Renewable Energy, Possible Options for Cerrado and Caatinga

D. BASTOS-NETTO

INPE/LCP, Rod. Presidente Dutra, km 40, Cachoeira Paulista, 12630-000, SP, Brazil

ABSTRACT

This work suggests and discusses some alternatives to implement and/or complement the use of existing renewable energy sources by small and medium size communities in the Cerrado and the Caatinga Regions of Brasil.

INTRODUCTORY REMARKS

The enormous area covered by these two regions, so diverse in their overall characteristics and yet with so many important problems in common[1-5], has led this work to be done under the following constraints:

1- It may be applied to small and medium size communities,only;

2- The specific energy demands of a given community, be it located either in the Caatinga or the Cerrado, can be defined only after a detailed survey of its energy consumption patterns and major energy consuming activities, which will then be matched with the local solar biomass and wind energy potentials;

3- It should not be applied if hydro eletric power is easily available;

4- By the same token, in the case of electricity needs, one should always compare the overall costs of setting up a facility based upon a single non-conventional energy source or upon an optimal combination of those sources with those of a conventional fuel powered electrical energy plant, carefully weighting its financial, social and environmental pluses and minuses.

NEEDS VS. SOURCES

The following energy needs have been considered here:

1. electricity for domestic consumption;
2. electricity for social/educational requirements;
3. electricity for industrial/agricultural use;
4. portable fuel for existing conventional power users;
5. mechanical energy for driving devices other than electrical machinery (e.g., pumps);
6. thermal energy for high and low temperature uses.

These requirements should be fulfilled with the rational use of the following renewable energy sources:

– Solar
– Wind
– Biomass

The needs listed above can be described in a more detailed way:

Many settlements lack any kind of electricity, relying on wood, kerosene and/or LPG as their only energy sources. Some of these, for their size and relative local importance, should have some electricity for ligthing, communication and educational TV. Besides,these villages should have a local workshop with a minimum of electrical appliances for communal work. A few of them already have conventional Diesel generators but too often these equipments do not have enough fuel to run in a regular basis nor funding for a proper minimum maintenance program. Nearly all of them have the agriculture as their main/only activity. The lack of energy imposes severe limitations in their productivity as it curtails any chances of preserving and transporting their products to the nearest market. Some of them have nearby rivers or dams which could be used for irrigation purposes if energy were available for such chore. Quite often the existing wells in the neighborhood of a community are heavily polluted or just brackish, but nearly undrinkable. Then the obvious need is water pumping and purifying for domestic consumption, irrigation and industrial use. And yet, every one of them, either in the Cerrado or in the Caatinga has some abundance of at least one of the following "God given gifts":

— An Average Daily Insolation of 5.3 kwh/m^2/day, with over 2800 sunny hours/year;

— A nearly constant, smooth Wind, with an annual mean value of 8.0 m/s;

— A huge amount of native biomass, fit for aerobic or anaerobic fermentation, yielding liquid (alcohol) or gaseous (biogas) fuel or for gasification, providing synthesis gas.

A REVIEW ON THE EXISTING OPTIONS

I - SOLAR ENERGY

a - Photovoltaic Cells: Solar Energy can be harnessed through photovoltaic cells, thin silicon wafers that directly convert sunlight into electricity, a technology still relatively expensive but whose costs keep coming down as innovation is coming up. A module consists in an array of single cells delivering tipically 21 Volt,DC, with a short circuit current of 3.2 Ampere with a conversion afficiency of around 13%. This system usually requires a battery for off-hours operation and a DC/AC inverter which might then feed an electric motor to run, for instance, a pump (Photovoltaics can also be used in many other ways, obviously). The system is very practical and reliable, being specially suited for use in isolated spots with low level electrical power requirements[6,7].

b - Solar Collectors: These devices convert solar energy into thermal energy, which then can be used directly for heating or as the heat source in a conventional Thermal Engine. They can be plane (or flat plate) collectors or Concentrating Collectors.

