# WATER FOR WHO HAVE THIRST: SIMULATION WIND PUMPING FOR THE BAIANO SEMI-ARID

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*Abstract.* *Two insumos in the modern society have had attention for organisms and governments in the whole world: water and energy. Many times the two terms keep between itself sufficiently narrow relations, mainly when the use of the water is for generating energy. In this direction, when one searchs to associate a resource to the other we can establish for the societies suppliments of the necessities most basic, conferring an improvement of the partner-ambient conditions. The objective of this work is to analyze the perspective of use of wind pumping through computational System-wind simulation submerge pump (SEBS) being used existing wells and available data of wind in the state of the Bahia. The SEBS is composed for an wind turbine of small size, connected to a centrifugal pump machine. The data of entrance for simulation are: the time series of wind speed and average temperature of air, curve of power of the wind turbine, characteristic curve of the pump and height of pumping. The wind data had been gotten of the Platforms of Collection of Dados (PCD) installed and operated by the CPTEC/INPE in the Bahia. The characteristics of the wells had been collected of the data base SIAGAS of the Company of Research of Recursos Minerais (CPRM). The procedure consists of calculating the monthly average wind speeds for each place of interest and the same esteem the energy produced for an wind turbine of small size in period. From this information and with the characteristics of a submerged centrifugal pump machine standard and of the data of the well calculates the monthly volume of water pumped for each place. The result of this analyzes sample the great potential for use of simulation with the SEBS for water pumping in the Bahia.*

*Keywords*: *wind energy, wind pumping, simulation*

## 1. INTRODUCTION

The northeast region of Brazil, more necessarily the half-barren northeastern, presents great problems due to drinking waters lack for the population. In this region devoid communities exist, with scarce economic resources and absence of conventional electric energy (Lima Jr, 2006). The picture evidenced for Lima Junior is growing concern mainly if to consider that Brazil is one of the countries that the biggest fluvial volume of the planet has and the water availability for these communities ally to the partner-ambient distortions of these regions depends on action politics not very orthodox. The Bahia has a total of 9.945 wells registered in cadastre in the data base SIAGAS, being majority is intent in the central region of the one of the state where if it can perceive the regions Southwestern, Chapada Diamantina, North, Recôncavo, with a distribution disperse in the regions West and South, in a very ample universe for the development of water prospection of the underground layers through wind energy. In this work the wells of the Southwestern region of the Bahia had been evaluated for the attainment of necessary data to the simulation.

## 2. METHOD OF SIMULATION

The methodology used in this work consisted first place, to develop a tool capable to process given of wind from an anemometric station. The series had been gotten from the Platforms of Collection of Dados (PCD) of the CPTEC/INPE. The data then had been treated with statistic so that the same ones were used in the simulations. From the data they had been calculated the average speed, shunting line standard, intensity of turbulence, parameters k and c of Weibull, determined the predominant direction and had been also corrected by measurement-correlation-prediction method (MCP). The information on the wells are originated in the data base of the Sistema de Informações de Águas Subterrâneas (SIAGAS) of the Companhia de Pesquisa de Recursos Minerais (CPRM), beyond the information on the wind turbine used in the simulation and data of the pump and the windmap of the Bahia elaborated for the Brazilian Center of Wind Energy (CBEE). The region chosen for the simulation was the Southwestern region of the Bahia, as show the Fig (1).
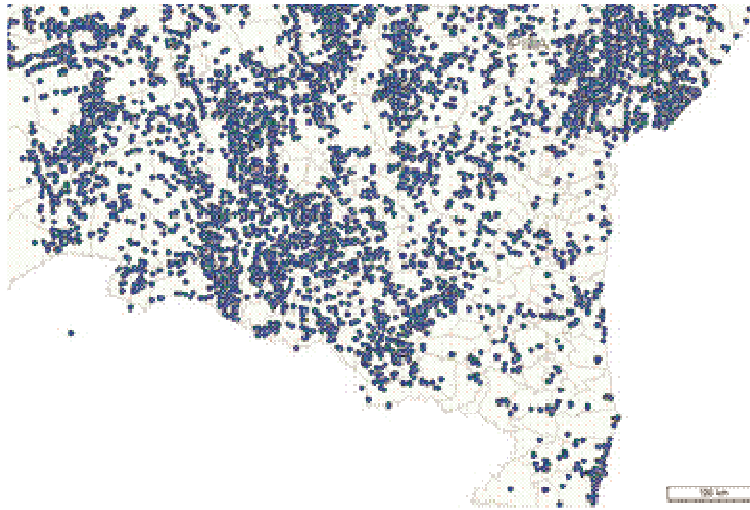
Figure 1. Map localization of underground wells of the Southwestern region of the Bahia.
Source: SIAGAS/CPRM

