Feasibility Study For Hybrid Electric Generating System With Wind-Diesel And Grid Sources

Márcia da Rocha Ramos
(marciar@cepel.br)

Ana Paula Cardoso Guimarães
(pcardoso@cepel.br)

Lauro Barde Bezerra
(laurobb@cepel.br)

Hamilton Moss de Souza
(moss@cepel.br)

Centro de Pesquisas de Energia Elétrica – CEPEL
Avenida Horácio Macedo, 354
Cidade Universitária - Ilha do Fundão
Rio de Janeiro - RJ - Brasil
Cep 21941-911
+55 21 25986348

Gabriel Landa Noronha
(gabriellanda@hotmail.com)

Leonardo Dalcin Silva
(dalcin@petrobras.com.br)

Centro Federal de Educação Tecnológica
Celso Suckow da Fonseca – CEFET/RJ
Avenida Maracanã, 229
Maracanã - Rio de Janeiro - RJ - Brasil
Cep 20271-110
+55 21 25694637

Abstract

Considering the renewable energy potential of Brazil, it becomes important the development of studies allowing an evaluation of the applicability of alternative and complementary energy systems in order to use this potential. The objective of these studies is to diversify the sources of energy available for the country, feeding the energy demand with more reliability and keeping or improving the clean characteristics of the Brazilian electrical matrix.

This work is a technical and economical feasibility study of a hybrid generating system, composed by wind, diesel and grid sources, feeding a great costumer with high reliability requirements for its electric supply.

The attractiveness of the project is justified by the great potential of the wind resource in the region considered for the project, by the low cost of operation of a wind energy generation system and also because of the high peak load tariff prices in Brazil. This work presents an alternative with potential to benefit both costumers and utilities with special load characteristics and in areas where good wind is available.

1 - Introduction

This work is a technical and economical feasibility study of a hybrid generating system, composed by wind, diesel and grid sources, feeding a great costumer with high reliability requirements for its electric supply.

The Diesel set generator is adjusted for operation in the schedule of a high load demand when the winds will not be enough for the supply. This set makes possible a significant economy in the expenses with electric energy, because the value of the tariff in this schedule. The criterion of operation of the system privileges the wind, whenever possible, in view of cost zero of the "fuel".

It was part of the applied methodology, the survey of the wind resource of the region, the typical load curve of the consumer, the sizing of the generation system (wind turbine and diesel set generator) and, finally, the development of reference studies and analyses for the financial and economic feasibility of the investment. Moreover, in this work, it has been used real data of wind and profile of consumption.

2 – System Description

The considered system is constituted by a wind generator, used as the main power source, linked to the electric net of the utility, and a device UPS (Uninterruptable Power System) necessary to guarantee the stability of the electric supply during the exchange of the source. A diesel generating set is also enclosed, for emergency operations (low wind speed and lack of energy in the net, for example) and for operation during the peak demand.

In any schedule the main source will be the wind generator, during the peak load schedule the secondary source will be the Diesel generator set, because the high price of the tariff of electricity in this period. In the off-peak schedule the secondary source will be the electric net of the utility company. The source voltage of the electric energy of the system will be 480 V. In Figure 1 is presented the basic block diagram of the considered system.

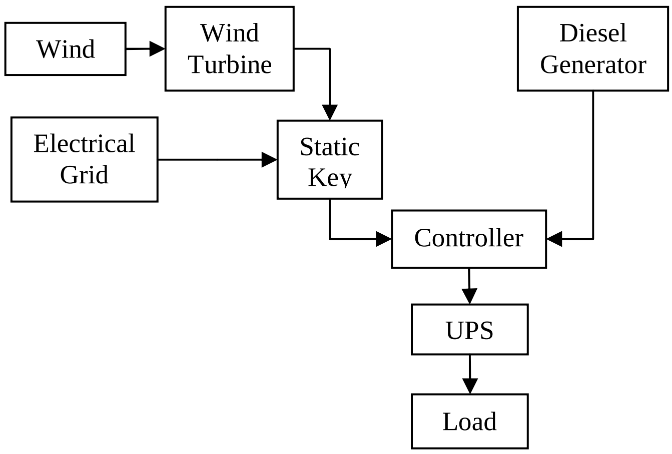


Figure 1 - Sketch of the system

3 – Load and Local Wind Characteristics

The consumer has an installed load of 380 kW, approximately. It has been analyzed the data of the costumer demand of electric energy for building a typical daily load curve. In Table 1 the monthly values of the demand and the local consumption of electric energy are presented. In Figure 2 the representative curve of the typical day of the demand of electric energy is illustrated.

