The Brazilian Electricity Supply Industry: a new technological trajectory?

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ABSTRACT:

Pro-market reforms have radically altered the context of infrastructure industries. Those industries were built around vertically integrated monopolies, which are now being broken up and unbundled in order to operate in a competitive environment. This creates demands and stimuli radically distinct from those of the past. Our paper explores the effects of these reforms on technology choices for the Brazilian electricity supply industry (BESI). This was built upon large hydropower plants, operating in co-ordination a large complex of water reservoirs in the river basin system. Pro-market reforms have placed this industry in an environment that in principle would favour thermal power plants. Nevertheless, the dynamics of this process is far less simple than it appears, as recent events have shown. Additionally, the federal energy policy attributes an important role to hydropower expansion. The complex interplay of stimuli to expansion is our focus of attention.

INTRODUCTION

From the XIXth century onwards, network infrastructure industries were built around regulated and vertically integrated monopolies. This acknowledged the natural monopoly features of the physical networks in railways, power, gas, telecommunications, water and sewage systems. It also reflected the value of these services to society; indeed, access to them was perceived as a requisite for full citizenship, as may be seen in the French term "service public" – and also in the Anglo-Saxon expression "public utility services". This industry structure worked well for more than a century, despite real or perceived shortcomings of the various regulatory schemes used, thanks to the very real economies of co-ordination, scale and density that the growing networks were able to achieve.

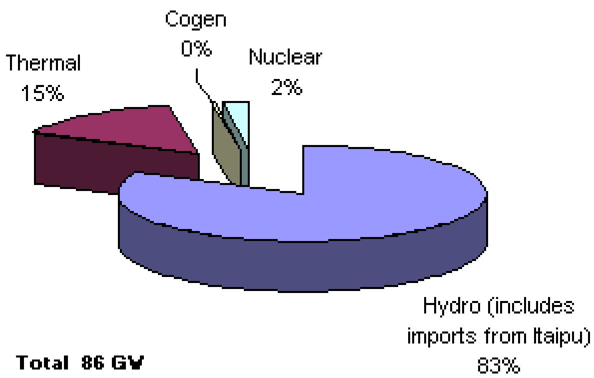
A few decades ago, however, this industry structure came to be challenged on a variety of grounds. Even where the physical network continued to be seen as a natural monopoly, there was a marked switch in the conception of infrastructure industries. Technological innovations in computers and telecommunications meant that most network industries could be segmented, so that production and trading could be operated competitively, and separated from network activities (transport and distribution). Accordingly, pro-market reforms were variously applied to infrastructure industries, in many industrial and developing countries.

Thus, industries that grew under a regulated monopoly regime have mostly been unbundled, and now operate in a competitive environment. This abrupt change in operating conditions poses a very different set of demands and stimuli on decision-making from the past, with implications for technological trajectories of those industries. In what follows, we investigate the effects of pro-market reforms on technology choices for the case of the Brazilian Electricity Supply Industry (BESI).

THE BRAZILIAN ELECTRICITY SUPPLY INDUSTRY

The capacity mix of the Brazilian ESI has remained remarkably stable and dominated by hydropower (around 90%), despite a hundred-fold growth between 1930 (around 800 MW) and 2003 (86 GW, including imports from Itaipu). The importance of hydropower may be seen from the fact that large hydropower plants with very large reservoirs provided in 2002 most of the 70 GW of hydropower capacity, out of 81 GW total installed capacity in public electric utilities (Figure 1), and an even larger share in energy generation since peak demand is 42 GW (in 2002, Eletrobrás). Another way of describing this system would be as follows: in 1995, 52 reservoirs had a capacity above 1 million cubic metres, of which 21 had over 5 million cubic metres each. Large plants are distributed over roughly a dozen large river basins, with significantly different régimes[1].

Figure 1 – Installed Capacity in the BESI, 31/12/2002



SOURCE: ANEEL, 2003 (WWW.ANEEL.GOV.BR)

At first, this dominance reflected the large water resources available; later on, institutional factors played a key role. Only during the late fifties and early sixties did a timid trend towards thermal power appear; this came about from lack of investment due to regulatory conflicts, and a consequent surge in self-generation. This trend was quickly reversed after the creation of the National Bank for Economic Development (BNDE) in 1957, which was charged with the National Fund for Electrification.

