THE USE OF NATURAL GAS IN MOTRIZ POWER HAVING AS PARAMETER THE RELATIONSHIP BETWEEN PRICE OF ELECTRICITY AND GAS.

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Abstract. *This work aims to compare the advantages of the local generation/cogeneration using a natural gas internal combustion engine to generate/cogeneration from a thermo electrical power plant that should be installed in the axis of a gas pipeline that will feed an electric motor in the same place. This analysis scopes is restricted of the point of supply of the gas for the generation of electricity to the point of final use, being that electricity transmitted at the same distance that the necessary for the transport of the natural gas, when that is the final energy. In many of those applications the electric motor can be substituted by the natural gas combustion engines. The rate between price of natural gas and the price of the electric power in Brazil presents a larger value in relation to the practiced at other countries, which even certain point obstruct the substitution of the electric motor. The study presents the substitution viability for values where the relationship among the price of the* cubic meter *of natural gas and at price of the electric kWh it is inside of values that can be calculated with a larger use exegetics of the natural gas internal combustion engine. The calculations presented in the economic analysis take in account the exergetics exploitation of the system.*

Keywords: *electric motor, natural gas engine, generation, exergy, motor power.*

1. INTRODUCTION

To obtain useful energy, power, you can have the option to use natural gas as energy final. One of these transformations, for example, is performed with the internal combustion engine. This work aims to compare the benefits of the local generation / cogeneration combustion engine using natural gas with generation / cogeneration of a thermo electrical power that must be installed on the axis of a pipeline, which feeds an electric motor in the same place. The part of the analysis is restricted to the point of supply of gas to generate electricity to the point of end use, and that electricity sent to the same distance that needed to transport of gas natural when this is the final energy. Most drives come from the power of mechanical energy transmitted by the electric motor. With the advent of electricity, at the end of the XXI century, and created with easy access to such energy, with technological developments in electric motors, it became possible to demand, increasingly growing in the drive machinery by means of electromechanical equipment. By the end of the XIX century, the drive of rotating machinery was done by external combustion engines, the steam machine, in this case using a mechanism for transforming the reciprocating motion into circular. Even before the advent of the electric motor it was used the internal combustion engine in the drive of various machines, the French chemist, Abbe d'Hautefeuille used gunpowder in the seventeenth century, as fuel to drive a piston, which moved through a cylinder could act as driving force (MEINCK, 1996). The price of electricity, the capacity of national hydropower exploitation and dissemination of technology among many Brazilian electric motors manufacturers helped set their framework of using until the beginning of the XXI century. In recent years, with the challenge of diversifying the national energy matrix and the increase in supply of natural gas, it is necessary to search for alternatives, and not using it for generating electricity, helping in a practical and economic way the driving engine in the various sectors of consumption.

The combustion engine performs the same functions of the electric motor, or provide work to the shaft for use in various processes, trigger a pump, a compressor, a generator, a fan, etc.. In many applications of the electric motor can be replaced by a natural gas combustion engine. This replacement will depend on a number of factors, ranging from the possibility of access to fuel, to a scale of manufacturing for the insertion of national manufacturers of stationary engines that operate with natural gas, mainly from small and medium businesses. After XX century, with the spread of cogeneration systems, internal combustion engines have added their characteristics the possibility of recovery of heat rejected in the thermodynamic process. The objective of this study is to compare the use of electric motors with internal combustion engines to natural gas in end use of power to drive a machine, such as a centrifugal pump or a fan. To achieve this goal the following aspects are studied, important, to the development of work: 1. Are assessed on the impacts of primary resource on the environment and the transport of electricity and natural gas, when replacing the final energy, electricity, natural gas is made to drive a driving machine. 2. The feasibility of replacing the economic point of view for the consumer. 3. Study of the use of exhaust gas and the cooling circuit of the engine combustion, using as a tool for analyzing the principle of exergue, complemented by economic analysis of investment. For purposes of comparison is used the parameter that takes into account the ratio or relationship between the price of natural gas and the price of electric energy along a particular case. The ratio between the price of natural gas and the price of electricity in Brazil presents a higher value on the practice in other countries. In a survey done by the author between the price of cubic meter of natural gas and electric price of kWh in the residential and industrial sectors, it was a great relationship between the first and second for the charges in Brazil.

