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Energy Policy in Brazil in the Context of Global Energy Security and Environmental Constraints: The Case of Electric Power

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1 Introduction

The goal of this paper is to discuss the present Brazilian energy policy from the global energy security point of view, by considering both the St.Petersburg Declaration of the G8 Summit 2006 and the interests of emerging countries, such as Brazil. The rise of the international oil price affects natural gas and, therefore, electricity generation – even though today the share of oil in the world economy is lower than at the times of the 1973 oil shock. In a global scale, that share in the costs of the products in general is half of what it used to be. The price of US$ 70/barrel is lower than what it reached in 1979[1] with the second oil shock. The oil supply issue, aggravated by the geopolitical tension in Middle East, and the environmental constraint, mainly due to global warming[2], put energy policy again in the center of international debate. Brazil has been involved in this debate due to his successful program of sugar cane ethanol in substitution for gasoline. It is considered now as an alternative for the ethanol from corn in the US[3], with the advantage of burning sugar cane bagasse instead of fossil fuel in the distillation process, avoiding net greenhouse gas emission. Brazil achieved self sufficiency in crude oil production. However, the electric power in Brazil deserves attention because it is moving from hydroelectricity to thermoelectricity, that means higher greenhouse gas emissions.

2 The electric energy problem

The debate on electric energy in the beginning of President Lula's second term in office, in 2007, became more intense. A governmental plan[4] was announced with great expectation to overcome the low rate of growth of the Brazilian economy over the last decade. Therefore, the success of the plan is important and energy must not be a bottleneck. The problem is that thermal power plants are being introduced without taking into account the Brazilian hydroelectric system. The recent energy auctions lead to coal and diesel thermal plants, which are both expensive and pollutant, besides emitting more greenhouse gases.

The first sign of the problems that are in the root of the current debate was the shortage of electric energy[5] in 2001 after the privatization of most of the utilities in the electricity distribution sector and part of the generation and transmission sectors.[6] In the beginning of the president Lula first term, in 2003, there was the interruption of the privatization process and the "New Structure of the Electric Sector" was approved. Eletrobrás is a holding which includes all the federal electric power companies, that operate most of the hydro-plants in the country, and includes also the Brazilian partnership with Paraguay in Itaipu bi-national hydro-plant.

After the 2001 electricity shortage, there was a strong decrease of demand. The energy surplus in the short term pulled the price down at the *spot* market. By order of the regulation applied by the government, the federal power companies (that belong to Eletrobrás) had to sell their energy at the *spot* losing revenues and reducing their investment capacity. To give an idea, hydroelectric energy was sold to the private distribution utilities according to former contracts at U$ 40/MWh, while at the *spot* it only reached U$ 9 /MWh. Some of that energy at the *spot* served to substitute contracted energy from thermal power plants, that remained turned off, since the National System Operator wouldn't dispatch them if there was an adequate level of water in the hydroelectric power plants' reservoirs. The free consumers, large industries that are energy intensive, bought cheap hydroelectric power and currently absorb important part of the Brazilian electricity.

The introduction of the thermal power plants unfolds in the problem of the natural gas that is not available for electricity generation. A second aspect related to that last issue is technical in nature: how to insert the thermal power plants in the Brazilian mostly hydroelectric system. For this to happen there must be a review of the very method used to define risk and cost of the deficit and the use of the aversion to risk curve due to hydrological variation.

The result of the recent electric energy auction was symptomatic. One goal is to transfer to the consumer the advantage of the existence of old hydroelectric power plants. In that aspect, the auction's goal did not reach the expected result.

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1 In dollars of 2007

2 IPCC, Intergovernmental Panel on Climate Change, Forth Assessment Report, 2007

3 Meeting of Presidents Lula and Bush, 2007

4 Plano de Aceleração do Crescimento (Economy Growth Acceleration Plan), PAC, 2007

5 L. Pinguelli Rosa and L. Lomardo, The Brazilian Energy Crisis and a Study to Support Building Efficiency Legislation, Energy and Buildings, vol. 36, p. 89-95, 2004

6 L. Pinguelli Rosa, M. Tolmasquim and J.C. Pires, New Strategies for Power Companies in Brazil, in European Energy Industry Strategies, Editor: A Midttum, Elsevier, Chapter VIII, 2001

A study[7] presented in a seminar at Industry Federation of S. Paulo on January 2007, shows that electricity in Brazil has become more expensive than in many rich countries, specifically than in those countries that rely heavily on hydroelectricity, such as Canada (Figure 1).

