the techno-economic perspective.

The model used is based on the calculation parameters of the Portuguese reality and the technologies most common in Portugal.

For the definition of the present model, we have considered the following aspects:

* Investment per kW
* Life cycle
* Fuel price 1992
* Electric energy tariffs
* EDP conditions for the purchasing of energy
* Maintenance costs
* Investment pay-off
* Electric and thermal efficiency

The following basic references were also taken into consideration:

* Medium voltage Consumers

* Sale of electric energy to the public grid line in high voltage (medium utilisation) according to Portuguese law. To simplify the model, the medium value estimated is 10 PTE/kWh.

* Imputation of the global investment to the electrical component considering that in most cases the investment associated to the thermal component is irrelevant.

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Having in mind the used calculation parameters, the results of this model are shown in figures 3 and 4.

Figure 3 shows the annual debt of exploration (fixed costs and variable costs) of the various technologies comparing them to the purchasing cost of the electric energy in medium voltage and the sale price of auto-production (10PTE/kWh, average value)

COGENERATION TECHNOLOGIES

PORTUGAL

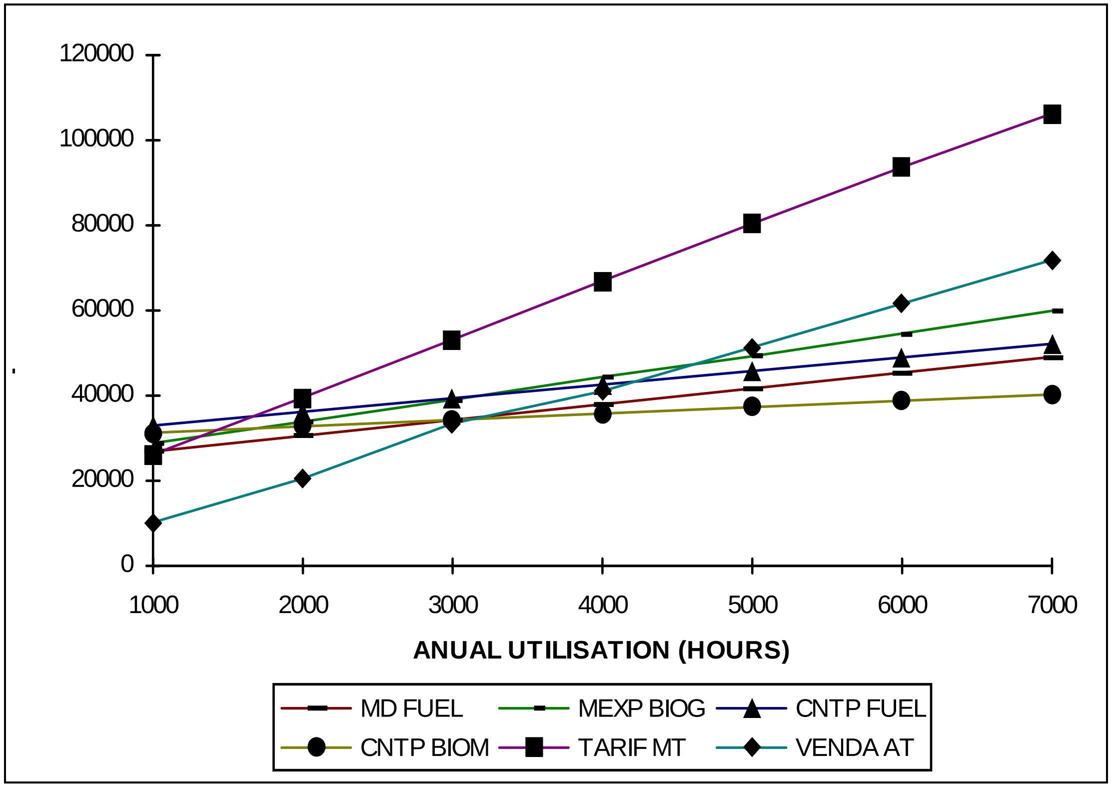

Figure 3- Annual responsibilities and annual gains of exploitation per installed kWe (average values)

Figure 4 shows the results of this model for the production charges per kWh (fixed costs and variable costs) of the various technologies, and compares them with the price of purchase kWh in an medium voltage and with the value of sale of the auto-production.