2. THE ELETRIC MOTORS

In most industrial processes, commercial and agricultural, use the power to drive the machinery necessary to carry out various tasks. Much of this power comes from the electric motor, which transforms electrical energy into mechanical energy, making it available on the axle to drive other machines. The electric motors, due to its versatility, construction, maintenance, installation and easy access to the source of energy, the electricity available in all industrial and commercial items, present wide application in the transfer of energy and great use in the modern world. It is considered in this case, as internal combustion engines, the Otto cycle engines, diesel cycle and gas turbines.This acceptance has made the electric motor the more used one in the world. Among the most interesting machines, are driven by electric motor: a centrifugal pump, the compressor, the fan, the industrial mill, etc. One of the characteristics of electric motors is the fact that to maintain constant speed depending on the number of poles of the winding and the frequency of the line.

3. THE INTERNAL COMBUSTION ENGINE IN NATURAL GAS

Many manufacturers and research groups have been improving the use of internal combustion engine to natural gas. Figure 1 shows the scope of the possible equipment of machines driven flow that can operate with natural gas, and compared in terms of turnover and cost of power to 8000,0 kW, which is the power in development for the largest combustion engines working with domestic natural gas (WÄRTISILÄ, 2005). This improvement is provided to call Ottorização, which is the adaptation of internal combustion engines Otto-cycle, used in road vehicles to small and medium sized stationary engines to natural gas, to adapt to larger engines (Diesel cycle), also transformed into a stationary gas engines. Currently, over a range of different manufacturers of power, internal combustion engines to natural gas can cover a wide range of power, ranging from 1,0 HP to 8000,0 HP.

3.1 THE USE OF HEAT OF THE COMBUSTION ENGINE IN THE COGERATION

Internal combustion engine to natural gas has already being used widely in automotive industry, replacing benefits with internal combustion engines Otto-cycle gasoline and in many cases also of Diesel cycle. For use in stationary engines, it has given preference to natural gas as main fuel, due to a number of factors, such as: the significant amount of reserves in the world, the technology relatively simple to obtain and distribution, mainly to low emission of harmful gases to the environment in the controlled use of this technology, especially the NOx and CO2 (CEPEL, 2001). The Waukesha Engine manufacturer has two ways of harnessing the heat generated by a combustion engine to natural gas. The first, individual, where the three possible sources of recovery of heat rejected by the engine, the exhaust gases, water-cooling and oil lubrication can be used individually. In this case, it will need a recuperator or heat exchanger for each of the sources. This condition can be seen in Fig. 1, and can provide greater flexibility to use the user, giving a lower overall yield.