1 Cf. M. Santos (1996), as well as dam data published in “Construção Pesada” magazine. See also ONS, www.ons.org.br.

With the creation of Eletrobrás in 1962 as the power sector co-ordinator and financer, hydropower was consolidated as the strategic policy choice.

The Eletrobrás-led expansion of the Brazilian power industry was favoured by the conjunction of availability of foreign capital, support from multilateral funding organisms, and a dynamic consumer market. This expansion was successful from various points of view: over a period of three decades it created a significant technological basis around hydropower plants, transformed a small (2 GW in 1950), loosely connected sector into a large interconnected system (53 GW in 1993, 73 GW in 2002), allowed industrialisation to proceed at an accelerated rate, and extended access to electricity services to 90% of the population in 1993 and 94% of households by 2000. [2] However, when context changed the industry ran into financial troubles, which ultimately led to its reform along market-friendly lines.

Before discussing the effects of reform on the BESI, let us first examine the constraints that a system such as the Brazilian one – based upon large hydropower plants, with substantial reservoirs and interconnected over a dozen river basins – poses to competition. In such a system, three hurdles to effective competition exist: First, such large reservoirs have multiple uses, giving rise to externalities, so that a utility operating such plants will have to deal with conflicting demands by various groups of interest; this may be one reason why this kind of plant tends to be owned by central governments almost everywhere and has seldom been proposed for privatisation, irrespective of ideological colour. A second hurdle is that hydropower plants have widely differing costs, which will create large differential rents in unregulated competition. However important these two hurdles are, this paper pays more attention to a third aspect.

The third hurdle also concerns externalities of two kinds, but limited to the power industry itself. First, in any given river basin, plants cannot be independently operated without wasting energy: a decision by an upstream plant affects all downstream plants. Second, different basins have different hydrological régimes and different regional markets have distinct seasonal and hourly load curves, generating economies of co-ordination over time. Thus, centrally optimised dispatch in such a system must not only keep the system in static and dynamic equilibrium at minimum cost: it should also enhance generation capacity. It has been estimated that co-ordination economies reach 23% [3] in the Brazilian hydropower system.

For competition to be introduced, then, physical co-ordination has to be decoupled from market decisions by power plants. This issue may be approached in at least two ways. One, taken by the Nord Pool, relies on basin agreements [4] to separate physical and commercial operations; another one, chosen by the Brazilian reform, has a mandatory mechanism to evenly spread hydrological risk among hydropower plants (Mechanism for Energy Reassignment – MRE), effectively insulating them from competition among themselves and centralising decision-making. In either case, centralised physical dispatch is able to co-ordinate the operation of hydropower plants. It should be observed that a milder mandatory mechanism is conceivable, in which risk is spread over each basin but allows decentralised decisions among basins (considered as pools for decision-making). This would

2 Cf. Melo, Araújo and Oliveira (1994); IBGE, Censo Demográfico - 2000 : Primeiros Resultados da Amostra, www.ibge.gov.br (2003).

3 Santos, 1996.

4 Dispersed generation made it easier to implement a decentralised mechanism. See Nord Pool, 2003; Hjalmarsson, 2000.

allow a small loss of co-ordination economies (most of the 23% figure has to do with decisions within each basin) in exchange for a certain amount of decision decentralisation. Such a mechanism would be rather similar to the Scandinavian scheme, saving its mandatory character.

Whatever the mechanism chosen, a hydropower-based system such as the Brazilian one has a distinctive peculiarity: it is essentially dependent on the volume of rain and river flow into reservoirs. This varies not only seasonally but also from year to year; therefore, reservoirs have to be very large to enable smooth operation over time. Even so, there are times where reservoirs are full and water not used for generating electricity (secondary energy) must be poured out, while at other times reservoirs may be dangerously low as in the recent crisis (a situation that had been avoided in the past by aiming at substantial energy reserve margins – as opposed to the more usual capacity reserve margins in other systems). This also means that hydropower plants are built with considerably more turbines than their firm capacity would imply, in order to deal with peak demand. Typically, firm capacity lies between 50% and 55% of installed capacity in Brazilian hydropower plants. This peculiarity, coupled with the weight of hydropower in the BESI, poses particular risks for thermal plants in a market environment.

