Keeping Nuclear as a Viable Option for Electric Power Generation in the Brazilian Matrix

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I - BACKGROUND

In order to dimension the problems concerning energy in Brazil, we have to realize that the country is the 10th largest primary energy consumer in the world and the 3rd largest producer and consumer of electricity in the Western Hemisphere, ranked behind the United States and Canada. This energy consumption has steadily grown at an annual rate of 3%, between 1992 and 2002, despite having a drop in 2001, when there was an electricity shortage, due to a prolonged dry period, thus affecting heavily the predominantly hydro generation system.

Brazil´s gross domestic product (GDP) which had a growth of 1.5% in 2002, contracted 0.2% in 2003, showing the worst figures in a decade.

Nevertheless, in 2003 the electric energy consumption reached the level of 300.6 TWh, showing figures 3.7% higher than in the previous year. Energy consumption in the industrial sector increased in 1.7% in comparison with 2002, mainly due to the migration of big industrial consumers to auto production of electricity, whether all other consumption classes presented an increase of circa 5%

Table 1 shows the installed capacity in the Brazilian Electrical Sector – status December 2003

Table 1. Installed Capacity – Dec. 2003

Type	Capacity (MW)	Participation (%)
HYDRO	67,728	77.78
THERMAL	17,330	19.89
NUCLEAR	2,007	2.30
OTHERS (wind, biomass, solar, etc.)	27	0.03
TOTAL	87,092	100.00

According to Brazil`s National Agency of Electric Energy (ANEEL) the forecast for the start-up of plants under construction is shown in table 2

Table 2. Forecast of Start-up for New Plants (in MW)

YEAR	2004	2005	2006	2007	2008
A	4,863	2,463	2,542	240	-
B	6,578	5,807	5,314	2,045	1,439
C	5,896	1,813	843	230	-
Total	17,337	10,084	8,701	2,515	1,439

A – no restrictions for start-up

B – some restrictions for start-up (environmental license, etc.)

C – strong restrictions (regulatory /legal/ environmental, etc.)

In fact, out of the 40,000 MW which are expected to be installed until 2008, only circa 10,000 MW are to be considered realistic considering the present difficulties.New investments can be jeopardized by the regulatory risks, associated with new rules recently established by the federal government, introducing new aspects about prices configuration and energy commercialization.

Taking into account that the brazilian economy has shown some growth in the first quarter of 2004 (2.7% compared with 2003) and is expected to react faster due to a relatively stable scenario,

and also that 2004 has had an unusually rainy period, the existing conditions seem to present an equilibrium between offer and demand of electricity for the years 2005/06.
If the present restrictions are not solved in due time and if there will be a dry period in the next years, an energy shortage can be expected from 2008 onwards, reaching even stricter conditions than those occurred in 2001.

Let us now go through all alternatives that are part of the general solution for the electric energy problem in Brazil.

II – ALTERNATIVE SOURCES FOR ELECTRICITY

II.1 - HYDRO GENERATION

The electric energy matrix in Brazil, which has an installed capacity of 78% of hydro origin, seems to still count on this source for the increase of generation needed for the next five years. Out of the 5,000 medium MW which are to be added to the grid up to 2008, circa 2,700 depend on the construction of 24 new hydro plants, which are presently delayed due to pending environmental licensing.
Besides this, the federal government is financing the construction of several small hydro plants, through a program called PROINFA, in a total of 1,100 MW, ensuring the purchase of energy at special prices, through 20 year contracts,.
Also at stake are very big hydro projects in the Amazon region, which are about 2,500 km distant from the great consumption centers located in the southeast region of Brazil.
Although the new rules foresee that new plants will only enter a bidding process after having been licensed, this can become a bottleneck for new hydro projects.
According to the organization which looks after the interests of populations suffering consequences from new water reservoirs (MAB), if the construction of 120 dams up to 2007 will be confirmed, around 100,000 families will have to be resettled, involving 400-500,000 people.
MAB has not further estimated the environmental damages, which are considered the main reason for rejection of hydro plants, although they produce energy from a renewable and clean source.

II.2 – GAS - FIRED PLANTS

Brazil´s natural gas reserves stood at 8.5 trillion cubic feet (Tcf) in the beginning of 2002, which were newly estimated, by recent discoveries, at 14.8 Tcf.
It will take several years for the commercialization of these fields, in order to increase the 5.7% participation of natural gas in Brazil´s energy mix, as occurred in 2002.
Since 1999, Brazil is importing gas from Bolivia, on a take-or-pay basis for specified volumes over a 20-year term. This was tied to Brazil building 16 gas-fired power plants, which have not been materialized mainly because the dollar priced fuel would produce electricity sold at brazilian currency, subject to frequent devaluation.
The energy shortage in 2000-2001 caused the federal government to launch a $ 5 billion program emergency program for constructing 49 new gas-fired plants, corresponding to an increase of 17,000 MW by 2003.
This was greatly jeopardized due to uncertain regulation for contracts (amounts, incentives and consequent tariffs) and when rains returned, the system would rather dispatch cheaper hydro plants, which caused several companies to reconsider their investments in Brazil.
Due to political changes in Bolivia, the contract for supply of bolivian gas to Brazil has not yet been renegotiated in terms of prices and quantities, what could reduce the fixed costs for production, thus placing gas-fired plants at a more favorable condition.