Figure 2 shows the southwestern region of the Bahia with its main cities where if it finds 1563 wells registered in the SIAGAS.
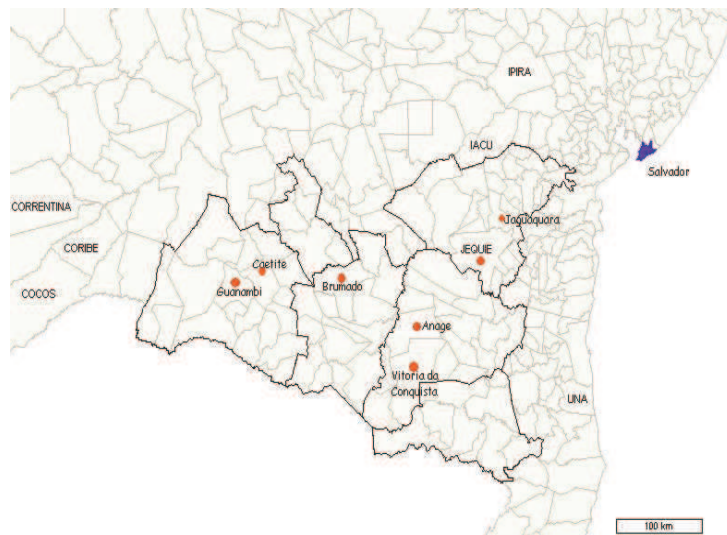


Figure 2 Map of the southwestern region of the Bahia

Of the total of the wells of the southwestern region, only 219 had been used in the simulations, Tab. 1

Table 1. Wells registered in cadastre and simulated in the southwestern region of the Bahia

| Microregion | registered in cadastre wells | Simulated wells |
|---|---|---|
| **1 Jequié** | 241 | 50 |
| **2 Livramento do Brumado** | 144 | 15 |
| **3 Guanambi** | 563 | 64 |
| **4 Brumado** | 294 | 38 |
| **5 Vitória da Conquista** | 321 | 34 |
| **Total:** | 1.563 | 201 |
| **Bahia** | 9.945 | |

In table 2, the average depths, average outflows, levels static and dynamic of the wells of each microregion are shown.

Table 2 the average depths, average outflows, levels static and dynamic of the wells of each microregion

| Microrregion | Average depths (m) | Average outflows (m³/h) | Static level(m) | Dinamic level(m) |
|---|---|---|---|---|
| 1 Jequié | 60,7 | 4,71 | 7,2 | 41,3 |
| 2 Livramento do Brumado | 49,9 | 3,90 | 5,95 | 39,6 |
| 3 Guanambi | 33,5 | 4,40 | 8,61 | 48,4 |
| 4 Brumado | 57,8 | 4,14 | 7,1 | 37,4 |
| 5 Vitória da Conquista | 80,6 | 3,90 | 7,1 | 48,4 |
| Average | 50,5 | 4,21 | 7,19 | 43,0 |

Before being used in the calculation tool, that not will be showed in this work, the wind series had been submitted the measurement-correlation-estimate methods (MCP). This method is necessary therefore, in general, the series presents derived from imperfections of diverse factors such as absence of data, given not numerical and others. The data are compared then with a site that this with the complete series, correcting from the correlation enters the data of these two series. Rogers (2005) considers a model that if she very showed useful for the cases in general evaluated. Thus, the series for each site had been adjusted so that the imperfections were eliminated and could operate with complete data.