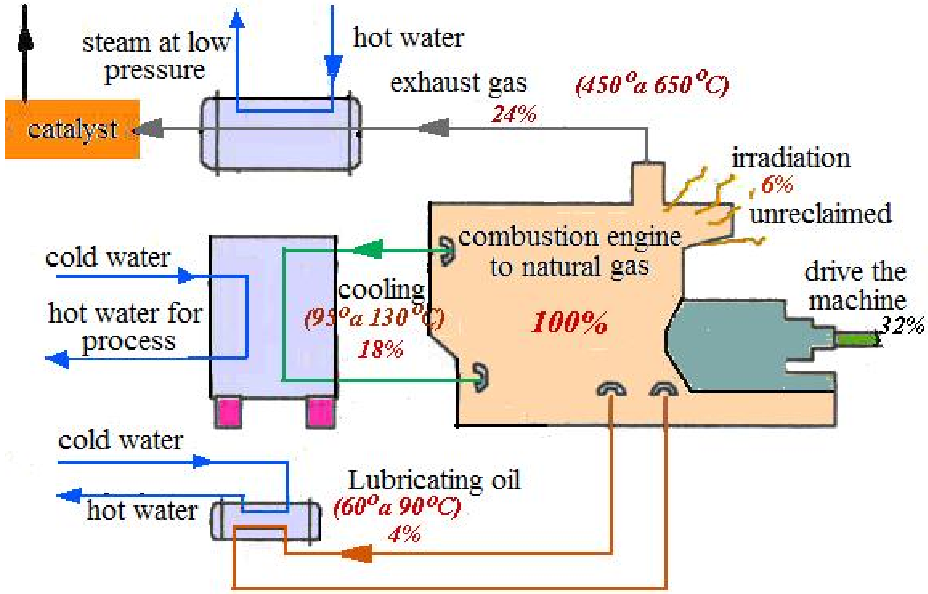

Figura 1 Recovery of heat rejected in an internal combustion engine.
Adapted from: WAUKESHA ENGINE, 2003.

The second case, where the heat rejected from sources besides food retrieval for each source is used in a single final heat recuperator, which concentrates all final heat for later use. This case is also called the effect "looping" and can be seen in Fig. 2.

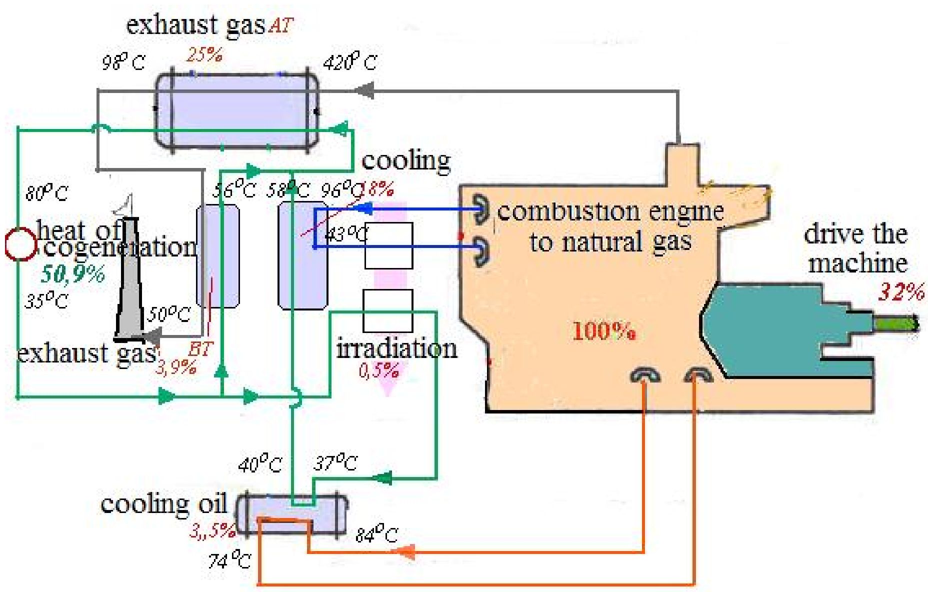

Figure 2 Use of the heat rejected using the looping effect.
Adapted from: WAUKESHA ENGINE, 2003. 4.

4. COMPARISON OF GENERATION AND THE GENEARTION OF LOCAL THERMOELECTRIC

Next, it has presented an analysis of the consumption of natural gas for local use of an internal combustion engine of 1000 kW compared with the generation of electricity in a power with the gas turbine that provides energy to an electric motor in the same location (Fig. 3). In this first case it was computed only for generating electricity from a thermal power plant with natural gas combined cycle with a yield of 40% (STRAPASSON, 2004).