Flat Plate Collectors can be manufactured and qualified in any country with a minimum industrial infrastructure. They are convenient for fairly low temperature processes and can use water, air or some low boiling point liquid to be the working fluid in a thermal engine. The standard type, operating in temperatures of up to 85^{o}C is convenient in the drying process of agricultural items and in air conditioning systems. The collectors with a double glass cover operating up to 95^{o}C, find their use in thermal plants up to 50 kw and the ones with selective coatings, more expensive, able to operate with temperatures up to 150^{o}C, besides being used in thermal power plants (up to 50 kw), are also used in the production of Process Heat for industrial processes and in absorption type refrigeration units.

Concentrating Collectors work at much higher temperatures and offer better energy outputs as they are made to track the sun, being a lot more expensive and sensitive to the local clouds pattern. They can be of parabolic trough type (with one or two axis tracking capability) which operates up to 300^{o}C, normally used in power plants up to 500 kw for destillation, desalination and refrigeration. There are also hemisphere and paraboloid concentrators which operate up to 800^{o}C and Heliostats with central absorbers which work up to 1000^{o}C, for very large Solar Power Plants (1Mw), for production of Hydrogen or small devices for liquid fuel processing. There are many other devices such as solar ovens and solar stills[8,9], which have been in use for a long time. Fuel Cells are also used in connection with solar energy devices.

II - AEROGENERATORS

Wind engines[10] can move electrical generators or directly drive mechanical devices such as water pumps or mills. They are specially suited for areas with nearly constant, permanent winds. The electricity generated by aerogenerators can be hooked into the existing local power grid line through proper regulation, control and synchronization. An array of wind machines can be also hydraullically interconnected, the network then feeding a water turbine which will move an electrical generator[11]. Although there are several types of wind machines, they fall into two main categories:

a - Longitudinal Axis Machines: Those in which the machine axis is parallel to the wind during the operation, like the conventional windmill and the modern, large (up to 500 kw each), 2-3 blade propeller aerogenerators which are in use by the hundreds in the "Wind Farms" in the USA (California and Colorado).

b - Transverse Axis Machines: As the name suggests, those machines in which the rotating axis is normal to the wind direction, such in the Savonius and Darrieus types and in the Chinese Windmills.

III - BIOMASS ENERGY

Besides the generally unwise way of direct burning, biomass can yield energy through aerobic fermentation, anaerobic fermentation or gasification processes[12-14].

a - Aerobic fermentation: Vegetals rich in starch or celluloses (For instance, Sugar cane, cassava and babaçu palm, etc.) can be processed this way. These biomasses yield alcohol as their main energetic output.

b - Anaerobic Fermentation: In this process, certain vegetals, industrial residues and animal rejects are converted to biogas with a reasonably high methane content. This biogas can then be used for heating, cooking,to run a conventional internal combustion engine or, if extra energy is available it can be synthetized into a liquid fuel[15].

Many bodies of water are seasonaly clogged with the well known plague, feared by river pilots and dams maintenance people, the Water Hyacinth or Water Lilly, the *Eichhornia Crassipes* (known in Brazil as Baronesa, Aguapé, Mururé or Santa Luzia). This plant, with a productivity of around 300 ton of dry matter/ha/year, yields a first rate biogas (nearly 60% methane) through anaerobic digestion, its remains can be used as a fertilizer and the drying and bricketing of the plant for off-season use can be easily done[16-20].

c - Gasification: This way vegetals are converted to synthesis gas, which can be used for heating purposes or transformed into liquid fuel or yet be used as the fuel source of a fuel cell for electrical energy generation.

SYSTEMS CHOICE AND SIZING

For this to be effectively done, it is not enough to have reliable information on the available energy sources and actual needs, but economical, social and ecological aspects must also be carefully investigated:

— The local weather has to be known, i.e., the yearly distribution of solar energy (direct and diffuse), the amount of sunshine hours, the cloudness distribution, i.e., its incidence rate, and pattern. The same for wind parameters, such as its velocity (speed and course) distribution and frequency. Although these are data usually collected by weather stations it is also helpful to observe if in the prospective location there are spots used by the people as better suited for sun drying and if there exists (or existed) any wind mills around, as these are good indications of solar and eolic energies satisfactory availability, respectively. Also the local story of floods, draught, very high wind gusts, thunderstorms and other Nature extreme manifestations should be investigated.