### 2.1. Data of entrance of the tool

Time series of wind: it corresponds to the wind collected in station PCD corrected for MCP method. The time series was submitted to a normalization having used as show the Eq. (1)

$$v' = (v - v_m)/v_m \tag{1}$$

where $v'$ and the normalized speed of the wind in one determined moment, $v$ is the instantaneous speed collected by the PCD and $v_m$ is the average speed calculated for the place. This form of normalization shows to the behavior of the difference between the measured speed and the average of the series around the average. After that, using the wind map of the Bahia, a new average speed $v_{mm}$, gotten from the map, she is inserted in the calculation and gotten a new series of wind, now with the average speed adjusted of the wind map $v_n$, calculated from

$$v_n = v'v_{mm} + v_{mm} \tag{2}$$

After transformation above, the power curve of the wind turbine is used to make the interpolation of the data of wind of the PCD for the attainment of the power that is absorbed by the turbine and transferred to the pump, getting a series of power, in watt (w). The pump data, it corresponds to the relation enters the height of pumping and its respective outflow, in order to determine the type of pump to be used in the simulation. This relation is gotten experimentally through assays carried through for the manufacturer of the equipment for one determined regimen of functioning. More necessarily, for one determined normal rated power of the bomb, a series of curves is gotten to determine the relation between the total manometric height and the gotten outflow. However, as the wind power plant is not constant, the attainment of the outflow will be dependent of the power transferred to the bomb at that moment. For in such a way the calculation of the outflow it is gotten from the mathematical model (Mohsen, 1998)

$$Q = \eta_p P/(\rho_w g H) \tag{3}$$

where $Q$ is the outflow in m³/s, $P$ the power, of supplied to the pump for the wind turbine (watt), $\rho_w$ is the density the water (kg/m³), $g$ is the intensity of the terrestrial gravitational field, $H$ is the total height pumping, composed manometric height for the depth of operation of the pump, more the height of rise of the water in relation to the ground, and $\eta_p$ to the losses in the suction and in it stresses of the pipes. For the calculations it was used an wind turbine of 1000 W and submerged pump of 1,5 hp . The power mechanics effectively converted by the aerodynamic rotor of a wind turbine is gotten through the inclusion of the power coefficient cp that it takes in consideration the aerodynamic losses in the shovels and represents the fraction of the available wind energy that is being converted (Rohatgi and Nelson, 1994).

$$P= c_P\rho Av^3/2$$

Where $c_P$ is the aerodynamic coefficient of power of the machine, $\rho$ is the density of air in kg/m³, $A$ is the swept area of blade by turbine and $v$ is the windspeed in m/s.

## 3. RESULTS

The results gotten for the developed tool had propitiated the calculation of the monthly average outflow of each city in each one of the microregions of the Southwestern region of the Bahia. The Fig. 3 up to Fig. 7 show the monthly average outflows of the cities
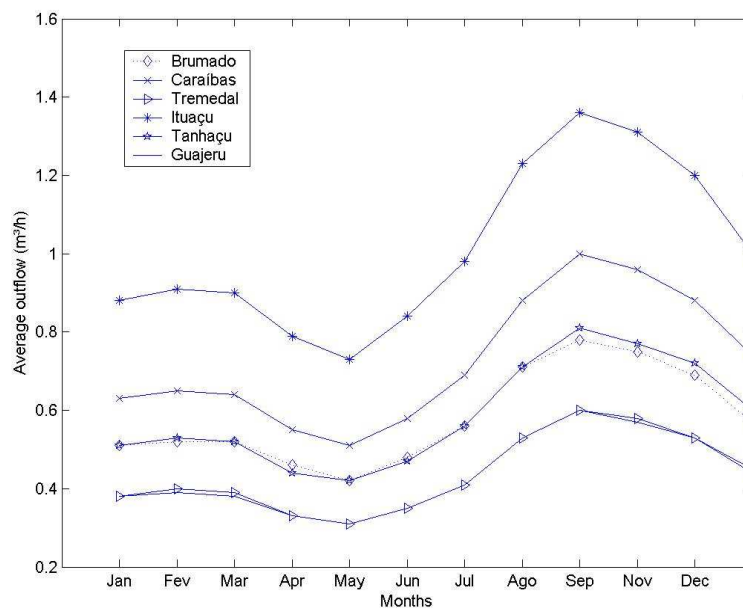