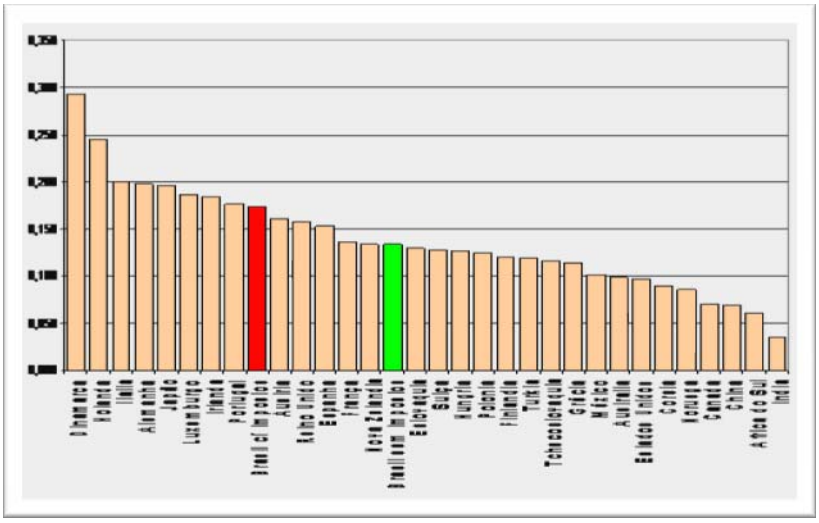

Figure 1 – Residential electricity rates (US$/kWh) (Source: D'Araujo, 2007) .

In the first auction for the building of new power plants it was expected that the supply growth should give priority to renewable energy, especially to new and cheaper hydroelectric power plants. But, from seventeen hydroelectric power plants in the first phase, the government only obtained environmental licenses for six of them. Since the environmental licensing process of a hydroelectric power plant is more complicated and takes longer (years) than that of a thermal power plant (few months), oil, diesel and coal power plants were enabled in the auction, besides natural gas and sugar cane bagasse, which are much better.

3 Thermoelectricity and the natural gas issue

As far as the thermal power plants are concerned, fossil fuels pollute the atmosphere too much and produce expensive energy due to the fuel price. The criterion used in the auction was to select the thermal power plants with the best cost-benefit ratio, which takes into account both the investment cost and the additional cost when the plant operates using fuel. That latter cost depends on for how long will the plant be operated within a period of twenty years. That will depend on the availability of hydroelectricity in the system, since the thermal plants operate as a complement. It makes no sense to burn fuel, which is both fossil and expensive, if there is water to turbine in the dams. Therefore, it is necessary to estimate the actual operation time.

The problem is that there is uncertainty in that estimate. In an optimistic prediction, the thermal plant will remain turned off for most of the time, serving to provide security to the system in the case of lack of rains. In this case, however, they will consume too much expensive fuel besides the air pollution they will cause.

In short, Brazil, that is proud to have a clean energy mix, moves from hydroelectricity to low efficiency thermal plants. And, successively, it will move from natural gas – which barely began to be used – and from sugar cane bagasse – which could be used more often to produce electricity to the network – to oil, diesel and coal – which are more expensive and more pollutant besides contributing more for the global warming of the Earth, discussed in the IPCC Report (ref 2).

In the turn from 2006 to 2007, there was a growing concern about the possibility of a new electric energy shortage. But the current situation is different from what happened in 2001. The rains in the end of 2006 and in the beginning of 2007 were favorable. In the reservoirs of the hydroelectric plants the average water level is above that which is determined by risk aversion curve, defined as the limit to be avoided. If the rains decrease and/or the economy grows and consumption increases, the thermal plants will be turned on to avoid a high shortage risk in in 2009-2010. But many of them do not have gas available. That's the question.

There is no gas available for those thermal plants to operate for a longer period of time. As thermal power plants in the Brazilian system operate as complements to the hydroelectric ones, it makes no sense to spill out water while burning natural gas, which is fossil and imported from Bolivia. However, when the average level of the reservoirs drops too much, the thermal plants must be turned on, if there is a lack of new hydroelectric plants. There is the problem of the usual contracts of natural gas, in which there is payment for the use of gas without interruptions according the take or pay system. To face this problem, Brazil intends now to import liquefied natural gas (LNG) by ships, which either may be

[7] Roberto D'Araujo, Seminar at Fiesp, January 2007

done or interrupted according to the need. The problem is that it takes a time to build re-gasification plants.

