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CHP FUNCTIONALITY IN THE CASE OF ENERGY MARKET TENDENCIES

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In order to better understand the steps that a heat and power producer (CHP) have to follow to achieve a good efficiency, and thereby to maximize the net income, the authors have realized a study on the potential of the existing equipments on the market, to respond at the legislation conditions. In this paper the study is dedicated to the Gas Turbines used to create configurations for small and medium CHP, and the results have been checked using the thermal modeling program, GateCycle 6.00 from GE.

Keywords: Combined Heat and Power, Energy Market, efficiency, Gas Turbines

1. Introduction

The diminishing of the available conventional primary resources led to a wasteful consumption, and to the exploration of new energy production sources, more environmentally friendly. One of the solutions found currently is the cogeneration of the two forms of energy, electricity and heat from the same fuel.

Because the trend is to pass from the centralized production to the decentralized generation of energy, in order to reduce the transportation losses, one of the most discussed sources of energy is the small and medium CHP plant used in the tertiary sector. In this sense the Romanian authorities have adopted and implemented the European directives into national legislation, creating a series of restrictions and benefits for the combined heat and power producers.

In brief, national legislation provides a “bonus” for each electricity unit produced in High Efficiency Cogeneration (HCHP), delivered in the National Grid, and sold on the competitive market, if the comparative fuel economy with the separate generation is higher than 10 % [1]. There is also a second condition to be achieved by the CHP source: the global efficiency has to be higher than 75% for the produced power measured at the generator clamps [2].

The budget for the bonus is 4.103.048.758 €, for the period 2010-2023 and its value for each year can be seen in the table 1. The maximum number of years

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in which a HCHP producer can receive the Bonus (B), is limited to 11 years of functionality [3].

Table 1

Budget Repartition, for the HCHP producers, for the period 2010-2023

Year	*Value [€]*	*Year*	*Value [€]*
2010	156.965.962	2017	356.260.424
2011	263.520.526	2018	331.501.898
2012	363.997.831	2019	306.807.959
2013	458.566.513	2020	282.009.402
2014	432.228.153	2021	187.493.253
2015	406.426.424	2022	119.295.493
2016	381.185.719	2023	56.789.532
Total			**4.103.048.758**

The low is providing a decreasing trend of the B value and an ascending one for the thermal energy price. [4]

In order to realize the two objectives mentioned above, an investor in a CHP plant has to be sure about the configuration's Gas Turbines (GT) that its parameters will led to the mentioned efficiency and the fuel consumption economy.

The aim of this article is to offer an overview of the existing GT on the market, to create a HCHP system.

2. Methodology

A data base of Gas Turbines was created from different sources [5-8]. The parameters from the manufacturers are shown in the table 2:

Table 2.

GT entry data, from different manufactures, for the case study

Parameters	*Abbreviation*	*Unit of measurement*
Electrical Power	P_e	kW_e
Heat rate	b	kJ/kWh
Exhaust Gas flow	F_{gex}	Kg/s
Electric efficiency	$\eta_{e,cog}$	%
Lowe Heating Value	LHV	kJ/kg
Inlet Air flow	F_{air}	Kg/s

The data base was completed with 225 Gas Turbines, with an Electric Power between 504 kW and 50836 kW.

In order to simplify the first set of calculation, some hypotheses have been made:

- The specific heat at constant pressure was consider de same for the two gases of the thermal cycle: cp air = cp gas=1 kJ/kgK;
- Efficiency in the case of the recovery heat exchanger for the exhaust gases, was considered to be β= 0.8;

Starting from the above hypotheses and using simple thermal equations, the following properties were calculated (table 3):

Table 3.