Figure 3. Monthly average outflows of wind pumping for cities of the microregion of Brumado, included cities Caraíbas, Guajeru, Ituaçu, Tanhaçu and Tremedal
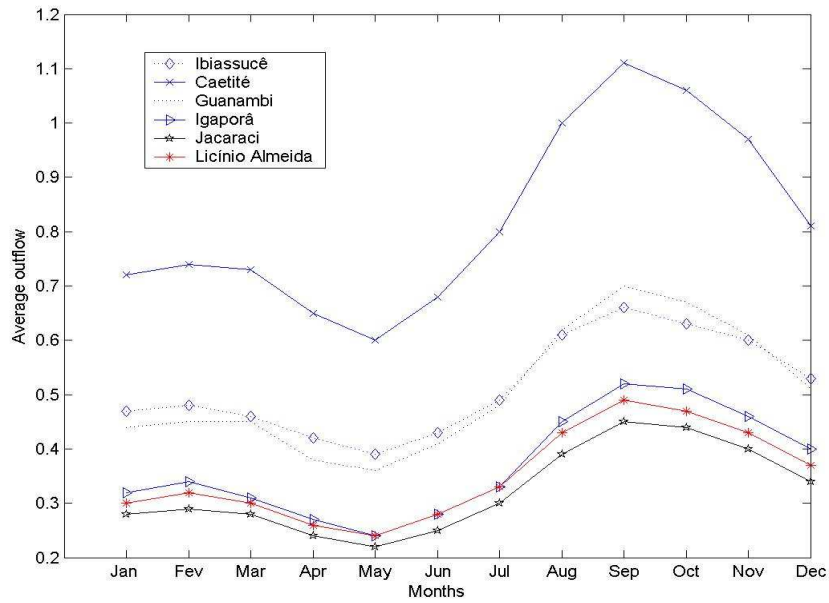
Figure 4. Monthly average outflows of cities of the microregion of Guanambi, included cities Caetité, Ibiassucê, Igaporã, Jacaraci, and Licínio Almeida
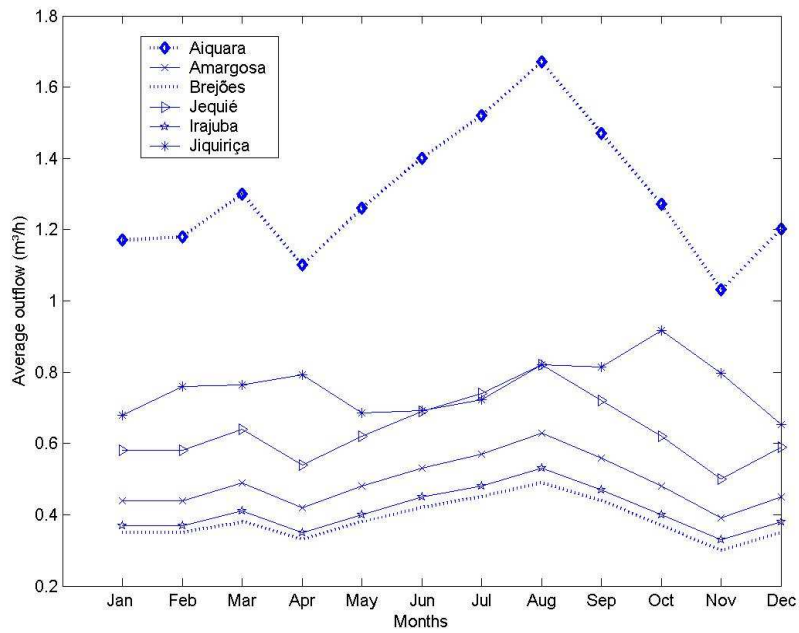