Table 1 – Monthly demand and consumption electric energy

Peak Demand Schedule		**Off-Peak Schedule**	
Demand (kW)	Consumption (kWh)	Demand (KW)	Consumption (kWh)
345,5	32.916,0	335,9	91.477,6

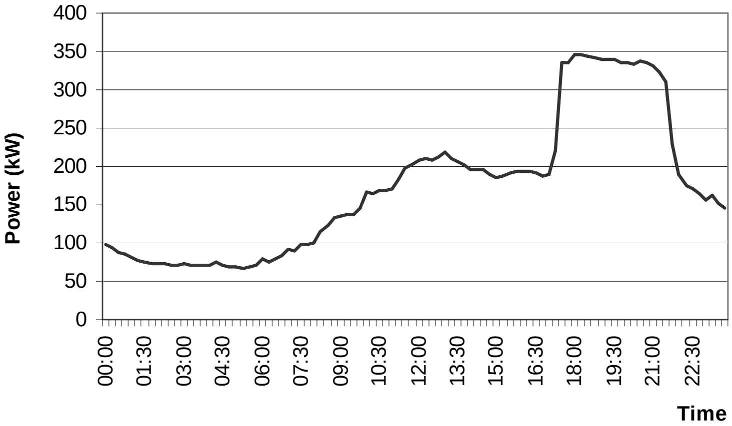
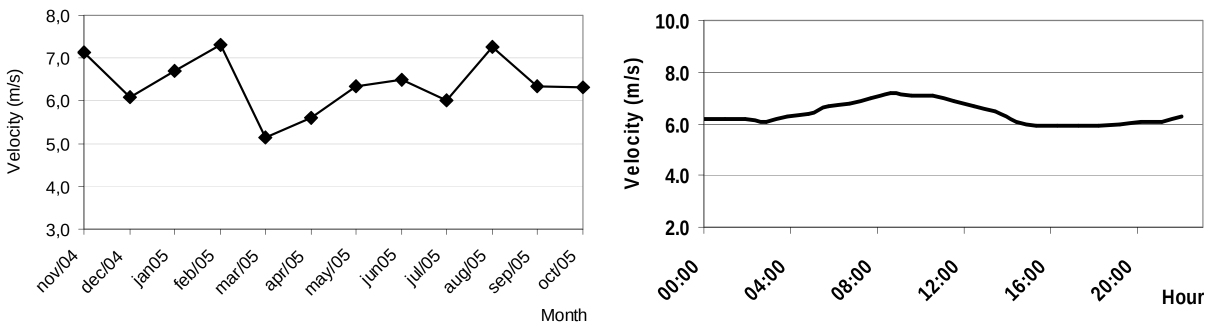


Figure 2 - Typical load curve of a day

The used data of wind in the development of this work are referring to a historical series consolidated of the period of November of 2004 to the October of 2005 of a hypothetical place, but corresponding to a possible real situation. The Figure 3 shows the behavior of the winds throughout the period in question in accordance with the average value of the monthly speeds. It is observed that the highest average values of speed had occurred in the months of February and August, whereas the lowest values happen in the months of March and April. The figure 3.b presents the curve of the typical day, which was taken from the hourly average wind speed values. In all the hours of this graph, the average speeds had surpassed 6 m/s reaching the maximum value of 7,2 m/s. The resulted sample shows that the highest intensities of the wind are concentrated, in general, during the day.



(a) (b)

Figure 3 – (a) Monthly average values of wind speed; (b) Characteristic curve of wind speed of a typical day

In Table 2 the values of the average speed and the parameters of the corresponding distribution of Weibull to the analyzed period are presented. The calculation of the power density carried through the WASP (Wind Analysis Atlases and Application Program) uses the value of the air density in the Standard Conditions for Temperature and Pressure (SCTP).

Table 2 - Parameters of the Weibull distribution of the measured period

Period	**Average speed (m/s)**	**c (m/s)**	**k**	**Power Density (W/m^2)**
Nov/04 to Oct/05	6,5	7,2	3,17	228

4.0 – HOMER Modeling

For this purpose simulations had been carried using a computational program called HOMER (Hybrid Optimization Model will be Electric Renewable), developed by NREL (National Renewable Energy Laboratory), which is capable to simulate sizing and operation of this kind of systems. This is a methodology used with great security and large-scale in diverse successful projects around the world. The results showed in this article are, therefore, rigorous from the point of view of applied methodology. HOMER makes possible substantial connection between simulated and measured results. In this work the HOMER was not used to carry through the financial analysis.

The simulation was carried through only using the wind generation and the Diesel generator set to attend the demand, that is, the electric net of the utility was not enclosed. As the HOMER does not make distinction enters the peak load schedule and out of the peak demand (off-peak), the results had been exported and treated in a macro to the Excel spread sheet. This macro separates the data in two groups, peak load schedule and that off-peak demand, and inside of each group, verifies, for each hour, which source is capable to supply the load, in accordance with the criteria established and described in item 2.0.