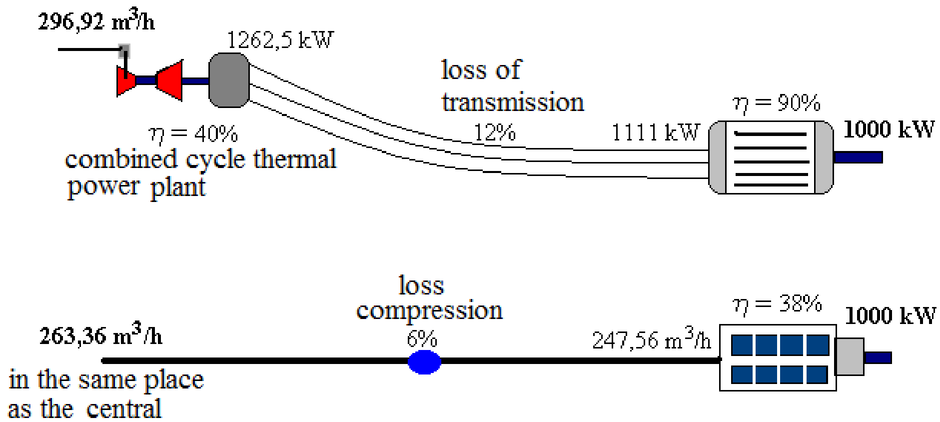

Figure 3 Food and local generation of power away from the center of consumption.
Source: Mello Jr (2006)

It can also consider the use of waste heat from internal combustion engine, as shown in Fig. 4.

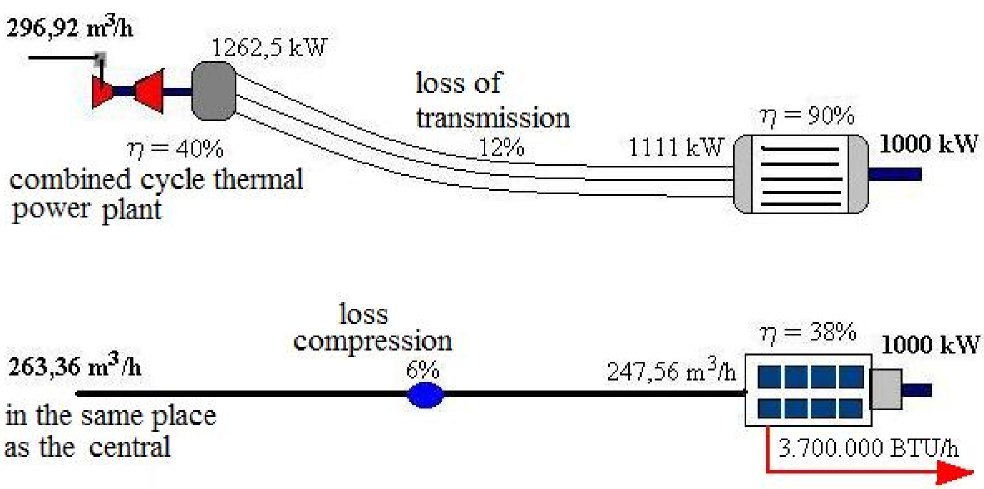

Figure 4 Power and local generation of electricity consumption away from the center with the possibility of cogeneration.
Source: Mello Jr (2006)

Table 1. The main characteristics of internal combustion engines to natural gas. Source: NREL, 2003. Adapted by the author. Used 1US $ = R $ 1.70

Nominal capacity	100,0 kW	300,0 kW	1000,0 kW	3000,0 kW	**5000,0 kW**
Type of combustion	Rich	Poor	Poor	Poor	**Poor**
Eletrical efficiency (%) PCA	30,0	31,0	34,0	35,0	**37,0**
Mechanical efficiency (generador 94%) (%)	31,9	32,9	36,1	37,2	**39,3**
Consuption of gás MMBTU/h (m^3/h)	1,15 (30,82)	3,29 (88,172)	10,05 (269,34)	29,1 (779,88)	**46,1 (1234,50)**
Rotation of the motor shaft (rpm)	1800,0	1800,0	1200,0	900,0	**720,0**
Cost motor generator installation (R$/kW)	1.400,00	1.200,00	820,00	820,00	**800,00**
Cost motor generator installation maintenance(R$/kW)	0,03	0,92	0,015	0,015	**0,012**
Gas pressure required (psi)	< 3	18	3 - 43	43	**65**
Noise (dB)	60,0 – 70,0	60,0 – 75,0	65,0 – 78,0	70,0 – 80,0	**70,0 – 85,0**
Emission of CO_2 (lb/MWh)	1,35	1,28	1,18	1,14	**1,08**
Emission of NO_x (lb/MWh)	46	6,2	3,1	2,2	**1,6**
Emission of CO (lb/MWh)	**37**	**6,2**	**6,2**	**7,8**	**7,4**

5. THE CONTRAST OF THE PRICE OF NATURAL GAS

The ratio between the price of natural gas and the price of electricity in Brazil presents a higher value on the practice in other countries. In a survey done by the author between the price of cubic meter of natural gas and electric price of kWh in the residential and industrial sectors, it was a great relationship between the first and second for the charges in Brazil. The data were obtained from the International Energy Agency (IEA) released in 2007, with the data of 2005, published in Key World Energy Statistics.