— The local biomass potential has to be carefully assessed. The amount of human and animal waste and the type of agricultural refuse should be determined, as well as the relative abundance of native biomass such as the water hyacinth and other appropriate vegetation suited for energy extration (other than direct burning).

— It is essential to know the local energy consumption pattern and its more demanding activities energywise. Besides common needs such as lighting, heating and cooking one has to check on the daily and seasonal energetic requirements for water pumping, irrigation, milling, food processing and storage. It is wise to plan also for the expected needs expansion once the new system goes into operation.

— The final decision upon which kind of source (or sources combination) will be used and up to which kind of sophistication degree one should go, cannot be taken without a careful assessment of the local technical infrastructure, as it is important to check on the existence and availability of local skilled labor (for maintenance and operation) and on existing shuttling facilities with bigger population centers. Quite often the lack of those facilities might lead to the so called "kiss"[1] approach as the only feasible way of solving the problem.

— In running the new system cost/benefit analysis one should also keep in mind that kerosene, diesel oil and LPG, items used for low and medium temperature heat requirements, are often shipped from far away places, thus increasing the overall fuel cost. Also, dung, animal matter and other assorted biomass, frequently consumed for heating through direct burning, can be better used in biodigestors, generating biogas and fertilizer as an important subproduct.

— It is also very important to enlist the good will and cooperation of local leaderships. If possible they should be present at meetings and be given responsabilities.

— The community traditional way of life should be known and respected. The new system should be taylored to fit into that pattern.

— Finally, the environment impact has to be carefully weighted and wisely minimized. It is well known that several renewable energy extraction techniques generate unwanted refuse, side effects and byproducts. For instance, the well known stillage ("vinhoto", in portuguese), generated in the aerobic digestion of biomass for ethanol production, requires special care and handling (which can be done easily); the Water Hyacinth, a very good plant for biogas production, can pose as a serious navigation problem, as it floats down river in very large packs, during the rainy season. These packs ("camalotes", in portuguese) have shown to be able to become an ecological threat, as they can effectively block the surface from air breathing water living species (this was done to the Manatee – "peixe-boi", in portuguese, back in the sixties, in the French Guiana). These packs can also be a habitat for the "*planorbidea*" (the snail that hosts the *Schistosoma Mansoni* Larvae, responsible for the Schistosomiasis).

THE STATE-OF-THE-ART

Fortunately, several steps which have been taking place lately in the Caatinga and in the Cerrado, towards the rational use of renewable energy, are already bearing fruits and will be a very strong point when time comes to push the States and the Federal Governments into establishing a firm, well defined National Policy for Renewable Energy. Some of these steps are worth mentioning:

— The State of Ceará (SETECO) and Germany (BMFT and BMZ) have provided, through COELCE and GTZ, the installation of Photovoltaic Water Pumping Systems in fifteen small communities in the Caatinga Region. The equipments, operated and maintained by the local people, have been running perfectly for more than thirty months now. It might be interesting to note that the choice of the wells drilling points has been done by FUNCEME (using Satellite Images to spot "cracks" which tell about the existence of subterranean water courses) and with the assistance of the SEREHI of Ceará which performed the proper soil analysis, in a well coordinated effort.

— All the States with land within the Caatinga Region have been awarded projects with the U.S. Department of Energy (through CEPEL of Eletrobras) dealing with the setting up of Solar Photovoltaic Systems for domestic use in that Region. Each system contains, besides the obvious Photovoltaic Module (50 watt peak), two 20 Watt fluorescent lamps, a 100 A-h Battery, a load con-

[1]kiss = "keep it simple, stupid"

troller and one plug for B&W TV or radio set. The only donnated items are the Module, the Controller and the first Battery. Everything else is being provided by the State Power Company (i.e., the whole system installation and maintainance, the wiring, boxes, switches, lamps and future (once every 3 years) battery replacements). COELCE in Ceará has installed around 300 of its alloted 450 units and COELPE of Pernambuco has circa 400 operating units.