COGENERATION TECHNOLOGIES

PORTUGAL

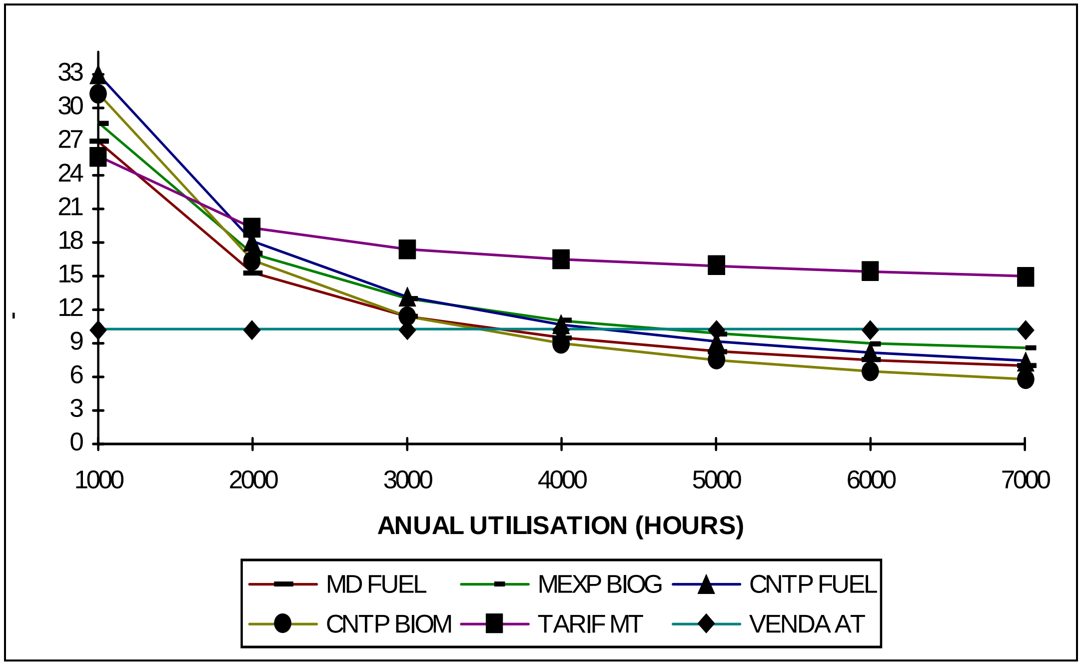

Figure 4-responsibilities and annual gains of exploitation per electrical kWh (average values)

As a result of this techno-economic analysis, the following conclusions are presented for the Portuguese case:

1) Any cogeneration technologies has duties of production of electrical energy inferior to the corresponding duties of the electric tariffs for utilisation superior to 2000 hours.

2) Electric energy sale, according to this model, only becomes attractive in the following utilisation and technologies:

* Diesel engines - for utilisations superior to 3500 hours.

* Backpressure steam turbines (using industrial wastes-biomass) - for utilisations superior to 3500 hours.

* Backpressure steam turbines (utilising fuel-oil)-for utilisations superior to 4000 hours.

* Explosion engines (utilizing biogas)-for utilisations superior to 5000 hours.

3) Considering the valorization of the heat produced, the presented values will decrease making the cogeneration even more atractive.

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2.3 - Environmental Aspects

Considering any of the above technologies, and in accordance with the present analysis, heavy fuel (3.5%), coal and biomass have greater environmental impact than most favourable gaseous fuels and fuel-oil of low sulphur content.

From the point of view of the technologies, one can conclude that Explosion Engines and Gas Turbines are the two Cogeneration Systems less polluents, followed by the Diesel Engines and Back-pressure steam turbines.