Figure 5 shows the ratio between the price of natural gas and electricity tariff of some countries. It may be noted that Brazil has, along with France and Austria, the largest ratio between the two rates in the industrial sector, while Brazil still has the highest ratio in the residential sector. A high ratio shows that Brazil makes the substitution of electricity by natural gas less favorable in relation to other countries.

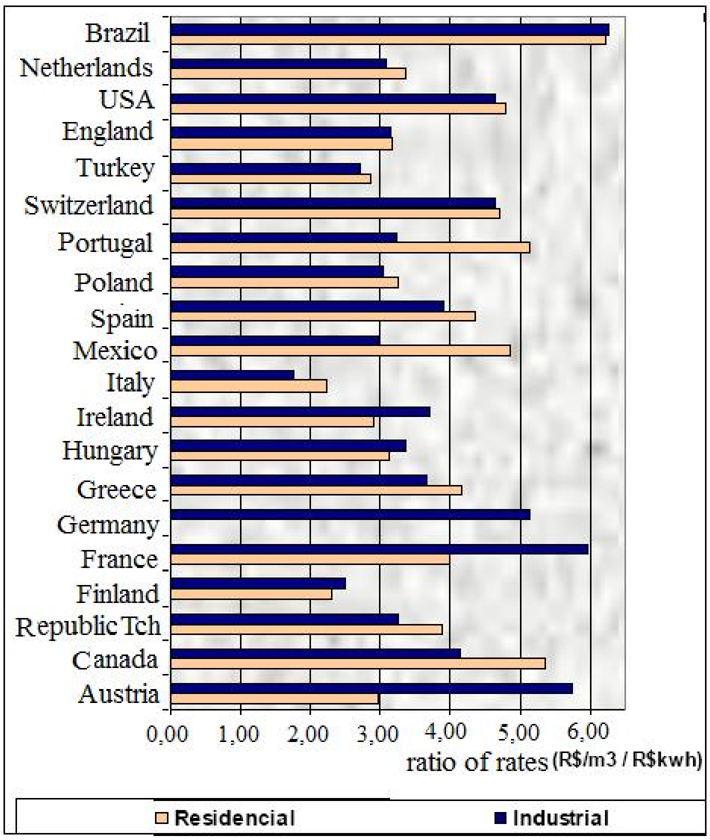

Figure 5. Ratio between the rate of gas and electricity for many countries.
Source: METROGAS, 2006. Analysis of the author.

6. CASE STUDY

The case study presented refers to the comparison of the installation of an electric motor and a combustion engine to natural gas for power of 1,000 kW and rotation of 1,200 rpm, with a utilization factor of 70%. The rate of electricity reflects the costs of consumer price in the Blue. Studies of the combustion engine with natural gas taking into account 3 alternatives: a) only in the power axis (without co-generation), b) co-generation with heat recovery of exhaust gas and c) co-generation with the use most of the exhaust gas cooling system. The recovery is based on the layout shown in Figure 1. The interest rate is 12% per month . The calculations were performed using the Excel Spreadsheet and figures can be seen in table 2.

Figure 6 shows the curves of time to return in comparison to the installation of an electric motor and a combustion engine to natural gas for the above parameters when using the power on the axis and co-generation of engine combustion.

It can be noted by examination of Fig. 6, between the lower price of natural gas and the price of electricity have time for much lower returns for replacement consideration. If still considered exergetic the use of heat for cooling and exhaust gas, the time of return becomes more appreciable for the internal combustion engine to natural gas.

