TERMOECONOMIC STUDY OF THE INCREASE IN CAPACITY OF A COGENERATION SYSTEM IN A SUGARCANE ALCOHOL DISTILLERY, ANALYZING THE RESULTS OF THE BAGASSE COMMERCIALIZATION AND OF THE ENERGY

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Abstract:. *In the last decade, the electrical power consumption in Brazil was higher than the generation capacity, urging the country to increase the investment in the electrical area and to regulate the national policy for the sector. This situation motivated the use of alternative sources, such as biomass, in order to decentralize the electricity generation. The most important residual biomass used to generate electricity is the sugarcane bagasse. The present work discusses a real case of investment to restructure and expand an existing cogeneration plant in a distillery, considering the value of surplus bagasse and electricity in the market, during a ten-year period. After the re-form, the distillery became self-sufficient in energy, having also 21240 MWh of electricity for commercialization. However, economical analysis indicates that the best option have been not to change the previous plant, and sell bagasse at R$ 26.00/t.*

Keywords: *Sugarcane bagasse, energy cogeneration, investment analysis, increasing electricity cogeneration*

1. Introduction

To avoid repetition of the recent electricity crisis in Brazil, caused by the depletion of hydro power sources in a drought, solutions are urgently needed, through rational energy use to reduce demand and/or introduction of new sources to increase supply. The economically viable option for many industrial and commercial enterprises is more rational energy use, including cogeneration, whereas increased supply will increase the revenue of the enterprise. Cogeneration is defined as rationalization of energy use of a fuel, including residue, by the combined generation of process heat and (electromechanical) power. Of course a program for more rational energy use may reduce energy "consumption", but is no guarantee of financial gain or even return of investment. Energy programs should only be adopted after careful technical and economic studies. It can be observed, furthermore, that there is no universal method for elaborating an energy program. In the distillery investigated in this publication, the energy planning started with questions directly or indirectly related to the use of bagasse, the main process residue. Questions as bagasse availability, humidity of the feed bagasse to the boiler, options to increase bagasse surpluses by more rational process energy use, choice between cogeneration and direct sale of bagasse, etc., require precise answers, and are prerequisites to planning a cogeneration project in this industrial sector. It should also have an accurate estimate of the quantity of bagasse needed to raise process steam and cogenerate electricity for self-use, assuring the independence from the unity and reducing expenditures. In addition, there must be a good grasp of the behaviour of market prices of energy and of bagasse, raw material for the paper industry, fodder or fertilizer.

This publication looks for essentially to discuss the enlargement of the cogeneration system of Japungu Agroindustrial S.A[1], motivated by the escalade in the prices of MWh, that in September of 2001 they got to cross the R$ 680.00/MWh (Gazeta, 2002) and for the signalling, on the part of the government, in defining the marks regulatory of the electric section. In that socket of decision, the company took into account the existence of a condensing/extraction turbo-generator of 15 MVA and their accessories. Some economical and financial aspects of the new system are compared with the previously existent, being analysed the results of the investment, tends in view the operation costs, and the prices of the bagasse and of the electric power.

[1] Japungu Agroindustrial S. A., is located in Santa Rita, to 40 km of João Pessoa, in Paraíba, has always sought technological leadership, having cogenerated 1 MWe surplus electricity in 1986 for sale to the utility.

2. The industry before the enlargement

The Fig. 1 is a sketch of the previous electricity cogeneration system. For analysis effect the constant equipments in this sketch, that deserve prominence, understand: a boiler Zanini of 3.24 MPa (33 kgf/cm^2 - absolute) and 340 ºC, with capacity of generation of steam of 60 t/h, a deaerator of plates with metallic cylindrical balloon, a pressure reducer structure, backpressure turbo-generators of 3.04 MPa (31 kgf/cm^2) and 340 ºC in the entrance and 0.245 MPa (2.5 kgf/cm^2) and 134 ºC in the exit, and last an installation of softening for the water of feeding of the boiler. The two backpressure turbo-generators supply a total potency of 4,800 kW, one generate 3,500 kVA, and the other 2,500 kVA. And as the medium demand of energy of the it manufactures, it was about 5,300 kW, the company arched with a deficit of 500 kW, that was supplied with energy of the local dealership.

Plant activity occurs in two distinct periods. The season, between July and March, corresponding to the time of the crop of the cane. In the off-season, April to June, molasses stored in season is processed and hydrated alcohol is converted to anhydrous alcohol, after which a complete plant maintenance is performed.