— The Eldorado Project (a German Government Project to finance up to 75% of the total cost, projects in the area of renewable energies, mainly Photovoltaics and Eolic) has installed a 1 Megawatt Eolic Park (a pilot plant consisting of four 250 Kw Tacke Aerogenerators) in the State of Minas Gerais, in the Cerrado, which is operating under a capacity factor of around 20%. This same Project has chosen the Port of Mucuripe in Fortaleza, Ceará, to install another 1 Megawatt Eolic Park. It will probably operate under a capacity factor of around 55%, as these machines are designed for a nominal 8 m/s wind and generate electricity with winds between 4.5 and 15 m/s (the yearly average wind speed there is just about 8.0 m/s). It is important to notice that the huge "wind farms" in California operate under a mean capacity factor of around 25%. It should be kept in mind that, although the coast of Northeast Brazil presents very good conditions for wind energy application, this is not so in the Caatinga Region, as the wind drops very quickly as one moves inland.

— Transmiting this shore wind generated power to Caatinga users does not seem to be wise nowadays, for there the population is very widely dispersed, thus presenting a very low specific power consumption profile. This is not so with the Cerrado, with more than 140 million ha. of land which can be used for agriculture and a far superior wind distribution regime.

— It is worth mentioning that there are plans in the Government of the State of Ceará to set up two Eolic Parks (30 Megawatt each). One of them has already been approved by the proper agencies (the financing being arranged through the Japanese Banking System). The author hopes that the States in the Cerrado do the same.

— The use of solar concentration units for high temperature power generation does not look too promising, on the average, for use in these regions, mainly because of the clouds distribution factor.

— This is not the case with photovoltaic panels and plane collectors which can operate satisfactorily under those conditions. The Northeast of Brazil is among the best customers in the world for those two items. It is a pity that all their manufacturing plants and representatives are located in the Southeast of the Country (Heliodinâmica, Siemmens, Solarex, etc.).

— Concerning the use of Photovoltaics, there exists a very large number of household items which can be readily adapted for that kind of power, such as a sewing machine or a blender. Many of them can already be bought abroad (Solar Battery chargers, radio sets, flashlights, blenders, etc.). A small freezer for vaccine conservation, adapted for use with Photovoltaics, would be very useful during vaccination campaigns. Photovoltaics could be used also in selective irrigation projects such as communitary vegetable (lettuce and tomato) and high vitamin content "acerola" gardens in rural schools for students' lunch complement.

— The Laboratory of Thermal Sciences of the Department of Mechnical Engineering of the UNB is developing techniques to optimize Otto-cycle I.C. Engines fueled with biogas. The existing system can support the daily requirement of three buses and of a fleet with seventy taxi cabs.

— The UFCe deloped techniques for biogas production from agricultural residues and rural ovens fueled by either biogas, charcoal or wood. This University is developing processing techniques for lignine extraction from sugar cane bagass and is working on the treatment of the cashew nut shell liquid (Brazil has 95% of the world production and India has the remaining 5%).

A NOTE ON A CONVENTIONAL ENERGY SOURCE

Among the so called Conventional Energy Sources, Hydro Power is the cleanest one, although a lot of care is always required to minimize the environmental impact caused by a new dam or a change in the regime of a river. As Hydro Power nevertheless is a renewable energy source it is worth to look into some aspects of this option, which might be of interest to the Caatinga and Cerrado Regions.

The rivers in the Northeast are temporary. The only naturally permanent rivers in the region are the São Francisco and the Parnaíba. Other rivers have become nearly permanent due to the presence of dams (this was the case of the rivers Acaraí, Curu, Jaguaribe, etc). However, that was not so in the past. Permanent rivers with natural water falls and reservoirs ("boqueirões", in portuguese) had their embankments eroded and became temporary. It would be interesting to rediscover these river "shoulders" and to remake them, giving these bodies of water the oportunity to go back to their original conditions.

Two very important rivers in the Cerrado, the Tocantins and the Araguaia, can be thoughrouly normalized as a follow up of the Tucuruí Dam System. This way, besides the obvious energy generation aspect, both rivers could be made navigable for barges and Aruanã, on the Araguaia, is just 400 km away from Brasilia.The Parnaíba river could also undergo the same treatment, an obvious consequence being the support to the last frontier of the soybean production in the Country.