Figure 5. Monthly average outflows of cities of the microregion of Jequié, included cities Amargosa, Brejões, Irajuba, and Jiquiriçá
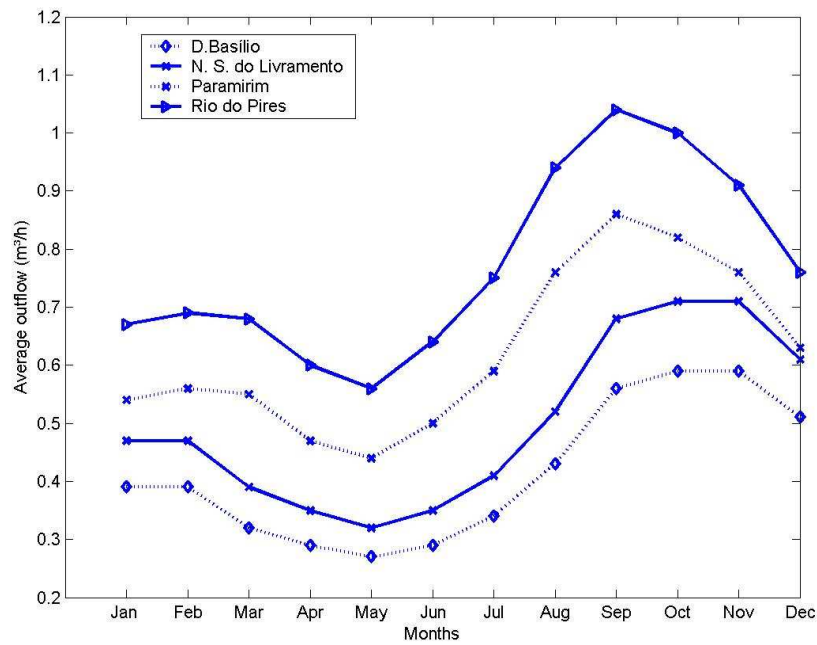
Figure 6. Monthly average outflows of cities of the microregion of N. S. do Livramento, included cities Dom Basílio, Paramirim, and Rio do Pires
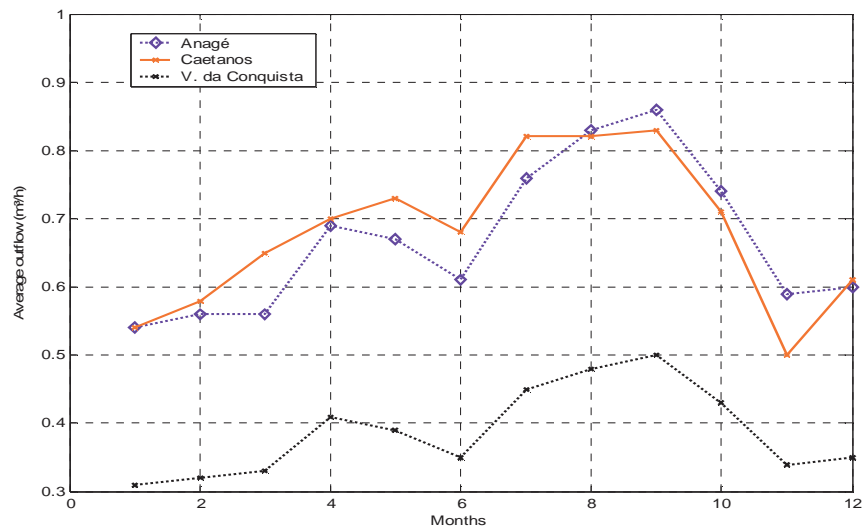