In the off-season, the demand of energy of the company falls for about 1,800 kW, because there is not more extraction of the cane, just maintaining in operation the turbine 1.

The capacity of extraction of the four tandem of cane grinding is limited to 4,000 t/day, what corresponds to an hourly average of 166 t/h.

2.1. Factors analysed for the increased power plant capacity

The planned increase in cogeneration capacity was based on certain assumptions, estimates and, most of all, within a technical scenery that strongly influenced the final project configuration. It was clear at the outset that raising the co-generation capacity would require higher steam flow, which could be obtained in two ways: 1) modifying the existing boiler[2], or 2) purchasing a new boiler. Investigation showed that, maintaining the design pressure of 3.24 MPa (33 kgf/cm^2 - absolute) and temperature of 340 ºC, the maximum steam flow possible by modifying the existing boiler would be 80 t/h, sufficient to meet the immediate demand. However to generate surplus electricity with an existing 15 MVA condensing/extraction turbo-generator operating in season, to meet the future plant goals, a more effective (energywise) steam generator, should be acquired, which should raise more than 80 t/h of steam.

The present bagasse production, at maximum crusher capacity, is insufficient to supply both boilers and feed the two existing backpressure turbines as well as the condensation turbine simultaneously.

In view of the above, it was decided to acquire a new boiler and to take the existing boiler out of service until the larger extraction capacity with the installation of the sugar mill increases the available bagasse.

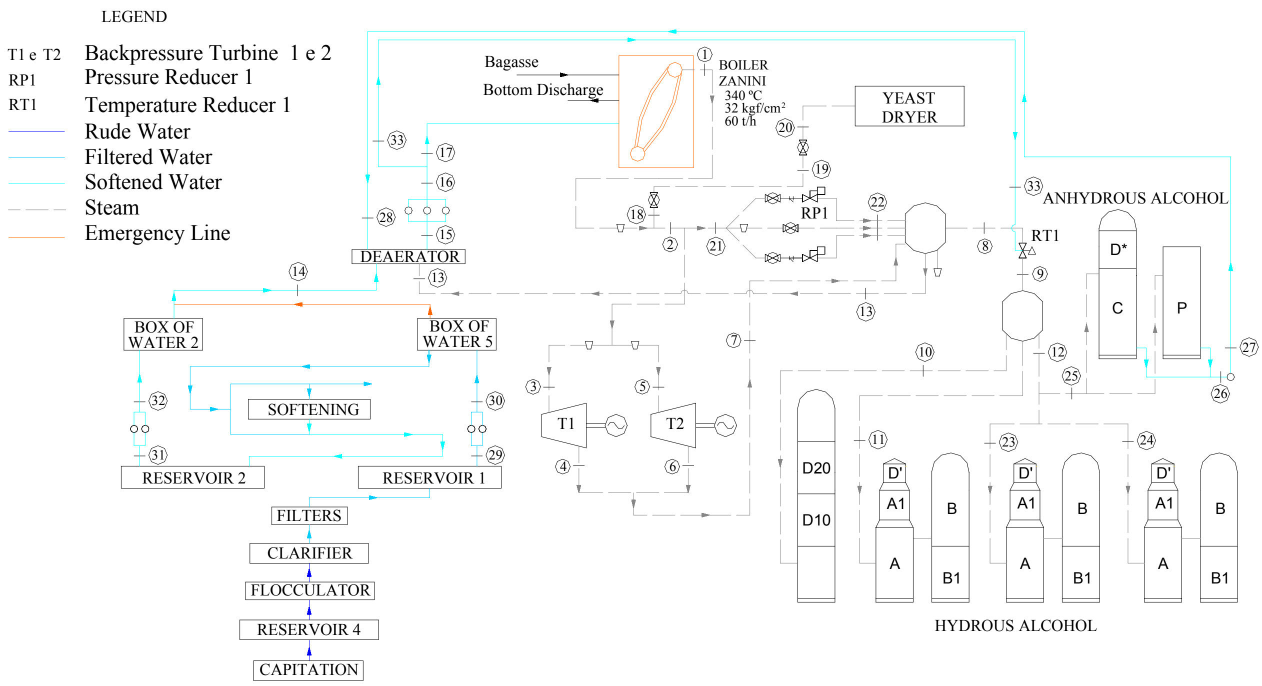

Figure 1. Scheme of the cogeneration system of the Japungu Agroindustrial S/A, before the modification.