4 Hydroelectricity and global warming

In the beginning of the first term of Lula government, investments were made to double Tucuruí hydro-plant in the North, for two new turbines of Itaipu in the South and to build Peixe - Angical hydroelectric plant in a partnership with Energy of Portugal.

The problems of hydroelectricity due to the environmental issues and to the movements against the great dams lead to the tendency of abandoning that power source. The government must negotiate democratically with the environmental movements. But the environmental rules must be obeyed and it is a government task to convince society of the quality of the projects.

Due to environmental impacts, the size of the areas flooded by future dams in Brazil must be reduced, such as in the case of Belo Monte. In 2003 Eletrobrás has reviewed its project, substantially reducing the area affected by the reservoir. Although part of potential power is lost on the other hand, that might be the price to be paid to minimize its impacts.

Concerning hydroelectric environmental problems, emissions of greenhouse gases (GHG) measured in several reservoirs by Coppe and by USP/São Carlos. Even though the emissions by hydroelectric plants were not considered in international GHG inventories, those studies that the research group of the International Virtual Institute for Global Changes of Coppe made in several reservoirs showed that they emit both methane and carbon dioxide, though in general it is less than the thermal plants do.[8]

5 Nuclear electricity

There is no consensus in Brazil concerning the nuclear optio. However, the criticisms made in the 1970's/1980's to the nuclear programs of the military governments still have an impact, specially regarding the Nuclear Agreement of 1975 with Germany, which intended to build eight reactors of 1,300 MW each until 1990 and to transfer the fuel cycle technology. Nuclebrás, a Brazilian state-owned company that joined the German Siemens, forming several subsidiaries in Brazil, was created for that reason. The facts justified the criticisms. Today, more than thirty years later, only one of the Agreement reactors, Angra II, has been built and the *jet nozzle* technology to enrich uranium did not work. Later the Navy successfully developed enrichment through ultracentrifuges within the project of a nuclear submarine, which includes the development of a small PWR reactor for naval propulsion, yet to be materialized. Enrichment technology is being transferred from the Navy to the civilian Nuclear Industries of Brazil (INB).

During President Collor's term the secret project of a nuclear test at the Cachimbo Air Base, denounced by a report of the Brazilian Physics Society, was eliminated. After that, Brazil ratified the Treaty of Tlatelolco, for the de-nuclearization of Latin America, and implemented the Brazilian-Argentinian Agency for the Accountability and Control of Nuclear Materials (ABACC), an agency for mutual inspections of both Brazilian and Argentinian nuclear installations. President Fernando Henrique signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and Brazil integrated, along with Sweden and other countries, the coalition for a new agenda within NPT, for the reduction and later elimination of the military powers' nuclear arsenals. Unfortunately, that reduction is not taking place.

President Lula's government resumed the issue of nuclear energy with the decision to build Angra III. That would be the second reactor predicted by the Agreement with German and much of its components was imported from Germany and has been stocked for decades in Brazil. There are almost 700 million dollars worth of Angra III equipment stocked, but to finish the work it will be necessary another 3.5 billion dollars, part of which would be funded by France, since the French company Areva currently controls Siemens - nuclear.

Hydroelectric power remains the least expensive one. When we compare thermal power from fossil fuels with nuclear power there is great sensitivity regarding the return rate, as well as regarding the future price of natural gas.

From the environmental point of view, today nuclear energy has the advantage not to emit

[8] L. Pinguelli Rosa, M. A. Santos, B. Matvienko, E. Santos and E. Sikar, Greenhouse Gas Emissions From Hydroelectric Reservoirs in Tropical Regions, Climatic Change, vol. 66, 9-21, 2004; L. Pinguelli Rosa, M. A. Santos, B. Matvienko, E. Santos and E. Sikar. Scientific Errors in the Fearnside Comments on Greenhouse Gas Emissions (GHG) From Hydroelectric Dams and Response to His Political Claiming, Climatic Change, vol 75, 1 – 2, 2006

sgreenhouse gases. The thermal plants emit a lot of carbon dioxide using fossil fuels such as coal, oil and natural gas.

In the case of nuclear energy the most difficult issue is the problem of the radioactive waste. Low and medium radioactivity waste may be treated in a similar way to the material contaminated in a accident in Brazil. High radioactivity wastes are much more problematic, remaining dangerous for thousands of years. There is no consensual solution for them in the world.

6 Technological perspectives of nuclear energy

The uranium enrichment technology by ultracentrifugation has been developed by the Navy for a nuclear submarine project (moved by nuclear propulsion) and it is expected to be used for Angra I and II. During the 1973 oil crisis the contract that ensured enriched uranium to Angra I, which was being built at the time, was suspended. The jet nozzle technology for uranium enrichment bought by the Nuclear Agreement with Germany failed.