Figure 7. Monthly average outflows of cities of the microregion of Vitória da Conquista, included cities Anagé, and Caetanos.

With the tool, he was possible to effect to calculate the water production for each station, as they show the figures 8 until 12 with the average outflows for each one of the seasons, summer, autumn, winter and spring which allow to observe the occured variations during the seasons. A similar behavior for each distinguished microregion can be perceived, varying only in the intensity of occurrence of the simulated outflow.
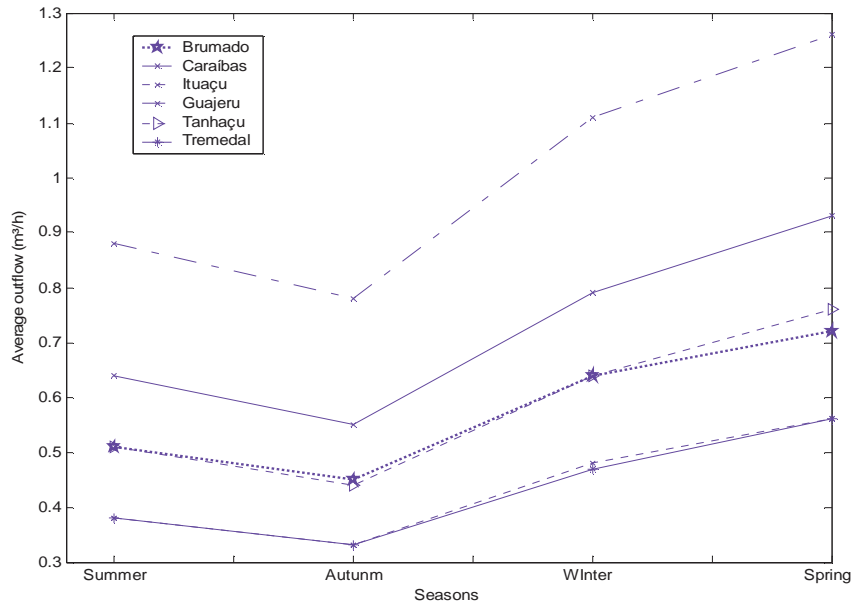
Figure 8. Average outflows of wind pumping per seasons of cities of the microregion of Brumado
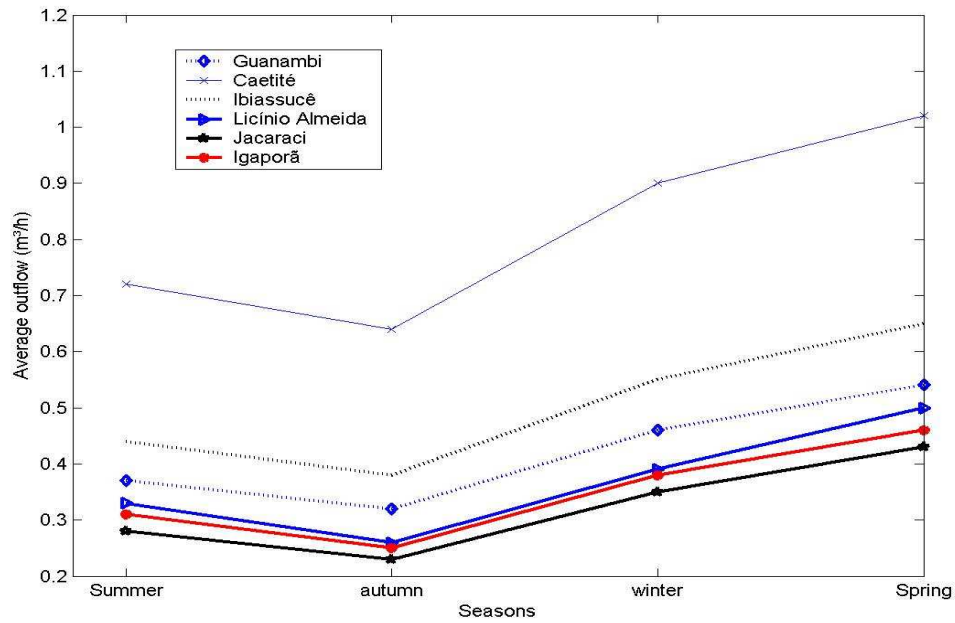