[2] The cost of this enlargement was estimated in R$ 300,000.00

3. The new system of generation of energy

The direction of the industry, together with consultants in the area, conceived the project schematized in Fig. 2, as the new system of generation of energy, now in operation. For analysis effect, the constant equipments in this flowchart, that deserve prominence for our study, understand: a boiler Equipálcool, with capacity of 100 steam t/h, with pressure of 4.22 MPa (43 kgf/cm²) and temperature of 420 ºC, a deaerator of plates with metallic cylindrical balloon, two pressure reducer structure and one of temperature, two backpressure turbo-generators and one of condensation, and a demineralization installation and softening (inactive in this plant).

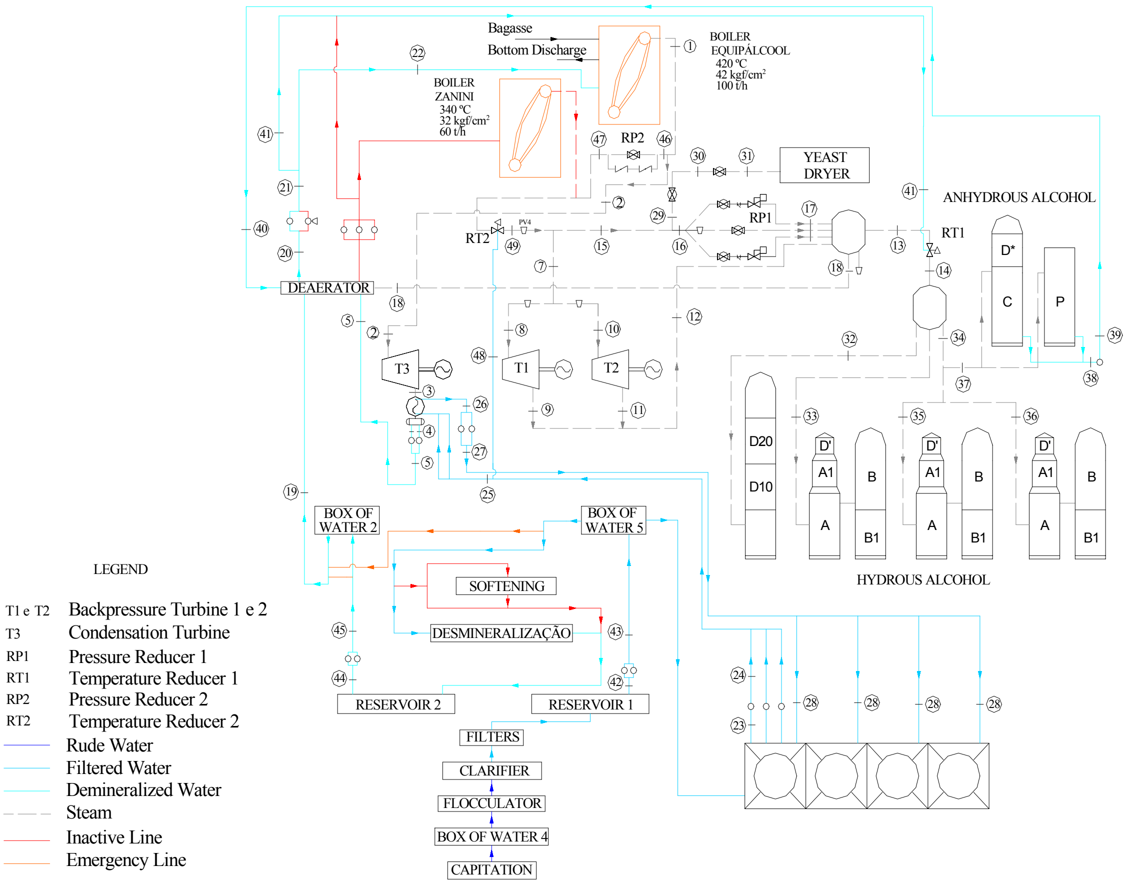

Figure 2. General scheme of the cogeneration plant adopted by Japungu Agroindustrial S/A.

Two sceneries will be considered in the present study:

a) the plant operates looking for supply her demand of energy, selling the bagasse surplus (actually this is the form adopted now by the industry, due to the low price of the energy pays and the not definition of the marks regulatory). All of the parameters associated to this situation will be referred along the text, for the letter, or index “a”;

b) the plant consumes the whole bagasse for the generation and commercialization of the electric power surplus (situation hypothetical). All of the associated parameters the this situation will be represented by the letter, or index “b”.