CONCLUDING REMARKS

It is important to list some Government efforts which might also help the establishment of the so much needed National Policy on Renewable Energies:

— The PRODEN (MME): A development project for the use of renewable energies on a county level, to be financed by Petrobrás.

— The ARIDAS Project: To be a follow-up of Project PAPP, envisaging the self sustained development of the semi-arid region, coordinated by SEPLAN-PR with the support of the World Bank and the IICA.

— And last but not least, the very recently presented "Declaração de Belo Horizonte", a document prepared under the auspices of the MME and the MCT, which will serve as basis for the National Policy in the fields of Solar and Eolic Energies[21].This document contains the conclusions of a meeting to define the guidelines for the development of solar and wind energies in Brazil, which took place last April in Belo Horizonte, MG. The Document is very clear and positive (as it was approved by 106 participants from 76 entities and capably coordinated by CEPEL, which undoubtly should lead the overall effort in the field). One may pass as pessimist but this author wonders about the goals to be reached by the year 2005: One thousand Megawatt of harnessed wind power (i.e., four thousand 250 kw aerogenerators, obviously hooked to the existing power grids); Fifty Megawatt of photovoltaics (the whole world shipments of photovoltaic cells during the year of 1992, increased 5%, to 58 Megawatt) and three million square meters of thermal-solar generation (nearly ten per cent of the 1994 projected overall plane glass production in Brazil). He hopes he is wrong.

Finally, the Government must be aware of the Plans for the UN Solar Energy Decade. This 10-year program (with research, training and technology transfer components) was recently agreed at UNESCO and a 1995 Conference to be attended by heads of state is being planned as the formal launching platform for the event[22].

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LIST OF SYMBOLS

ABEAS:	Associação Brasileira de Educação Agrícola Superior
BMFT:	German Federal Ministry for Research and Technology
BMZ:	German Federal Ministry Economic Cooperation
CEBRACE:	Companhia Brasileira de Cristal
CEMIG:	Companhia Energética de Minas Gerais
CEPEL:	Centro de Pesquisas da Eletrobrás
COELCE:	Companhia Energética do Ceará
FUNCEME:	Fundação Cearense de Meteorologia
GTZ :	German Society for Technical Cooperation
INACE:	Indústria Naval do Ceará
INPE:	Instituto Nacional de Pesquisas Espaciais
MCT:	Ministério da Ciência e Tecnologia
MIC/STI:	Minstério da Indústria e Comércio/ Secretaria de Tecnologia Industrial
MME:	Ministério das Minas e Energia
PRODEN:	Projeto de Difusão de Energias Renováveis
SEPLAN-PR:	Secretaria de Planejamento-Presidência da República
SEREHI:	Secretaria de Recursos Hídricos (Ceará)
SETECO:	Secretaria de Transportes, Energia, Comunicação e Obras (Ceará)

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QUESTIONS

Question (1) – *I have a question about the prices and the way to produce photo- electricity? Do you have an idea about that?*

Bastos – Yes, we do have in Brazil. I didn't mention this because I had too much information. It is a pity because all the potential we have... We have a plant in São Paulo which uses outside technology and its cost is nearly twice as much as the price when you bring it from abroad. But the people claim and they have the potential to grow. It's a pity that all these people, the people who deal, not only the plants, but also the representatives of plane collectors and photo cell, there are only in the South, and they may be one of the best customers in the world for these kind of equipments. They do not have any representatives there. Why, I don't know.

Question (1) – *And what about wind energy? You mentioned that in the States there are some attempts?*

Bastos – Oh, yes. If you have, for instance, the kind of wind you have in the coast of the North-East, which you have a mean average wind at a speed of 8m/second, you can think in terms of wind energy use. Two ways: a local way, you use a small wind generator, then you better use one of these transfer generators. Just two oils drums is the consumption. We operated then in Cabo Frio many years ago, for nearly two years. I just pointed to Admiral Ibsen and may be he remembers. But we operated a wheather forecast station, an automatic station, for nearly two years. It was made out of just two oil drums. And then we had a electric car engine.