If a decision is reached not to build Angra III, a way to avoid the loss of nuclear technical competence would be to divide Eletronuclear (company which belongs to Eletrobrás) into a federal company for nuclear and thermal generation and another one for reactors technology, that one being within the scope of the Ministry of Science and Technology, joining in it teams that were formed in the nuclear submarine project. The latter would provide support to operate the reactor and would develop the prototype of an advanced reactor, towards the intrinsically safe ones that are objects of study in the United States, in Europe and in Japan. The small reactor designed by the Navy could serve as a starting point. As an example, South Africa has developed a small reactor concept. A partner for Brazil could be Argentina. It is important to guarantee that Brazil carries out to the letter its obligations under the Treaty on the Non-proliferation of Nuclear Weapons.

The world situation can be summarized as follows. There are no new reactors being built in the United States, which, despite that fact, are extending the life time of their reactors and have voiced its intention to build the so-called advanced reactors. Similarly, there is no reactor being built in France, which had an intense nuclear program until not long ago. In Europe, at the moment, there is only one nuclear reactor being built in Finland. The countries that currently have important reactors programs underway are China, Japan and South Korea. Figure 2 shows that in the last few years the nuclear reactors installed capacity did not grow substantially[9], although the derivative is positive.

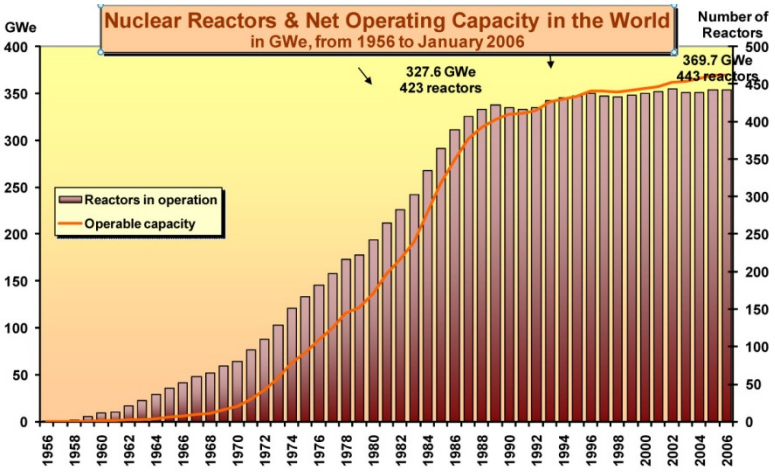

Figure 2 – Nuclear power in the World (Source: Schneider, 2006)

At the moment the main way for the advance of the reactors technology is to increase safety against serious accidents. The most advanced concept is that of intrinsically safe reactors – but they are still far from being carried out. Today the most realistic ones are the projects of advanced PWR and BWR reactors, such as the ABWR (*Advanced Boiling Water Reactor*) and the AP-1000 (*Advanced Passive Reactor*) in the United States. In Europe, the EPE (*European Pressurized Reactor*) project is being developed.

7 The alternative energy sources and poverty

Brazil must pay more attention to the renewable sources. In 2003-2004 Eletrobrás has implemented the Program for the Incentive to the Alternative Sources of Electricity (Proinfa), for a total of 3.3 GW of wind energy and biomass power plants as well as small hydroelectric.

[9] Mycle Schneider, Status and Trends of Nuclear Power, An Update of Myths and Realities, in the Round Table on Nuclear and Energy Policy, coordinator Lutz Mez, Conference Chernobyl 1986 – 2006, Berlin

There is a research and development effort on alternative sources going on in the universities, in the research centers, such as the Center for Electricity Research (Cepel) and the Petrobrás Research Center (Cenpes), and in companies, such as the Energetic Company of Minas Gerais (Cemig), Eletronorte and others, involving biomass, solar energy, the use of urban and agricultural residues, energy from the waves and the tides and hydrogen fuel cell. There is a high potential for biomass use in electricity generation.[10]

However, there is a clear need for a coordinated action to unite efforts in some cases concentrating resources from the very disperse funds. That also has to do with the technological innovation issue.