The boiler Equipálcool will work (in the way “a”, or in “b”), at 4.22 MPa (43 kgf/cm²) and 440 ºC. In what it concerns to the backpressure turbines, they will operate, in the entrance at 350 ºC and 3.04 MPa (31 kgf/cm^2), and in the exit, in the way “a” the temperature will be of 184.5 ºC, while in the way “b” she will be reduced to 142.4 ºC. In both situations the pressure will be limited to 2.5 kgf/cm^2. Already the condensation turbine presents in the entrance the same parameters of the boiler, and in the exit the temperature will be of 44 ºC and the pressure 1.01 kgf/cm^2. In Tab. 1, it can observe, among other parameters, the potencies of the generators of the new system, where the turbo-generators of 3,500 kVA, 2,500 kVA and 15,000 kVA, they are represented respectively by the numbers 1, 2 and 3. In the off-season the backpressure turbine is inactive for there not being more available bagasse, and the plant turn to operate with the old boiler, because of the high cost of the water demineralized (1.20 R$/m^3), in relation to the of the softened water (0.08 R$/m^3). This way, in the off-season, the system “a” turn to work as in the old system, and in the system “b” the two backpressure turbines start to generate 4,800 kW.

The Tab. 1, with performance data of the turbines to steam, it was obtained starting from the bulletin of the turbo-generators (Japungu, 2003), and of equations easily found in the specialized literature, (Camargo *et al.*, 1990; Bejan, 1998; Hugot, 1969; Jones and Hawkins, 1986; Kotas, 1995; Moran *et al.*, 2002 and Sonntag *et al.*, 1998).

Table 1. Performance of the steam turbines.

Variables	Turbines							
	Season						Off-season	
	1a	1b	2a	2b	3a	3b	1a[3] e 1b	2b
Produced potency (kW)	1,800	2,800	1,000	2,000	3,400	5,400[1]	2,800[2]	2,000
Steam flow (t/h)	23.13	27.41	12.85	19.58	16.95	26.92	27.85	19.89
Specific steam consumption (kg/kWh)	12.85	9.79	12.85	9.79	4.98	4.98	9.95	9.95
Efficiency (%)	53.0	69.58	53.0	69.58	53.0	53.0	69.58	69.58
Effectiveness (%)	60.97	75.49	60.97	75.49	51.81	51.81	75.43	75.43
Irreversibility (%)	1,152.1	908.97	640.06	649.33	3,163.55	5,024.46	911.96	651.4

[1] Potency adopted with views to consume the whole bagasse
[2] Increment of 1,000 kW to assist the irrigation
[3] Turbine 2a inactive

In Tab.1, it is important to highlight that in the way “a” uncoupled 1,800 kWe of the load, previously generated by the backpressure turbines. This fact is explained by the configuration looked for by the direction of the company of serving as the two backpressure turbines and the one of condensation, to reach the self-sufficiency. In such configuration, two new structures were inserted: one of pressure reduction and another of temperature, (to see in Fig. 1 the devices RP2 and RT2), so that the two backpressure turbines could be coupled with the new boiler of 4.12 MPa (42 kgf/cm^2) and 420 ºC. Being analyzed Tab. 1, it is verified that with that choice, the two backpressure turbines started to work to 1,800 kW and 1,000 kW. This turbines producing the 4,800 kW, as it happened in the previous system, it would induce the condensation turbine to generate only 1,400 kW, what would implicate in a drastic reduction of her efficiency and in the damage of her own operation.

In the case “b”, the effect of the pressure reducer structure and of temperature it looked for to adapt the landing of energy of the new boiler, to the of the old boiler. The results produced by the backpressure turbines, in this case, were, obviously, similar to the of the previous system, as prove the data of Tab. 1.

4. Costs of implantation of the new cogeneration system

The total costs of the reform in Japungu were above R$ 8,000,000.00. With the investment it was acquired, among other the following components: the boiler Equipálcool models type 100-V-2-S; four cooling towers alpine; a station of demineralization of water; a substation of 69 kV.