TABLE IV

Pollutant emissions

FUEL	Pollutant	CNTP	T.Cond.	M.Diesel	M.Exp.	T.Gás
Heavy Fuel 1%	Part.	1	1	3		1
	SO2	2	3	2		2
	NOx	2	3	3		2
	CO2	2	3	2		2
	CO	1	1	2		2
Heavy Fuel 3,5%	Part.	1	1	3		1
	SO2	4	5	4		4
	NOx	2	3	3		2
	CO2	2	3	2		2
	CO	1	1	2		2
LPG	Part.	0	0	1	1	1
	SO2	0	0	0	0	0
	NOx	1	1	1	2	1
	CO2	2	3	2	2	2
	CO	1	1	1	2	1
Coal	Part.	4	5			
	SO2	2	2			
	NOx	4	5			
	CO2	3	4			
	CO	1	1			

Source: CCE

TABLE V

Pollutant emissions

Fuel	Pollutant	CNTP	T.Cond.	M.Diesel	M.Exp.	T.Gás
Natural Gas	Part.	0	0	1	1	0
	SO2	0	0	0	0	0
	NOx	1	1	1	2	2
	CO2	2	3	2	2	2
	CO	1	1	1	2	2
Biomass	Part.	2	2			
	SO2	0	0			
	NOx	1	1			
	CO2	3	5			
	CO	4	5			
Biogas	Part.	1	1	1	1	
	SO2	0	0	0	0	
	NOx	1	1	1	2	
	CO2	3	4	3	3	
	CO	1	1	2	2	

Source: CCE

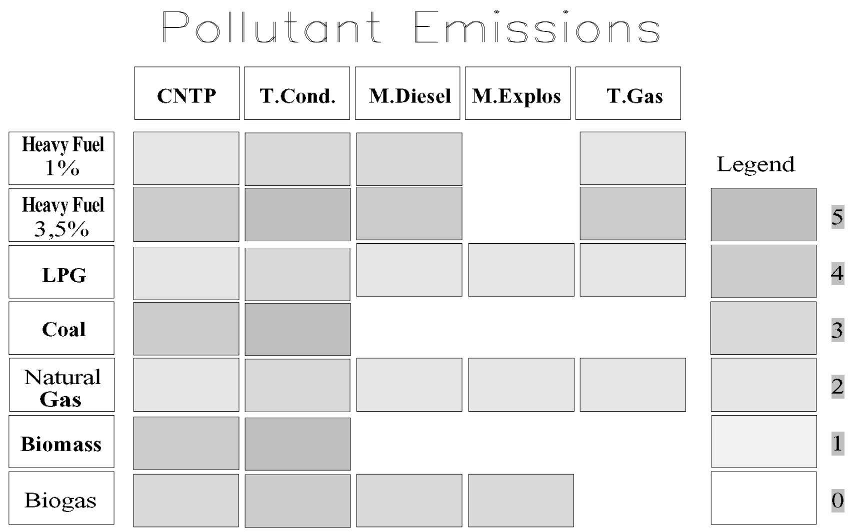

Figure 5-Pollutant emissions

3-CONCLUSION

From this short analysis, and considering the knowledge of the Portuguese reality, we conclude that the perspectives of cogeneration in Portugal are highly favourable.

The advantages of cogeneration in Portugal are evident at the macro-economic level as well as micro-economic level.

As far as the macro-economic level is considered, the advantages are clearly seen when one considers the reduction in fossil fuel consumption for the production of the same quantities in electrical energy. In the second level, those advantages are emphasised by the reduction of the energy bills paid by the consumer.

The introduction of natural gas will enlarge investments in cogeneration with aditional benefits such as:

* minor maintenance responsibilities
* minor pollutant emissions
* broader possibilities of applicable technologies such as gas turbines and Combined cycle

Generally, and summarily, it can be concluded that cogeneration is one solution to consider and to implement in all main sectors of economic activity in Portugal.

ANNEX 1

* CALCULATION PARAMETERS UTILIZED *

FUEL CHARACTERISTICS

FUEL	PCI (MJ/Unid.)	PRICE
HEAVY FUEL (3,5%) [kg]	40,57	28$00
BIOMASS		
Wood Residuals [kg]	10,49-12,9	3$50
Cork Powder [kg]	18,8	6$00
Solid Combustibles [kg]	14,6	7$00
BIOGAS [Nm^3]	21,77	15$00*

* Biodigestor Amortization