A concrete example is the need to design aeolic generators according to the characteristic of the winds that prevail in the country. The propellers used today, including those produced in Brazil, are designed according to the wind that prevails in the Northern hemisphere. Another example is an electric generator that uses sea waves, currently being developed by the Ocean Engineering Department of Coppe with the support from Eletrobrás. A third case is the project of a thermal power plant, joining natural gas and the burning of urban garbage or biogas from sanitary embankments, which is being studied with the support from Petrobrás, for distributed generation. It will be tested at the campus of Federal University of Rio de Janeiro (UFRJ).

Regarding energy and poverty, the "Light for everyone" Program of the federal government is very important, since it promotes the universalization of electricity for the population, involving the state governments, the companies of the Eletrobrás Group and the private and state electric distribution companies. There are difficulties to meet the goal of the "Light for Everyone" program in the Northern region, attributed to the complexity of the network extension where the population is very disperse in the Amazon forest. In the Northern region there exists a great amount of diesel generators and Manaus still depends on fuel oil to produce electricity while a gas pipeline is still being built. The subsidies that the consumers pay in the energy bill, through the Fuel Compensation Account (CCC), reached almost US$ 2 billion in 2006. The isolated systems of the Northern region are a natural laboratory for alternative energy sources. Coppe Virtual Institute (IVIG) developed a biodiesel plant that will be transferred to Pará, in the Amazon Region, where it will process palm oil from a Rural Producer Cooperative for producing biodiesel to be used in a diesel generator.

Finally, the energy intensive development model is always under consideration. Thus, the need for an energy policy dealing with the demand side has been discussed, aiming at increased efficiency of the equipment and the rationalization of their use, even in the residential sector, without denying the right of a great portion of the poorer population to increase its consumption.

8 Final Comments

We can resume the principles and approaches of G8 for common global energy security [11]:

- increasing transparency;
- improving investment climate;
- improving energy efficiency, energy saving and diversification;
- physical security of critical energy infrastructure;
- reducing energy poverty,
- addressing climate change and sustainable development.

Based on the above considerations about the situation of Brazil, it is possible to pick up from the text, the following points that show the relationship between the Brazilian energy policy and the quoted principles and approaches of the plan of action for energy security:

Concerning fuels supply

a) The present situation is that the country has achieved self sufficiency in crude oil but he needs to import part of it to make a mix for refining because Brazilian off shore crude from deep water is heavy in general.

b) Besides the importation of natural gas from Bolivia, Brazil intends now to import liquefied natural gas (LNG) by ships, which either may be done or interrupted according to the need for thermoelectricity.

c) Brazil has been involved in the World effort on biofuels to face climate change issue through his successful program of sugar cane ethanol in

[10] M. S. Muylaert and L. Pinguelli Rosa, Carbon Emission Mitigation Measures in Brazil – case study of biomass policy for a ferroalloy plant, Renewable and Sustainable Energy Reviews, Volume 10, Issue 6, Pages 590-602, 2006

[11] G8, St Petersburg Plan of Action, July, 2006

substitution for gasoline; it is considered now as an alternative for the ethanol from corn with the advantage of burning sugar cane bagasse instead of fossil fuel in the distillation process, avoiding net greenhouse gas emission.

Concerning electric power

a) Brazil faces the problems of hydroelectricity due to the environmental issues and to the movements against the great dams; the government must negotiate democratically with the environmental movements, but the environmental rules must be obeyed and it is a government task to convince society of the quality of the projects.

b) To avoid greater environmental impacts, the size of the areas flooded by future dams in Brazil must be reduced.

c) Emissions of greenhouse gases (GHG) were measured in several hydroelectric plants even they were not yet considered in international GHG inventories.

d) The "Light for everyone" Program of the federal government promotes the universalization of electricity for poor population.

e) The need for an energetic policy also directed towards the demand side is being discussed, aiming at the increased efficiency of the equipment and the rationalization of their use.

Concerning nuclear energy

a) Brazil carries out to the letter its obligations under the Treaty on the Non-proliferation of Nuclear Weapons and he ratified the Treaty of Tlatelolco for Latin America.

b) The Brazilian-Argentinean Agency for the Accountability and Control of Nuclear Materials (ABACC) was implemented, an agency for mutual inspections of both Brazilian and Argentinean nuclear installations.

Concerning alternative energy sources

a) There is a research and development effort about alternative sources going on in the universities and in the research centers.

b) Brazil must pay more attention to the renewable sources. In 2003-2004 Eletrobrás has implemented the Program for the Incentive to the Alternative Sources of Electricity (Proinfa), for a total of 3.3 GW of wind energy and biomass power plants as well as small hydroelectric.

We can conclude from the text that there are several problems to be solved in the Brazilian energy policy in spite of the positive aspects.

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