5. Expressions

5.1. Bagasse Consumption

The bagasse consumption, B, in t, to maintain the plant operating during the season, B_{sf}, or the off-season, B_{ef}, is given by the product of the flow of bagasse consumption, $\dot{m}_b$, in t/h, for the duration of the period, N, in hours, h (Jaguaribe *et al.*, 2002; Lobo *et al.*, 2002 and Souza, 2004):

$$B = \dot{m}_b \cdot N \qquad (1)$$

5.2. Bagasse surplus

The bagasse surplus, B_{exc}, in t, is calculated being subtracted of the produced total bagasse, B_T, the portions corresponding to the bagasse consumption during the season, B_{sf}, and the off-season, B_{ef}, and a portion corresponding to a stock of safety, B_{est}, in t (Jaguaribe *et al.*, 2002; Lobo *et al.*, 2002 and Souza, 2004):

$$B_{exc} = B_T - B_{ef} - B_{sf} - B_{est} \qquad (2)$$

5.3. Medium potency supplied by the backpressure machines

The medium potency of the backpressure machines, $\dot{W}_{cp}$, in kW, is given by the sum of the medium potency produced by the turbo-generator 1, $\dot{W}_1$, in kW, and the turbo-generator 2, $\dot{W}_2$:

$$\dot{W}_{cp} = \dot{W}_1 + \dot{W}_2 \tag{3}$$

5.4. Energy produced by the backpressure machines

The energy produced by the backpressure machines, E_{cp}, in MWh ($E_{cp,sf}$ for the season and $E_{cp,ef}$ for the off-season), is the product of the produced medium potency, $\dot{W}_{cp,sf}$ in the case of the season and $\dot{W}_{cp,ef}$ in the off-season, for the duration of the period, N, in h (Jaguaribe *et al.*, 2002; Lobo *et al.*, 2002 and Souza, 2004):

$$E_{cp} = \dot{W}_{cp} \cdot N \tag{4}$$

5.5. Medium potency supplied by the condensation machine

The medium potency of the condensation machine, $\dot{W}_{cp}$, in kW, it is given by the sum of the medium potency produced by the extraction module, $\dot{W}_{3,ex}$, in kW, and for the condensation module, $\dot{W}_{3,cd}$:

$$\dot{W}_{cd} = \dot{W}_{3,ex} + \dot{W}_{3,cd} \tag{5}$$

The extraction module, for the case in study, no this operating, this way can be fast that $\dot{W}_{3,ex} = 0$.

5.6. Energy produced by the condensation machine

The energy produced by the condensation machine, E_{cd}, in MWh ($E_{cd,sf}$ for the season and $E_{cd,ef}$ for the off-season), is the product of the produced medium potency, $\dot{W}_{cd,sf}$ in the case of the season and $\dot{W}_{cd,ef}$ in the off-season, for the total duration of the period, N (Jaguaribe *et al.*, 2002; Lobo *et al.*, 2002 and Souza, 2004):

$$E_{cd} = \dot{W}_{cd} \cdot N \tag{6}$$

5.7. Produced total energy

The produced total energy, E_T, in MWh, is the sum of the energy produced by the backpressure machines, E_{cp}, with the energy produced by the condensation machine, E_{cd}:

$$E_T = E_{cp} + E_{cd} \tag{7}$$

5.8. Electric consumption of the factory

The electric consumption of the factory, E_F, in MWh, is given by the product of the demand electric average of the factory, $\dot{W}_F$, in kW, for the total duration of the period, N (Jaguaribe *et al.*, 2004; Lobo *et al.*, 2002 and Souza, 2004):

$$E_F = \dot{W}_F \cdot N \tag{8}$$

5.9. Available energy for the sale

The available energy for the sale, E_{exc}, in MWh, is obtained being subtracted of the produced total energy, E_T, the energy consumed by the factory, E_F:

$$E_{exc} = E_T - E_F \tag{9}$$

5.10. Medium potency exported in the season

The medium potency exported in the season, $\dot{W}_{exc,sf}$, in kW, is given by the sum of the potencies supplied by the backpressure machines, $\dot{W}_{cp,sf}$, and for the condensation machine, $\dot{W}_{cd,sf}$, less the demand electric average of the factory, $\dot{W}_{F,sf}$, or be:

$$\dot{W}_{exc,sf} = \dot{W}_{cp,sf} + \dot{W}_{cd,sf} - \dot{W}_{F,sf} \quad (10)$$

5.11. Medium potency exported in the off-season

The medium potency exported in the off-season, $\dot{W}_{exc,ef}$, in kW, is given by the potency supplied by the backpressure machines, $\dot{W}_{cp,ef}$, less the demand electric average of the factory, $\dot{W}_{F,ef}$, or be:

$$\dot{W}_{exc,ef} = \dot{W}_{cp,ef} - \dot{W}_{F,ef} \quad (11)$$

5.12. Expense with water of feeding of the boiler

The expense with water of feeding of the boiler, D_{ag}, in R$, it is given by the product: of the flow of replacement water, Q_{ag}, in m^3/h, with the cost of the treated water, C_{ag}, in R$/m^3, and with the total duration of the period, N.

