Sensibility analysis applied to a Micro Thermal Power Plant with electricity generation up to 800 kW – The case of rice husk

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Abstract

The production of rice husk in Rio Grande do Sul, state responsible for more than half of this cereal production in Brazil, leads to the need of an adequate environmental management. Since 95.1% of the rice mills accept a biomass power system with capacity below 800kW, for an electrical efficiency of 10%, this need can be addressed with the installation of an Micro Thermal Power Plant (MTP). In this work were evaluated five MTPs (300, 400, 500, 700 and 800 kW) through economic and sensibility analysis. It was found that the smaller the MTP capacity, it becomes more sensitive to economic parameters, such as the price of buying electric energy from the concessionary by the mill (R$/MWh), the selling price of electric energy surplus (R$/MWh), the rate of interest charged by the loan financial institution; and the Certified Emission Reduction (CER) price (R$/tCO2eq). Furthermore, all assessed MTP presented feasibility only with CERs income, demonstrating its importance. This study contributed to present the strengths and weaknesses of this type of biomass power systems.

Keywords - component; rice husk; micro thermal power plant; sensibility analysis.

Theme Area: Energy and renewable energy.

1 Introduction

Rice is one of the principal food-stuffs consumed in Brazil, serving as a base for the diet of the majority of the population. Its average consumption is 31 kg per capita yearly [1], making the rice productive chain extremely important for the national economy, especially for Rio Grande do Sul state, which is responsible for more than half of the Brazilian production [2].

In Rio Grande do Sul there are 266 rice mills, responsible for the processing of approximately 4,5 million tons [3], which means that the 20 biggest industries of this type process more than 60% of the rice consumed in the country in the year [4].

Among the residual products generated through the processing mills, the rice husk is of large importance, not only because of the quantity generated, associated with low bulk density [5], but also because of the difficulty in its decomposition in the environment, becoming a serious pollutant of the companies in this sector, bearing in mind the obligations required by the environmental legislation in force. Besides that, the greenhouse gas emission through rice husk decomposition in landfill can be an environmental problem [5].

The total use of this agro-industrial residue helps in the environmental problems solution, and can also provide extra income through its direct use. One of the possible uses of the rice husk is through generation of electrical energy, commonly in systems that uses gasification/internal combustion engine [6,7,8], gasification/steam turbine [5,7], firing-grate combustion/steam engine [5,9,10,11], firing-grate/steam turbine [5,6,7,8], fluidized bed combustion/steam turbine [5,6,8] or external combustion engine [7].

All cited cases related to steam turbine generation system describe capacities larger than 500kW, demonstrating the lack of discussion of small scale thermal power plants systems from 100 to 1,000 kW. Reference [12] deals with a 300kW thermal power plant, called Micro Thermal Power Plant (MTP).

One example of MTP is that installed in a rice mill, in the town of São Pedro do Sul, Rio Grande do Sul state (Figure 1), which was financed by the National Council for Scientific and Technological Development (CNPq). This 300 kW MTP substituted a reciprocating steam engine, with a rise of 66% in the electrical system yield.

Figure 1. 300 kW MTP, installed in São Pedro do Sul.

Reference [12] analyzed the generation potential of electrical energy of the existing mills in the Rio Grande do Sul state, in accordance with Table 1. The biomass power systems proposed, use a boiler, a vapor turbine and a generator/alternator. The processing of the rice husk up to the generation of electrical energy was tested, or simulated, by various nominal capacities, divided in three ranges: "A", up to 100 kW; "B", from 101 to 800 kW; and "C", above de 801 kW.

The first capacity range analyzed could not be technically attended by the generation system considered. The viability for the 185 mills which form the range "A" could occur through the adequate management of the residual products produced in each unit, if they were used in a larger centralized thermal power plant, covering various mills, as long as they are located near to one another.

The group of greater capacity (above 800 kW), is already used by thermal systems and is where investments are concentrated in generation of electrical energy with rice husk, in Rio Grande do Sul state.

The mills in the range "B" (68 units), have to make a critical decision, in respect to rice husk use, because there are no specific studies about the economic feasibility for these cases.

The perform of a sensibility analysis could allow viewing the conditions which favor such investments and, at the same time, contribute to find viable solutions, encouraging the developmen of this important agro-industrial sector.