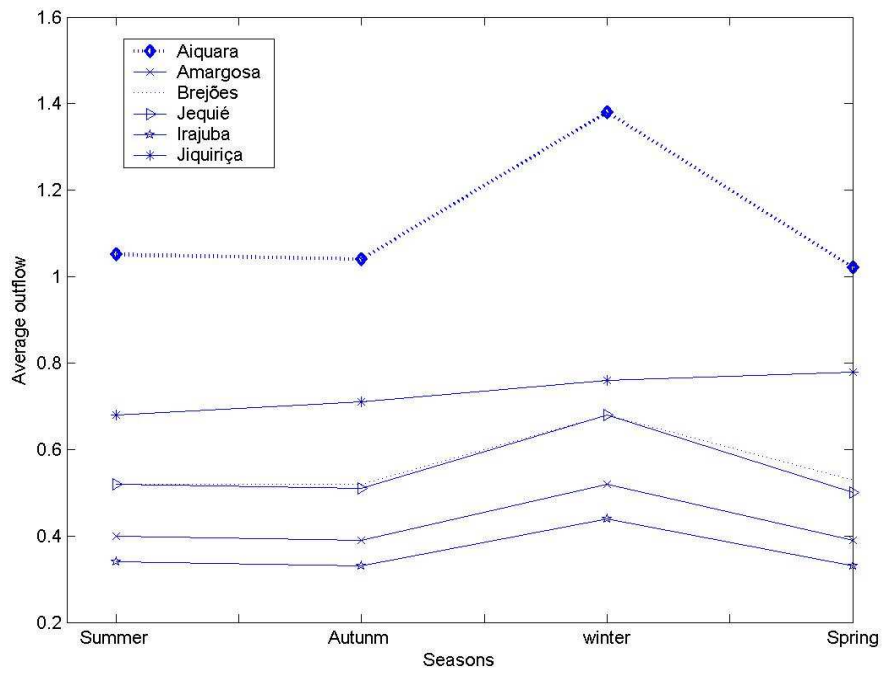Figure 9. Average outflows of wind pumping per seasons of cities of the microregion of Guanambi

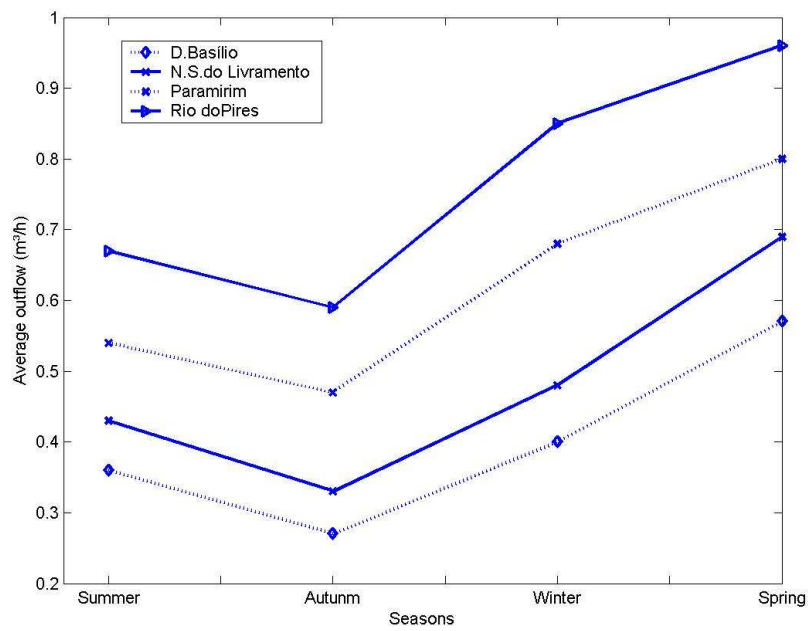Figure 10. Average outflows of wind pumping per seasons of cities of the microregion of Jequié