$$D_{ag} = Q_{ag} \cdot C_{ag} \cdot N \quad (12)$$

5.13. Expense with electric power

The expense with electric power, D_{en}, in R$, it is given by the product: of the bought energy of the dealership, E_{exc}, in MWh, with the cost of the electric power, C_{en}, in R$/MWh (Jaguaribe *et al*., 2004 and Souza, 2004):

$$D_{en} = E_{exc} \cdot C_{en} \quad (13)$$

5.14. Total expense of operation

The total expense of operation, D_T, in R$, is the sum of the expense with feeding water, D_{ag}, with the expense with electric power, D_{en}:

$$D_T = D_{ag} + D_{en} \quad (14)$$

5.15. Revenue with the sale of the bagasse

The revenue with the sale of the bagasse, R_b, in R$, is the product of the bagasse surplus, B_{exc}, for the value of sale of the bagasse, Y_b, in R$ (Jaguaribe *et al*., 2004; Lobo *et al*., 2002 and Souza, 2004):

$$R_b = B_{exc} \cdot Y_b \quad (15)$$

5.16. Revenue with the electric power sale

The revenue with the electric power sale, R_{en}, in R$, is the product of the available energy for the sale, E_{exc}, for the value of sale of the electric power, Y_{en}, in R$ (Jaguaribe *et al*., 2004; Lobo *et al*., 2002 and Souza, 2004):

$$R_{en} = E_{exc} \cdot Y_{en} \quad (16)$$

5.17. Net revenue

The net revenue, R_{liq}, in R$, it is the gross revenue, R, in R$ (R_b for the sale of the bagasse and R_{en} for the sale of energy), less the total expense of operation, D_T:

$$R_{liq} = R - D_T \quad (17)$$

5.18. Rate interns of return

The rate interns of return (TIR), i, of an investment, or be, the interest rate that annuls the present value of the net incomes resultants of the project, when compared with the present value of the payments, it is given by the relationship among the present value, P, and the uniform series of billing, R_{liq}, this is

$$P = R_{liq}\frac{(1+i)^n - 1}{i(1+i)^n}, \tag{18}$$

where $\frac{(1+i)^n - 1}{i(1+i)^n} = (P/R_{liq};i;n)$, that it is called factor of current value for an uniform series and it means that we can find P given R_{liq}, for an interest rate i in the period.

Of ownership of those concepts, the form of calculation of TIR can be defined starting from the equation below (Casarotto *et al*., 1998 and Marim, 1980):

$$- P + R_{liq}(P/R_{liq};\ i;\ n) = 0 \tag{19}$$

5.19. Net present value

It understands for net present value (VPL) the updating of all the terms of the cash flow (incomes and expenses), added to the initial investment of each alternative. The rate used to discount the flow (to bring to the Present Value) it is TMA (it rates low of interests that takes the investor to choose for certain investment project).

The calculation of the Present Liquid Value is obtained directly by Eq. (20) (Casarotto *et al*., 1998 and Marim, 1980):

$$VPL = - P + R_{liq}(P/\ R_{liq;}\ i;\ n) \tag{20}$$

6. Results

Tab. 2, obtained starting from Eqs. (1) the (13) and of the harvest report (Japungu, 2003), it presents data of grinding capacities, of generation of energy, and of operational costs, before the modification and later to the changes, and they distinguish the manners and operational results as manners "a", and "b", already defined previously.

Table 2. Parameters of comparison and evaluation of the performance of the plants of cogeneration.

Parameters	Plants of Cogeneration					
	Season			Off-season		
	Old	a	b	Old	a	b
Harvested cane (t)	700,000	800,000		0	0	
Milled cane (t)	672,000	768,000		0	0	
Produced total bagasse (t)	215,575	246,372		0	0	
Bagasse surplus (t) – Eq. (2)	51,266	29,406	0	0	0	
Generated medium potency (kW) – Eqs. (3) e (5)	4,800	6,200	10,200	1,800	2,800	4,800
Power generated (MWh) – Eqs. (4) e (6)	24,000	32,922	54,162	2,160	3,360	5,760
Electric demand of the enterprise (kW)	5,300	6,200		0	2,800	
Requested complemental potency (kW)	500	0		0	0	
Electric power consumption (MWh) – Eq. (8)	26,500	32,922		2,160	3,360	
Requested complemental energy (MWh)	2,500	0		0	0	
Potency surplus (kW) – Eqs. (10) e (11)	0	0	4,000	0	0	2,000
Energy surplus (MWh) – Eq. (9)	0	0	21,240	0	0	2,400
Expense with softened water (R$) – Eq. (12)	17,368.35	0		3,167.22	4,139.42	
Expense with deminer. water (R$) – Eq. (12)	0	274,760.94		0	0	
Expense with electric power (R$) – Eq. (13)	224,650.00	0		0	0	

It is verified starting from Tab. 2, that in the current system the harvested cane volume during the season, 800,000 t, is larger than processed by the previous plant. That value is constituted in the minimum goal projected for the future harvests.