Table 1 –Distribution of mills in the Rio Grande do Sul state (2006) – capacity distribution estimative.

Capacity range	Up to 100 kW	Between 101 and 800 kW	Above 801 kW	Total
Number of mills	185	68	13	**266**
% of total number	69.5%	25.6%	4.9%	**100**
Electrical yield (%)	10.0	10.0	15.0	**-**
Utilization factor	0.6	0.6	0.6	**-**
Total capacity (kW)	3,600	16,800	25,500	**45,900**
% of installed capacity	7.8	36.7	55.5	**100**
Total energy (MWh)	19,800	87,400	133,800	**241,000**
% of total energy	8,2%	36,3%	55,5%	**100**

Source: [5]

2 Methodology

The analysis of the investments was undertaken based on the data presented in Table 1. Five MTP were simulated which compose the intermediate group of generation capacity described by [12].

The investments were considered as being totally financeable, with an interest rate of 9.25% per year, with two years to start payment and seven years to finish paying. These are conditions found in Brazil which are applied to special projects of social and economic interest.

For each case three sources of revenue were considered: trading of the electrical energy surplus (R$130.82/MWh), non-operational income by the self-production of electricity (R$139.12/MWh) and resources from certified emission reduction (CERs) credits (R$17.00/t CO_{2eq}). The values are in local currency1

The feasibility indicator used in the sensibility analysis was the Net Present Value (NPV), whose variation was influenced by four parameters, listed as critical for the viability of these enterprises, these being: a) the price of buying electric energy from the concessionary by the mill (R$/MWh); b) selling price of electric energy surplus (R$/MWh); c) the rate of interest charged by the loan financial institution; and d) CERs price (R$/t$CO_{2eq}$).

3 Results

The 555 thousand tons of available rice husk are unequally distributed throughout the state as can be seen in Figure 2. There is a clearly division that separates the territory in two parts. The southern region is the region where rice is cultivated and milled. This region is also divided in areas of higher energy potential, highlighting the west portion of the state, by the way, the major rice cultivation area. Figure 2 also enables to visualize which scale the power plants may have if the projects were centralized.

[1] Considering US$1.00 equals R$1.70.