Table 2. Spreadsheet for comparison between electric motor and internal combustion engine to natural gas. Source: MELLO JR, 2006.

			Eletric motor	Natural gas engine	Cogeration exhaustion	exaus.+ cool.
Factor for use of pumps			70%	70%	70%	70%
Power Firm	kW	kW	1000	1000	1000	1000
Engine performance			90%	36%	36%	36%
		kW	1.111,11	2.777,78		
Price of the engine and instalation		R$	160.000,00	585.200,00	660.000,00	690.000,00
Energy	consumed	kWhe/ano	6.813.333,33			
		kWht/ano		17.033.333,33	17.033.333,33	17.033.333,33
Energia used	(Exergia) accumulated	kJ/s			535,53	321,43
Energy Exergia		kJ/s				856,96
Exergia total		kWht/ano			3.283.888,36	5.254.866,46
Energy paid by consumers						
Demand contracted		kW	1.000,00			
Demand point 20,67	16,3	R$/kW R$	195.600,00			
Demand f. tip	2,26	R$/kW R$	27.120,00			
Energy at the tip	0,08	R$/kW R$	97.333,33			
F. energy tip.	0,11	R$/kWh R$	936.833,33			
total energy	elétrica R$		1.256.886,67			
Natural gas	consumption	m^3/ano		1.602.383,19	1.602.383,19	1.602.383,19
Anual cost of	maintenance					
Gas engine	0,006	R$/kWh R$		40.880,00	40.880,00	40.880,00
Electric motor	0,002	R$/kWh R$	13.626,67			

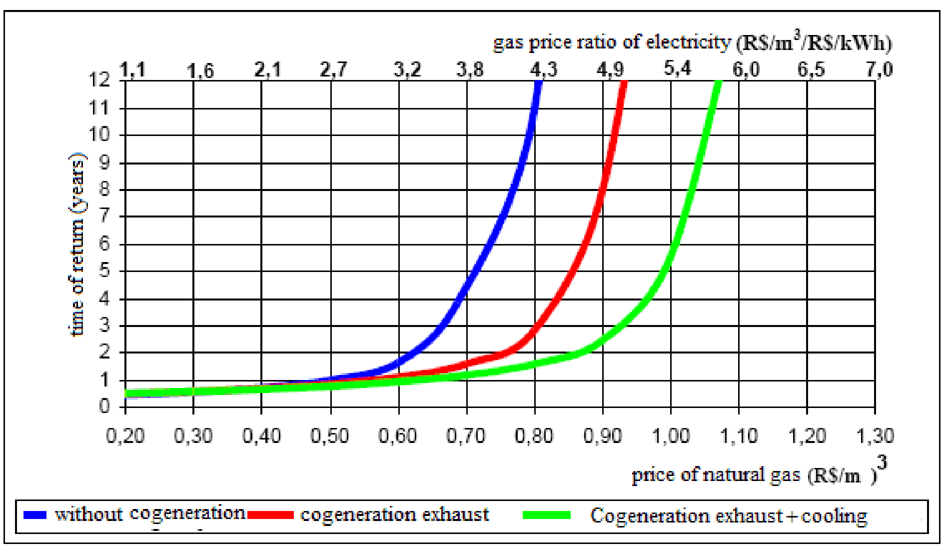

Figure 6 Time to return to various uses of exergue of the combustion engine, for fu = 70%. Source: MELLO JR, 2006

7. CONCLUSIONS

The use of natural gas to obtain power can become competitive in cases where access is possible for the same conditions of exploitation or distribution. Within this context, the internal combustion engine presents good prospects in technological terms, covering powers up to 8000 kW. On the other hand must be checked local conditions with respect to the implementation of environmental pressures taking into account the exhaust gas of the combustion engine to natural gas. Compared with the electric motor for analysis of economic feasibility in the implementation of the system of power, the internal combustion engine with natural gas may provide certain advantages, especially taking into account the relationship between the price of cubic meter of natural gas and price of kWh of electricity energy. Countries where the ratio is relatively low as Italy, Finland, Netherlands and the United States have taken up the use of natural gas for generation of power in the 8^{th}.

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