The Figures 3 and 4 present, respectively, the behaviour of the return rate for the plant operating in the way "a" (was adopted a net income of R$ 479,479.35 obtained with the sale of the bagasse in the value of R$ 26 for ton), and in the way "b" (that had as base a net income of R$ 1,848,699.54 obtained with the electric power sale in the value of R$ 89.89 for MWh) (ANEEL, 2002). For the construction of these figures broke of Eqs. (19) and (20), being adopted a rate of minimum attractiveness, TMA, equal to the interest rate of 8% a year, appraised in a period of 10 years. For the plant operating so much in the way "a", as in the way "b", VPL(i,0) present in Figs. 3 and 4, it just indicates that the initial investment in the assembly of this plant was about R$ 8,000,000.00.

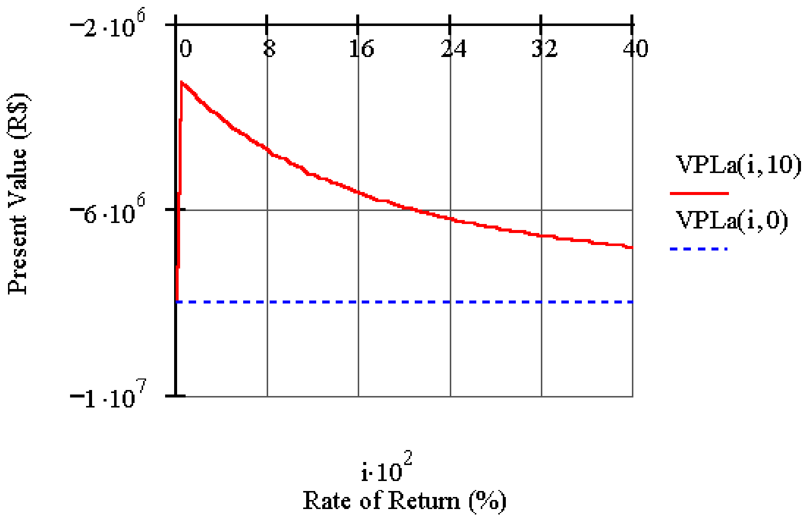

Figure 3. Rate of return for the system operating in the mode "a".

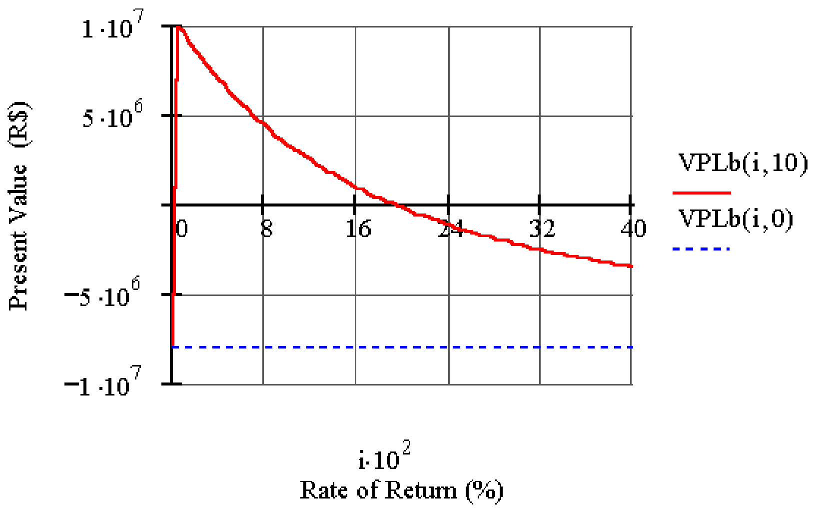

Figure 4. Rate of return for the system operating in the mode "b".