Calculated GT parameters

Properties	*Abbreviation*	*Unit of measurement*
Fuel consumption	B_s	Kg/s
Fuel thermal power	P_{FP}	kW_t
Thermal losses due to the exhaust gases	$P_{Th\ exg}$	kW_t
Thermal power recovered from $P_{Th\ exg}$	$P_{Th\ rec}$	kW_t
Internal GT powe	P_{IGT}	kW
Thermal Efficiency	$\eta_{t,\ cog}$	%
Global Efficiency	η_{gl}	%
Power to Heat Ratio	y	%
Fuel economy	EEP	%

The fuel economy is calculated according to the ANRE (National Authority of the Energy Market) formula:

$$EEP_k = \left(1 - \frac{1}{\frac{\eta_{t,cog,k}}{\eta_{t,\mathrm{Ref},k}} + \frac{\eta_{e,cog,k}}{(\eta_{e,\mathrm{Ref},k} + 0{,}005) * p_{pierdevit}}}\right) * 100 \quad (1)$$

The CHP configuration was considered of simple heat recover, without steam production. (fig 1).

Some interpretation of the calculation results can be seen in the Figs. 2 and 3. The results show that from the 225 analysed GT, 183 can be part of HCHP configuration and only 42 can create simple CHP plants.

In Fig. 2, is illustrated the variation of the GT potential to form HCHP plants, when we take in to consideration the exhaust gases temperature.

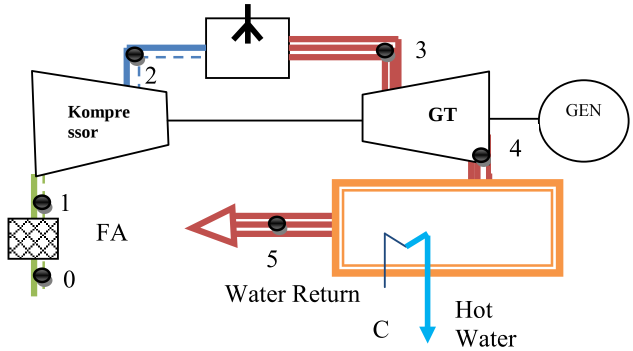

Fig 1. Configuration of the HCHP using only heat recovery hot water generator

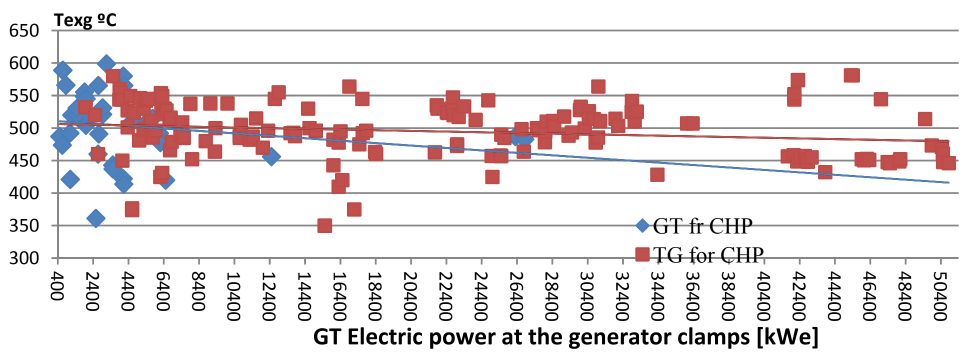

Fig.2. The GT potential to create a HCHP configuration, depending on the exhaust gas temperature and the electric power of each one

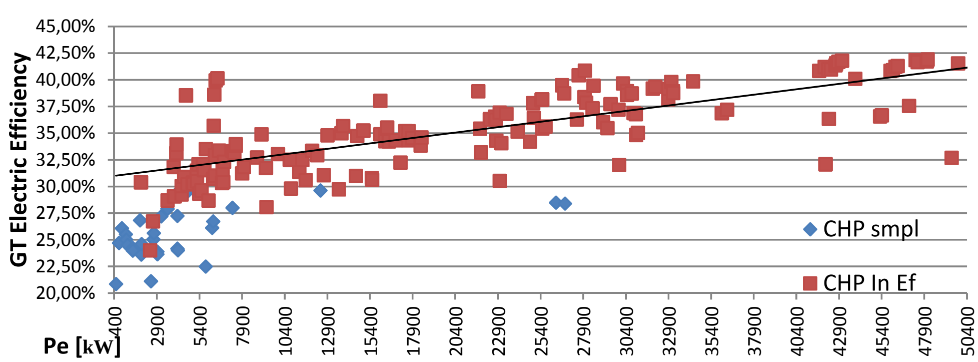

Fig.3. The GT potential to create a HCHP configuration, depending on the electric efficiency and the electric power of each one

This comparison between the 225 analysed GT was reported at the Gas Turbines electrical power at the generator clamps.