TECHNOLOGICAL CHOICES AND RISKS

When market-oriented reforms are introduced in an infrastructure industry, which until then functioned as an integrated, regulated monopoly, demands and stimuli undergo a radical change. A monopolistic environment under cost-plus regulation insulates firms from market risks (and reduces several other risks as well), enhancing capital-intensive technological choices with long lead times for maturation. In contrast, segmented industries in a market environment are subject to market risks in addition to macro-economic and regulatory risks; this enhances technologies with short maturation lags, to reduce exposure to increased risk. For the Brazilian power sector, this would seem to imply an abandonment of the hydropower option in favour of gas-fired plants.

Nevertheless, this did not happen. Instead, most of the investment in electricity generation since reform started has been in hydropower plants, not in gas-fired plants. What factors caused this seeming deviation from common wisdom?

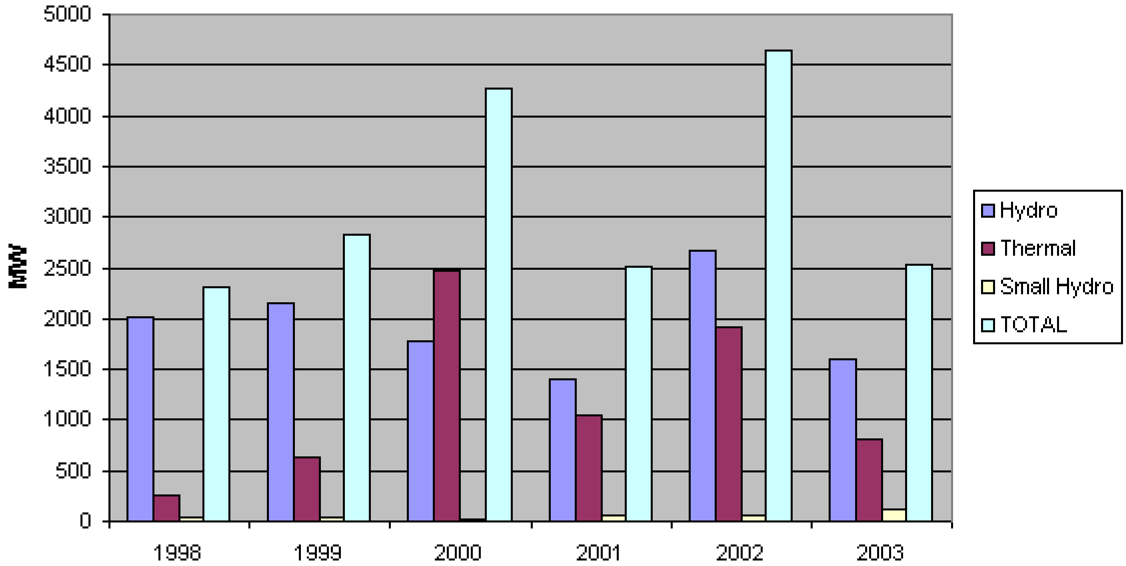
The fact is that gas-fired plants have problems in the BESI context under a competitive environment. To start with, gas distribution is a monopoly regulated by the States of the Federation. This was aimed at building up the gas distribution network, which is incipient except for the towns of Rio de Janeiro and to a lesser extent São Paulo, and is consistent with that purpose. Nevertheless, it is hardly compatible with the development of a gas-fired electric generation capacity. Another hurdle is the fact that a large programme of gas-fired plants would require a significant amount of imported gas from Bolivia and Argentina. This carries with it risks linked to the price of oil and to exchange rates. In view of the fragility of our external accounts, this is a serious deterrent to investment.

To these hurdles, one should add the formidable threat of hydropower plants: a series of wet years or the start of operation of a new large plant would send electricity prices tumbling down and put gas plants out of business, in the present trading framework. These problems explain why schemes like the “Emergency Programme of Thermal Plants”, launched with great fanfare in 1999 for 54 gas-fired plants totalling around 19 GW, failed to materialise.