II.3 – NUCLEAR POWER PLANTS

Brazil has two Nuclear Power Units on a site which is basically equidistant from the main consumers of electricity, the cities of São Paulo and Rio de Janeiro. The Angra Power Plant consists of Angra 1, a 657 Mwe PWR Westinghouse plant operating commercially since 1985, and Angra 2, a 1350 Mwe PWR Siemens/KWU plant in operation since 2000. Both plants have produced over 81.5 GWh until end of April, 2004.
A third unit, Angra 3, identical to the second unit remains partly completed, having reached an overall progress of 30%, with $ 750 million already invested, mostly in imported components, and still $ 1.835 million needed to complete the enterprise. The lack of decision to go on with the plant leads to annual maintenance costs of $ 20 million in order to preserve stored components.

The responsibility for the operation and construction of these plants lies with ELETRONUCLEAR, a State owned company established in 1997 as the sole nuclear utility in Brazil.
Energy is sold to FURNAS, also State owned , and the largest utility in the Southeast region of Brazil, at a tariff of circa $ 26 / MWh and limited to about 85% of the plants' effective supply capacity, and the difference is rated at spot market price, presently $ 6 / MWh.
Since the operational costs for both units are around $ 27 / MWh, this has caused ELETRONUCLEAR to suffer losses for the last four years, although in 2003, nuclear energy supplied 49.1%.of the total consumption of electricity in the State of Rio de Janeiro.
It should be registered that the medium tariff for electric energy generated by 57 companies in Brazil is circa $ 22.5 / MWh, including binacional company ITAIPU.

II.4 – COMPLEMENTARY SOURCES

PROINFA is also financing several projects both for wind and biomass plants for electricity generation, amounting to 2,200 MW, together with 20 year contracts which ensure the purchase of all energy at very attractive rates.
Although this is very encouraging for R&D activities for renewable energies, the investments which would be needed on an adequate scale, turn this alternative in a small contribution to the overall problem.
Coal and oil alternatives will not be analysed mainly due to uneconomic prices for fuel in Brazil, not to talk about environmental impacts and other unfavorable points.

III – DEALING WITH THE NUCLEAR OPTION

Keeping nuclear as a viable option for generating electricity in Brazil involves in any case the completion of the Angra 3 Unit.

Since the start of operation of Angra 2, ELETRONUCLEAR has been striving to receive an authorization from the federal government to proceed with Angra 3. At the end of 2001, a group was established with representatives of all concerned ministries, called "National Energy Policy Council – CNPE", and given the task to recommend the decision whether to finish Angra 3 or not.

CNPE established pre-conditions, which were fulfilled in due time by ELETRONUCLEAR, concerning three major aspects:
- Economical and Budgetary Equation.
- Proposal to meet Environmental Requirements.
- Solution for final disposal of low and middle level radioactive waste, before commercial operation.

On November 2002 CNPE decided that preliminary actions could be taken to restart the enterprise, so that the new elected federal government could have time, until May 2003, to confirm this decision, in order to have the plant finished by the end of 2008. This did not take place and, on May 2004, the present government created a new task force, which should reach a decision within 6 months.
Although the work is not yet concluded, the Ministry of Mines and Energy, responsible for this matter, has been giving signs that the major policy for new generation plants will give emphasis to hydro plants.
Despite the fact that Brazil still pursues a major hydraulic solution, the last available sites, reasonably near the concentrated consumption centers, are now being utilized, and sooner or later thermal power plants, of whatever available nature will have to play a bigger role in the national scenario.
Since brazilian coal is not competitive, and complementary new technologies are insufficient to fulfill the required demand increase, we could concentrate on a comparison between nuclear, new hydro and gas-fired plants.
With respect to hydro, the main advantages of nuclear are:
- Located near consumption centers.
- Outages can be perfectly planned independently of extended dry periods.
- Lower environmental impact.

As for gas-fired plants, nuclear has following advantages:
- Lower fuel costs.
- Lower impact on commercial balance
- Can be operated as base load.
- Regulatory aspects are well known.