Considering de fact that 81,33% of the market GT have the thermal potential to realise a HCHP by fulfil concomitantly the Energy Market demands, and that only 18,67% cannot be part of this type of configuration, we can affirm that a potential investor in combined heat and power plant have a large scale of gas turbines from where he can choose the appropriate equipment to implement a solution that can benefit from Bonus.

A more delicate problem seems to be for the small HCHP, with an electric power from 500 kW to 7 MW and where the electric efficiency is the key indicator, as we can see in Fig 3.

For an electric efficiency under 27%, there are very small chances to find GT proper to create a HCHP system.

The principal conclusion that can be taking from these results is that for a GT that is supposed to function as a high efficient combined heat and power plant, two characteristics are very important:

- The exhaust gas temperature has to be higher than 450 ◦C;
- The minimum electric efficiency has to be higher than 30 %.

Verification of the calculated results was made using the thermal modelling software, GateCycle 6.04. The HCHP configuration was realized for simple heat recovery hot water generator (the heat exchanger from the figure below Fig. 4).

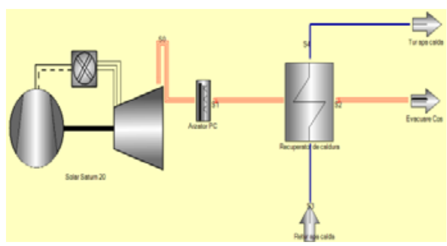

Fig.4. HCHP configuration in GateCycle program[8]

The duct burner from the schema was bypassed thanks to a calculation method option from the program (Fig. 5).

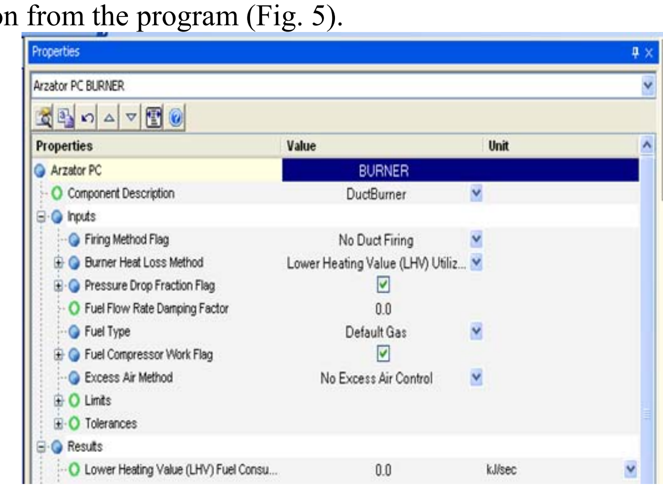

Fig.5. Bypass of the Duct Burner for the post combustion

In the verification model were used GT from GE library, similar to the analysed market GT.

Using a similar heat exchanger effectiveness with the one supposed in the main study, the results war very close and show a relative error < 2%

6. Conclusions

The study is useful for power utilities, respectively for power & heat producer's staffs, facilitating them to choose the proper CHP technologies and equipments, and predicting the technical HCHP energy flows balance, for improving the cost-effective flows, by benefiting from the HCHP bonus.

The Bonus, being a support offered by the legislation, to the CHP of high efficiency producers, they can obtained a more rapid return on investment and so a higher profit. At the same time more investments will be made in these technologies, the efficient gas turbines will be more developed on the market, this way their price will go down and the circuit will be restarted.

The final beneficiary of all this, will be the environment, the HCHP technologies leading to a less polluting way of producing energy and to a proper future, a sustainable development.

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