To be sure, there have been additions to installed generating capacity in recent years, mostly in hydropower but also in gas-fired plants, as shown in Figure 2. But a closer look shows that much of the investment in gas-fired plants has been borne by the State, directly or indirectly. Thus, Petrobrás participates in gas-fired projects totalling roughly 7.5 GW, of which 1.7 is operational; as these plants are not being dispatched, it faces huge financial losses. It has also borne the risks of other projects, guaranteeing capacity payments for merchant plants (which total 2 GW) commanded in the height of the 2001 rationing crisis, to the extent of US$ 1.3 billion – which it will lose if these plants are not dispatched. Additionally, for the 9.8 GW in the government-sponsored "Preferential Programme for Thermal Power Plants" (PPT), Petrobrás is involved for 22% of the investment in 4.7 GW, almost half of the total. In other words, investment in gas-fired plants is being heavily subsidised and guaranteed by the State.

In fact, in the Brazilian context it is far less risky to invest in a hydropower plant than in a gas-fired plant. This happens, in part, because of the rules that effectively dilute investment risks for hydropower plants. But even if it were not so, in competition between hydropower and gas-fired plants these are at a disadvantage due to the large share of hydropower installed capacity, as we have argued. This explains why the entry of gas-fired plants is being government-driven rather than market-led.

Figure 2 - Yearly additions to Installed Generating Capacity, 1998-2003



SOURCE: ANEEL

Additionally, government policy gives an important role to hydropower expansion, since there still are 30 GW of economically viable hydropower potential to be exploited. Since the reform at least in principle should lead to decentralised decision-making, the dynamics of capacity expansion becomes very complex.

Let us briefly examine the situation regarding both technologies, from the point of view of the different actors.

A hydropower plant has very significant capital costs but negligible operating costs. A significant share of the costs relates to construction lag and to reservoirs, especially compensation for flooded land and limitations imposed upon water use for generation. Additionally, hydropower generation is subject to fluctuations in rainfall, the amount of variation depending upon reservoir size and operating constraints. In some periods, when reservoirs are full and water inflow is abundant, the opportunity cost of generation is virtually zero. In others, when reservoirs are low and rainfall is scarce, the power available for generation is very low and opportunity cost is high. The risks perceived by investors in hydropower plants are thus of two kinds: up front risks (construction delays, compensation for land) and water availability (rainfall variation, dispute over water use).

In contrast, a gas-fired plant has relatively low capital costs and high operating costs. These latter are dominated by the cost of gas, which is often bought under take or pay contracts. The absence of alternative markets for interruptible gas supply makes these contracts a risky proposition, all the more so as for the greater part they refer to imported gas. Even discounting exchange-rate risks, the dominance of hydropower means that, in a market context, a gas-fired plant would not be dispatched (or take a price less than its operating expenses) in a wet period; it would have to recoup its losses in dry periods, with prices far above its long-run marginal costs. However, a succession of wet years would jeopardise the strategy above, as would the inauguration of a large hydropower plant (of say 2 GW installed capacity), given the high ratio of installed capacity to firm capacity in hydropower plants.

For the government and the regulator, there are several choices of policy.

In a hands off scenario, investment would be dominated by hydropower plants until exhaustion of the economically viable potential; gas-fired plants would either fold or raise prices to very high levels during water-scarce periods. In the absence of efficient financial markets to hedge risks, the consequence would be increased risks to consumers and to the BESI itself. This disruptive, California-like behaviour would last until thermal capacity could provide a sufficient share of generation to compete for firm energy. Given present growth rates of capacity addition, this would mean ten to fifteen years of instability.

An alternative would be the signing of long term contracts (power purchase agreements) with gas-fired plants to reduce their risks. This would transfer the risk to consumers or to taxpayers, and raises some questions. In effect, this policy would require centralised planning in order to avoid over-investing, unless the contracts are well designed to avoid covering all the risks. Even then, the question remains of who will sign the contracts, and how prices will be formed.

Still another variant would be to change dispatch rules to induce greater share of thermal plants, and an appropriate change in price-forming mechanisms. This might be justified on grounds that the value of water will tend to grow, and that peak demand is better dealt with by reserve capacity of hydropower plants than by combined-cycle gas-fired plants.

Other mechanisms might be imagined, more or less compatible with a market environment. But from the above discussion, two things are clear. First, a smooth diffusion of gas-fired generation plants in Brazil is inconceivable without active interference by the government and by regulators. Second, in the absence of an active policy the Brazilian Electricity Supply Industry will be subject to instability and crises for more than a decade.

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