Figure 11.  Average outflows of wind pumping per seasons of cities of the microregion of Brumado
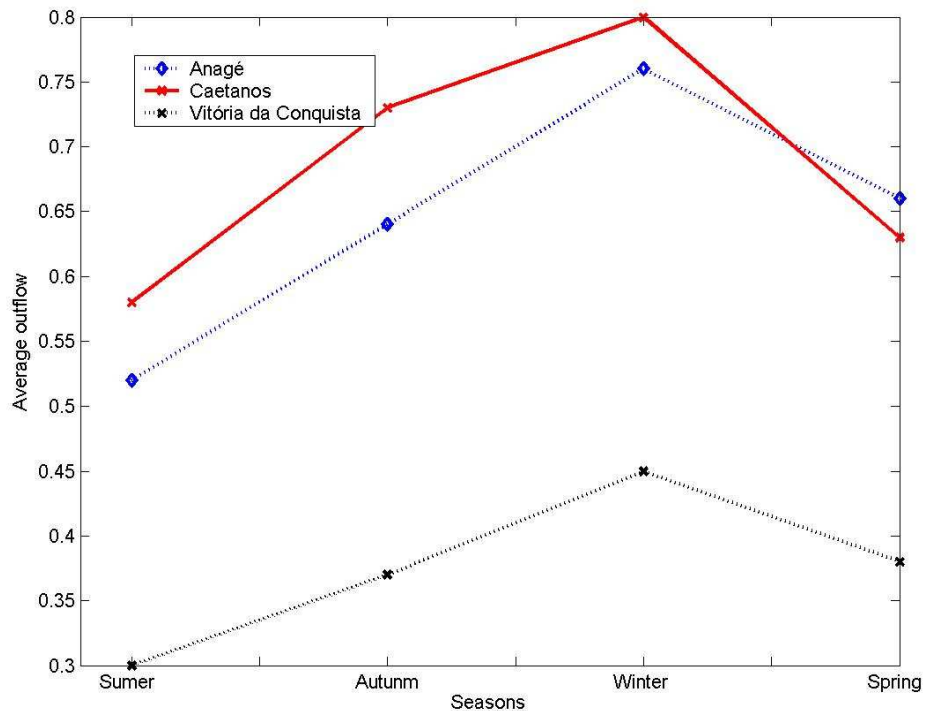
Figure 12.Average outflows of wind pumping per seasons of cities of the microregion of Vitória da Conquista

## 3. Conclusions

The main objective of this work was to make the water simulation that it pumps for half-arid of the Bahia, detaching the southwestern region, composed of for 89 cities and with deep marks for the lack of the water. However, the water many times is available only in the depths, stored in the intersticios of the rocks and the porosities of the subsoil. The possibility of extration of this water is many times limited for the access to the energy, mainly in the regions most remote, being able to be mitigated with the use of a renewable power plant as the wind. To carry through the simulation a program was elaborated that allowed the calculation of the average outflow pumped by month, the average outflow per season. The considered system was composed for wind turbine of 1000 W connected to a submerged pump of 1.5 hp of power nominal, the system with this configuration if it becomes thus an application for small communities, those that have difficulties in having suppliment of regular energy through the conventional net. For calculate it had been gotten given of wind of the PCDs stations of the CPTEC-INPE spread for all the state. Data of the wells had been gotten of the data base of the SIAGAS of the CBPM. For the correction of the data of wind speed for the simulation the wind map elaborated by the Brazilian Center of Wind Energy (CBEE) was used. Tables 1 and 2 will count given on the evaluated wells, presenting a depth average of 50.5 meters, outflow average of 4.21 meters for, levels static and second dynamic medium of 7.19 and 43.0 meters respectively of depth. The simulations had resulted in outflow data average of water pumped for the system Fig. 3 the 7. Also they had been gotten given of outflow average pumped for each one of the seasons as show in Fig. 8 the 12. The employed methodology allowed to establish a vision differentiated for evaluation of the conditions of exploitation of the wind energy through turbines of small connected transport the submerged bomb, mainly for regions where the water scarcity becomes useful a daily reality and revealing in the forecast of the capacity to get water from a renewable power plant as the wind one, so necessary in the current one I serve as apprentice of the modern society that passes for a crisis of global atmospheric heating.

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## 5. RESPONSIBILITY NOTICE

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