7. Analysis of the investment

For the conception of the system "a", there will be always bagasse surplus for the commercialization. Therefore, the economical discussions in that configuration will implicate in considerations on the sale of the bagasse. Beginning with him, by Fig. 3 is verified that VPL (Liquid Present Value) it is always negative. In the case "b" there will be just commercialization of energy. This way, being taken into account Fig. 4, it is verified that TIR is equal to 19%, being revealed superior adopted TMA.

The financial analyses, here made, were arrested to the ten year-old horizon, period of bank amortization of the investment. There was not concern of imposing limits for the profits, settling down as viability criterion, the option where the Internal Rate of Return (TIR), be larger than the Minimum Rate of Attractiveness, TMA, considered as 8% a year. The adopted model was simplified, having admitted that the effect of the inflation tax, in the inputs and in the sale of energy, it was the same, and despised the effect of the income tax on the profits of the investment; it was not also considered the costs with maintenance. These restrictions, though, do not impede that we formulate realistic comparisons among the situations examined along this work. In this way, of Fig. 5, it is noticed that in the examined horizon, the curves related with the modified system are below that of the previous system. For the tendency of the curve of the simulated system it is verified that there is a perspective, out of the ten year domain, of that curve to come to intercept the one of the previous system. However, additional considerations would have to be taken into account to affirm that such option would justify the investment.

Fig. 5 allow to compare the Net Present Value for the cases "a", VPLa, "b", VPLb, and for the previous system, VPL.

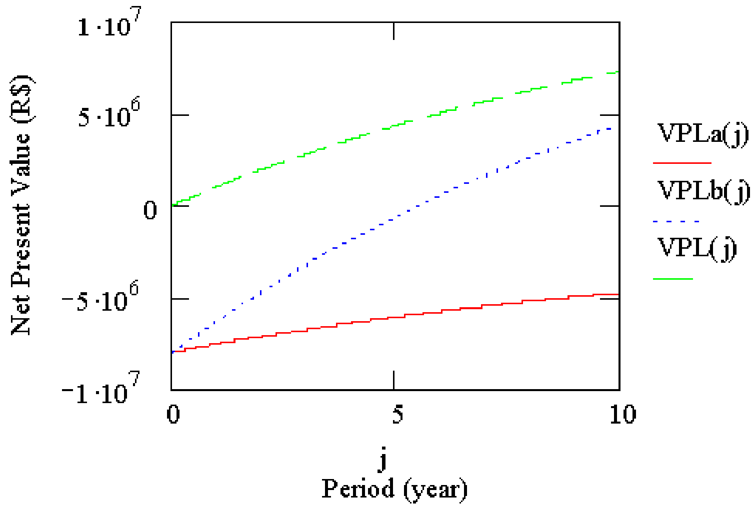

Figure 5. Comparative graph for VPL's.

8. Conclusion

In the exams of the results of this study, it is noticed that Japungu explored in the past and it continues to explore in several ways, the potential of the sugar-cane bagasse, be as fuel, or marketing it, in nature, as animal ration, fertilizer, or through the export of generated electric power of that energy input. That diversity of options of generating wealth, that the bagasse, or yours derived they offer, amid the energy crises faced by Brazil, it takes sugarcane alcohol industries, like Japungu, to enlarge the parks of generation of energy, be to guarantee her energy autonomy, be, to export energy, through, above all of the use of the cogeneration. It is verified, though, that to promote the industrial cogeneration it does not want to say that be guaranteed financial success, above all in the case of the sector sugarcane, given the mercantile options supplied by the bagasse. Like this, the ideal is that it is studied, thoroughly, any project of installation of a new system, or even of an enlargement of a cogeneration system, before executing it. In Japungu it does not seem to have had a rigorous previous study, and in that subsequent evaluation of the plant already in operation can be inferred that:

1. The new system, realized with the installation of a new boiler of 4.12 MPa (42 kgf/cm^2) and the condensation turbine, it is being served by a volume of harvested cane, already registered in previous years, from where is induced that it was not concern with the enlargement of the sector of extraction of the company.
2. In the way as Japungu is operating, it is no way to recover the done investment, once the Net Present Value, will always be shown negative. In the case "b", being considered that the Internal Rate of Return is same to 19%, and that the price of the electric power stays in R$ 90/MWh, either it will be had capital return, at least in the 10 year scenery, that corresponds to the payment of the loan taken by the company. It is patent, though, that the hypothetical case "b", can be made possible with success, depending on the future energy scenery, while, it can be inferred that there are no hopes for the current conception. Better option would have been, therefore, to have maintained the previous plant as it was, and if sells the bagasse surplus for R$ 26,00/t.

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