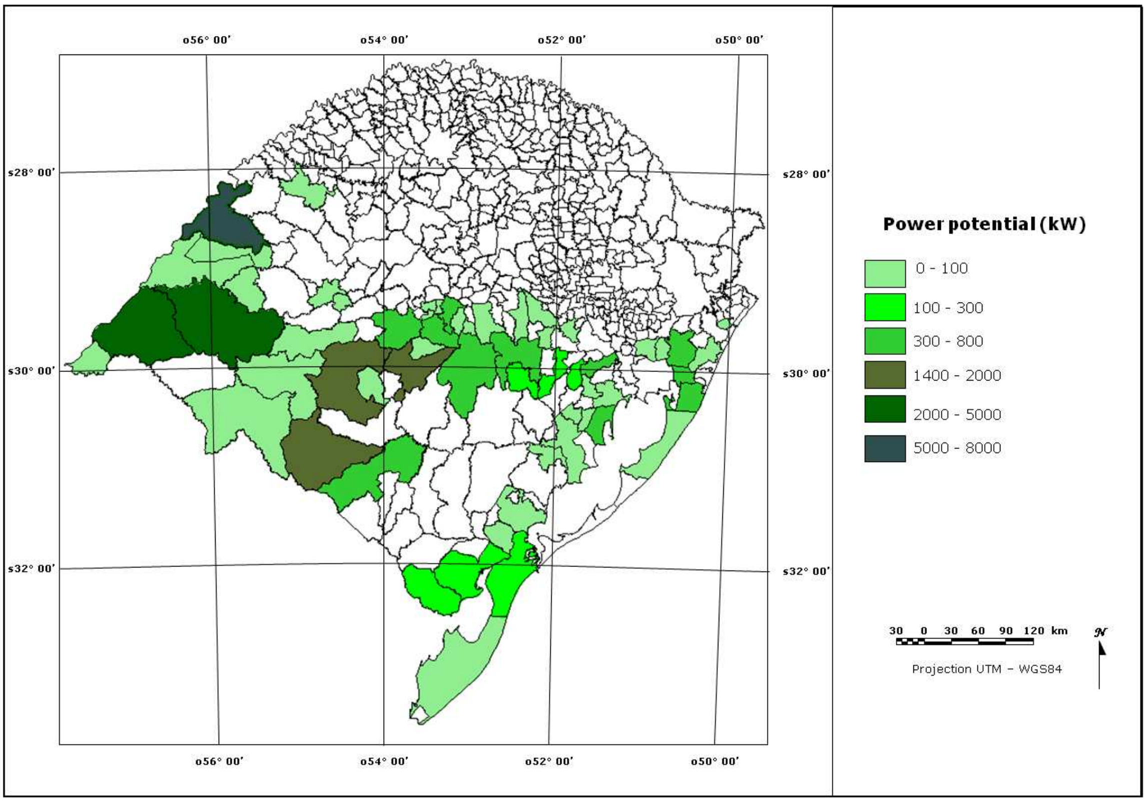

Figure 2 Map of the energy potential from rice husk in Rio Grande do Sul State.

Table 2 presents the comparative values for the five MTP evaluated. It is important to point out that the investments were not linear. The equipment used in 300 and 400 kW MTPs are of the same size, thus making the total investment practically equal in both cases, resulting in a major financial return for the 400 kW capacity.

Table 2 – Comparative values for the five potentials of thermal electric power

MTP capacity	Investment/kW[1]	Cost of generated energy[1]	Specific income (R$/kW)	Relation VPL/investment
300	1,000	1,000	1.028,61	-0,055
400	0,759	0,762	1.098,75	0,211
500	0,667	0,665	1.028,61	0,369
700	0,645	0,665	1.028,61	0,382
800	0,597	0,61	1.028,61	0,490

[1] The values of investment/kW and the cost of energy generated were relativized based on the values of the 300 kW MTP.

The Fig. 3, 4, 5 and 6 present the results of simulation for the five thermal electric systems. An analysis of the results suggested that when the feasibility of the MTP is smaller, it becomes more sensitive to the variations of the four parameters.

The commercialization of electric energy, the self-production of electricity and the CERs credits, correspond to 26.3, 46.4 e 27.3% of the income, respectively, for all the cases analyzed.

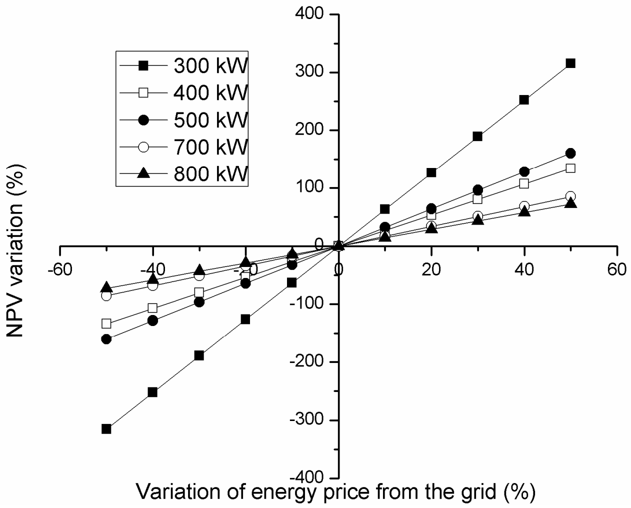

Figure 3. Sensibility to energy price from the grid.

Thus the price of buying electricity, which results in non-operational gain, was the item that presented greater impact on the VPL, followed by the interest rate, the value of the CERs and finally the price of selling electrical energy in accordance with the analysis of the figures.

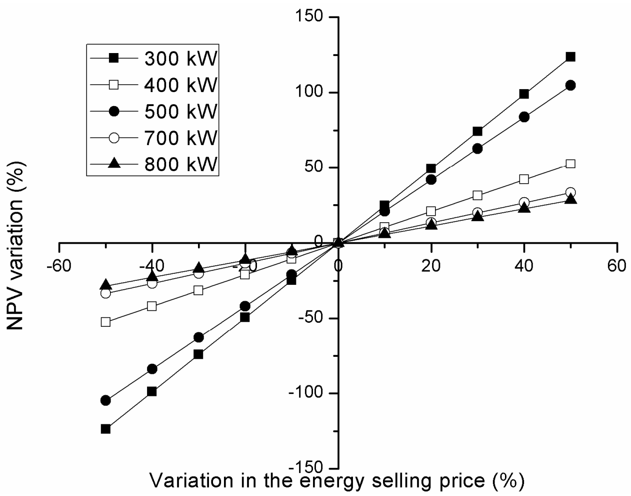

Figure 4. Sensibility to energy selling price.