As disadvantage to both alternatives, nuclear plants have higher investment costs and longer construction periods, what tends to discard nuclear as a viable option for emergency situations, specially when decisions are not taken based on a consistent planning on the long run.
The new rules for commercialization of electricity have not considered any differential conditions for

nuclear energy, and the losses inflicted to this segment have immediate consequences on ELETRONUCLEAR and on both INB and NUCLEP, respectively the mining and fuel fabrication, and the heavy nuclear components, all State owned companies in Brazil.

IV – ANGRA 3

Coming to the Angra 3 situation, we can point out the following positive points:

- Completely Installed Infrastructure.
Since the plant is located on the same site as the other two units, the existing infrastructure can be shared, including road and maritime access, water supply and discharge channel for sea water, environment control data, 138/500 KV substations, Emergency Response Plan.
- Extensive use (70%) of design documentation from Angra 2.
- Licensing procedure well advanced, taking Angra 2 as reference plant.
- All needed know-how completely available through ELETRONUCLEAR- engineering and management, INB- front end cycle, national design companies, research institutes, universities, civil construction and erection companies, NUCLEP- NSSS and the national industry.
- Financing – about 69% of required financing to complete the plant is in national currency.
- A defined 66 month time schedule from restart to end of trial operation.
- Estimated tariff of $ 42 / MWh, which is equivalent to the medium tariff of the 3,300 MW in complementary plants being financed by PROINFA, that have a guarantee of purchase of produced energy at profitable prices for 20 years. This tariff is slightly higher than gas-fired plants due to the present import contracts for bolivian gas.

Let us hope that, based on these arguments and on a national strategic vision, instead of a short term policy, which is subject to changes every four years, the government will take the advantage of fully possessing the complete technology for nuclear electricity generation, acquired through heavy investments made during a period of circa 30 years, besides having the 6th uranium reserves in the world, and will decide on the continuation of a nuclear program, starting with the decision to conclude Angra 3.

In the meanwhile, all efforts are being made in order to demonstrate that the nuclear plants in operation are a reliable and safe solution for generating electricity in Brazil. In this sense, the following actions are being taken by ELETRONUCLEAR:

- Replacement of Steam Generators in Angra1.Contracts have been placed in the range of $ 100 million for the fabrication and exchange of the two SGs. This will provide an extension of the plant´s life of 20 years, increase its nominal power in 6.3% and reduce the outage periods from 50 to 30 days.
- Preservation of SGs and Reactor Pressure Vessel head in Angra 1.
- Exchanging the process computer in Angra 2
- Radioactive Waste Management, including the extension and improvement of intermediate waste deposits, reduction of waste generation and studies for final waste repository.
- Human resources planning based on knowledge management.
- Development of an advanced fuel concept, together with Westinghouse, KEPCO and INB.
- Improvement of the external response emergency plan, including the maintenance of the federal access road

V – FUTURE TRENDS

Considering that a new nuclear plant in Brazil will require a new site, and will face completely different conditions than those of the first 3 units, ordered in the 70's, some characteristics have to be pointed out, in order to meet present requirements:

- Smaller size reactor.
It is possible that a fourth nuclear unit could be built either in the northeastern, or in the north region of the country.
In the first alternative, it could be well associated with a desalination plant, that would provide water for irrigation and residential consumption in severely dry areas of this region. This problem is so critical, that studies even consider to change the course of the São Francisco river for this purpose, thus reducing the capacity of the hydro plants installed along its course. As an alternative, a nuclear plant with a maximum capacity of 600

Mwe could perform this task, with a reactor size compatible with the local grid.
In the north region a 150-300 Mwe unit could initially substitute existing oil-fired plants.
For both cases, a modular construction concept would minimize the impact for financing of construction costs.

- Reactor with a passive safety design.
One of the very complex requirements for granting operation license to a nuclear power plant are those in connection with the need of external response to accidents. A reactor type which would avoid this response due to a safe-by-design concept would have much greater chances of receiving an order.

- Simplified licensing procedure
This is a very complex subject in Brazil for all types of new power plants. Measures which could ensure that a new design could be licensed in fewer and simpler steps would be of great advantage, both concerning time and costs.

- Competitive Costs.
In Brazil, nuclear plants have to be competitive with gas-fired plants and with hydro costs, there included transmission costs through long distances.
Expansion costs in the range of $ 35 / MWe could be considered as competitive, as long as the previous conditions are met.

ELETRONUCLEAR is looking for new designs that in the next 10-15 years could meet these parameters. In this sense our company takes part in the team that develops the" IRIS Reactor", an international initiative which aims at most of these goals.

Brazil is in a situation where an increase in the annual demand for electricity is still expected for the years to come, and where nuclear energy can clearly play a relevant role, as long as it can meet updated parameters, required by regulatory and licensing authorities and requested by utilities and by society in general.
I am confident that a restart of nuclear expansion will take place in Brazil, not as the only way out to overcome a future lack of water for our hydro plants, but as a consequence of a national strategy, choosing a reliable, safe and clean form of generating electricity.