Figure 4 presents the screen of the result of the HOMER for this configuration.

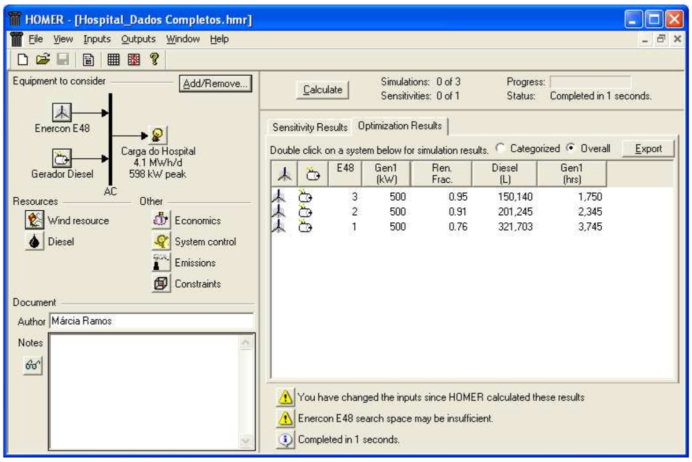


Figure 4 - Screen of the result of the HOMER simulation

5 – Results and Discussion

The result gotten through the simulation in the HOMER and posterior treatment in the Excel spread sheet is presented in the Table 3.

Table 3 - Availability of Wind Generation

Period of the day	Availability
Peak Load	23,65 %
Off-Peak	62,06%

With the use of the data of wind availability, an estimative of annual expense with electric energy was made, using Diesel and wind generation, as shown in Table 4.

Table 4 - Annual expense with hybrid electric energy

Period of the day	Demand/Consumption	Dry	Humid
Peak Load	Diesel generation	R$93.360,51	R$66.686,08
Off-Peak	Demand	R$47.943,01	R$34.245,01
	Consumption	R$55.318,85	R$35.871,01
Total Annual expense		R$196.622,37	R$136.802,09
		R$333.424,46	

Currently the annual expense with electric energy is R$733.356, 35, and the total cost of the investment, for this project, is about R$2.536.410,00. With regard to the Diesel generator set the value of R$0,5307 / kWh for the total cost of operation was considered, including the fuel, the lubricant and the maintenance. For the wind generation the cost of O&M was not considered. From these values was carried through the analysis of economic viability using the criterion of Net Present Value (NPV), with Minimum Attractive Rate of Return (MARR) of 10% in a year, what resulted in a NPV of R$868.567,50 and an Internal Rate of Return (IRR) of 15%. Figure 5 shows the graph of the distribution of the NPV throughout the years of useful life of the project, 20 years.

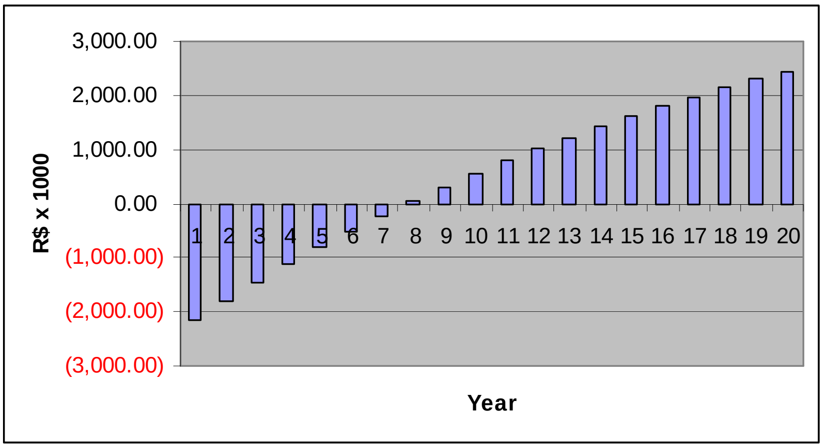


Figure 5 - Distribution Graph of the NPV

Through the graph of Figure 5 it is verified that the period for recovery the investment (payback) is of around 10 years.

6 – Conclusions

The analysis of economic viability showed to the attractiveness of the project, providing a reasonable payback time. In addition this alternative is on-line with the new world-wide ecological trends, using the advantage of a source of low environment impact and still little explored in Brazil. It must be noticed that was not considered in the analysis any form of official incentive as, for example, financing with lower interests or tax exemption. Moreover, the wind generator equipment, due to the great international demand, passes for a phase of upper prices. Coming back to a normal price situation, the project will be even more attractive. With an increase of the price of the fossil fuel or increase of the tariff of conventional electric energy, both possible circumstances in medium term, can also contribute to turn the investment still more attractive. A next step would be to develop a project pilot based on the results of the simulations indicated here.

7 – Bibliography

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