It is important to highlight that none of the five MTP evaluated presented economic feasibility in the absence of CERs credits income with exception of that of 800 kW.

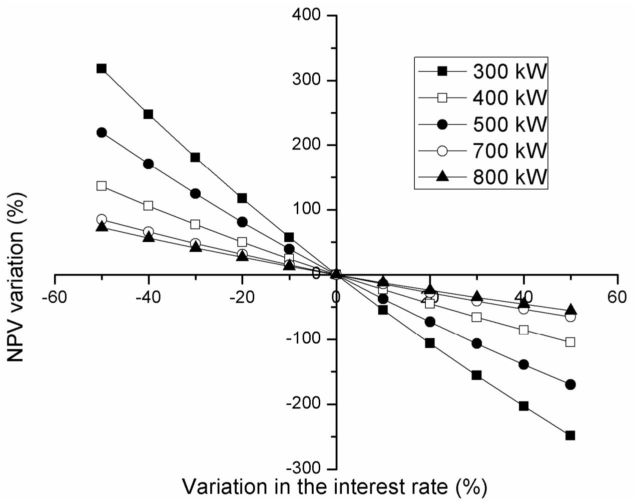

Figure 5. Sensibility to interest rate.

The sensibility analysis undertaken allows planning according to the proposed investments, evaluating the impact of each of the four items in the viability of MTP systems, which are:

- The price of commercialization of the excess of electricity is a secure source of income, as it can be offered to the energy market in the form of sale contracts, at prices corrected by inflation.
- The price of energy acquired from the grid is also secure (value corrected by inflation annually), with a fixed impact on viability.
- The CERs constitute the most sensitive point economically for the MTP generation, because their admission is what makes these viable. However their value depends not only on the international market price of CERs but also the exchange rate, volatilizing this source of income.
- The interest rate financing reduction can serve as governmental incentive program, together with reduction of equipment taxes, which corresponds to approximately 13% of the investment.

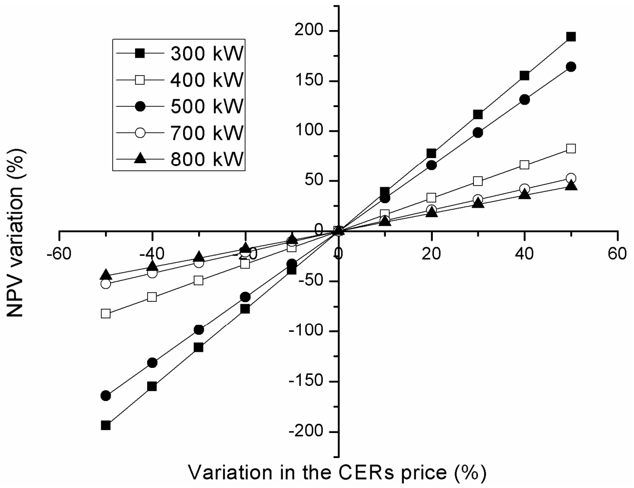

Figure 6. Sensibility to CERs price.

4 Conclusion

The feasibility and sensibility analysis values obtained corroborate the existing economies of scale, in which the costs of investment and operation are specifically inferior compared to the large size of equipment employed.

Thus the MTP of 300 kW is the only one which did not present viability in the five cases examined, indicating the need for incentives for its implementation, such as reduction of interest rates.

However, even though the other cases in which there is feasibility, there should be established some type of economic incentive as they depend greatly on the admission of the CERs, avoiding volatilization of the projects income.

Finally, the environmental gains that can be achieved justify the adoption of economic incentives for the installation of MTPs, whether to end the inadequate disposal of these wastes to the environment, either by greenhouse gases mitigation.

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