Latin America: Deregulation in a Hydro-Dominated Market

By Thomas J. Hammons, Hugh Rudnick, and Luiz Augusto Barroso

For the past two decades, deregulation and restructuring of the electricity sector and creation of competitive electricity markets has been under way in Latin America, where electricity generation is dominated by hydroelectric systems. This article describes how electric sector reform has evolved, what it looks like today, and how hydro is affected.

During the 1990s, the electricity supply industry in Latin America underwent profound transformation. New electric sector regulations were introduced in Chile in 1982, then began accelerating throughout the region about ten years later. The Chilean process was a pioneering one worldwide, driven by a government that wanted to introduce market-oriented reforms throughout society, electricity supply included. Electric sector regulations promoting market competition came to Argentina in 1992, Peru in 1993, Bolivia and Colombia in 1994, Brazil in 1996, and the Central American countries in 1997. Venezuela, Mexico, and Ecuador in recent years initiated actions toward market deregulation. This activity has occurred at the same time that sustained increased demand for electricity has required large capital investments in new generating facilities in Latin America's predominantly hydro-based electricity generation industry.

Privatization has been an important element of deregulation and restructuring throughout the region. For example, in the early 1970s, all of the electricity in Chile was being provided by state-owned companies; by the end of the 1990s, it was all supplied by private companies. Throughout the region, private investment has led to significantly expanded generating capacity, reducing the threat of power shortages. Similarly, privatization has assisted electricity generators and distributors in improving efficiency and profitability.

Privatization of generation and distribution companies is slowly bringing an end to power subsidies in many countries, leading to higher — but more realistic — consumer prices. For example, according to the Energy Information Administration, the average cost for electricity supply for a consumer in Ecuador has been about 30 percent less than the actual cost of generating and delivering that electricity. However, Conelec, Ecuador's national electric power regulator, said it will gradually increase consumer prices during 2002 (though the poorest customers will continue to be subsidized). The reason? Conam, Ecuador's privatization agency, announced plans to sell, at auction, 17 state electric power distributors, and realized that potential buyers could be attracted only if the tariffs charged by the distribution companies realistically reflected the costs of operation.

Even though consumer prices are going up in some countries, prices for wholesale power are going down. On average, deregulation, privatization, and competition in the sale of wholesale electricity has resulted in lower prices, stimulated by the ability of large consumers to choose their electricity supplier and enter into favorable long-term power purchase agreements.

Deregulation began with 'poolcos'

The deregulation models in all Latin American countries initially incorporated centralized "poolcos." In this approach, public utilities and independent suppliers provide power to a pool from which all users buy at a single set rate. The objective is to create perfect competitive conditions based on the marginal costs of generating the power. In Latin America, poolcos developed in different shapes, with different schemes for dispatch. Chile, Bolivia, Peru, Brazil, and Central America all established a centralized dispatching system in which

Tom Hammons, D.Sc., FIEEE, is chair, International Practices for Energy Development and Power Generation, for the Institute of Electrical and Electronics Engineers (IEEE), and is a member of the teaching faculty of the Faculty of Engineering, University of Glasgow, Scotland. Hugh Rudnick, FIEEE, is a professor of electrical engineering at Catholic University of Chile. Luiz Augusto Barroso, BSc, MSc, works in projects related to hydro and thermal economic evaluation at Mercados de Energia. ***This article is the second of a multiple-part series about the status of deregulation in various regions of the world and how these changes are affecting hydro. It is based on a recent discussion of deregulation by the authors and others during a IEEE Power Engineering Society meeting.***

the price of electricity is based on the audited cost of producing it. Argentina uses bids with caps. Only Colombia accepts unrestricted bids for power.

In general, all markets have been successful in creating competition and eliminating the effects of market power (i.e., the ability of large generators to manipulate electricity supply and, therefore, prices). Further, a market for contracted electricity supply has developed between generators and large consumers. Overall, private investment has entered the region, prices have declined significantly in most markets, and security and quality of supply has increased.

However, most recently, concern has grown over signals of a decreased interest by the private sector in continuing the high rate of investment both in generation and transmission in Latin America. This situation has been worsened in recent years by supply deficits in Chile and Brazil, affected by severe droughts in a region where 70 percent of all power generation comes from hydroelectric plants.

As a result, reforming existing electricity market regulations and increasing competitive conditions have been seen as a necessity. Argentina, Brazil, and Chile, among others, have been searching for alternatives. Criticism has arisen against the centralized poolcos, leading to the need for a second stage of reform to establish highly flexible mechanisms of decentralized exchanges, and achieve real market mechanisms with regard to wholesale and retail competition.

The defined objective of reform is to replace the centralized pools and force "perfect" competition with the *laissez faire* model of the power exchange, coupled with an independent system operator that dispatches based on long-term bilateral contracts plus short-term unrestricted bids. The reformers contend that this would promote a wider development of electricity markets as well as markets for ancillary services, such as reserve power, load shedding, and frequency regulation.

However, there are two significant reasons for concern: the possibility of supply difficulties severely affecting prices, and the potential for market dominance by a few private companies through a concentration of ownership of generation and distribution facilities.

The possibility of supply difficulties in Latin America is traceable to the predominance of hydroelectricity, with all the unpredictability of water availability. Severe droughts have affected the region, causing worrisome shortages. Additionally, there is little knowledge about the effects of the competitive marketplace on the proper stewardship of the water in reservoirs (i.e., setting aside water resources for irrigation, fish passage, or human consumption) and on price volatility.

The concentration of ownership within a few companies already is high in Latin America, and the long-term trend is for just a few operators to manage generation and distribution in the region. In such conditions, it may be more difficult to develop mechanisms that avoid market power and assure free entry to the market for all sources.

Given these unknowns, second stage reform of the electricity sectors in Latin America is a dynamic process, and further changes will undoubtedly develop. The path still is being defined, but clearly the naive approach to an "ideal" unregulated bid-based spot exchange market has been discarded.

Rise of interconnections

One of the dynamic issues present in Latin America is a trend toward regionalization of electricity systems through cross-border interconnections, and establishment of regional markets. In most cases, the exporting and importing of electric power is the catalyst behind the trend: shared grids and markets would considerably ease the effort and cost required to transmit electricity across borders.

Bolivia, where 33 percent of installed electric capacity is hydro, in 1994 established the Superintendency of Electricity as the regulatory body for the country's electricity sector. Among

Chile led Latin America in deregulating and privatizing its electricity sector. Privatized utility Empresa Nacional de Electricidad S.A. (Endesa), which became Chile's largest private company, developed or acquired hydro projects in Chile and elsewhere in Latin America through the 1990s, including the 450-MW Pangue Hydroelectric Project on the Biobío River, shown above near the end of construction in 1996.

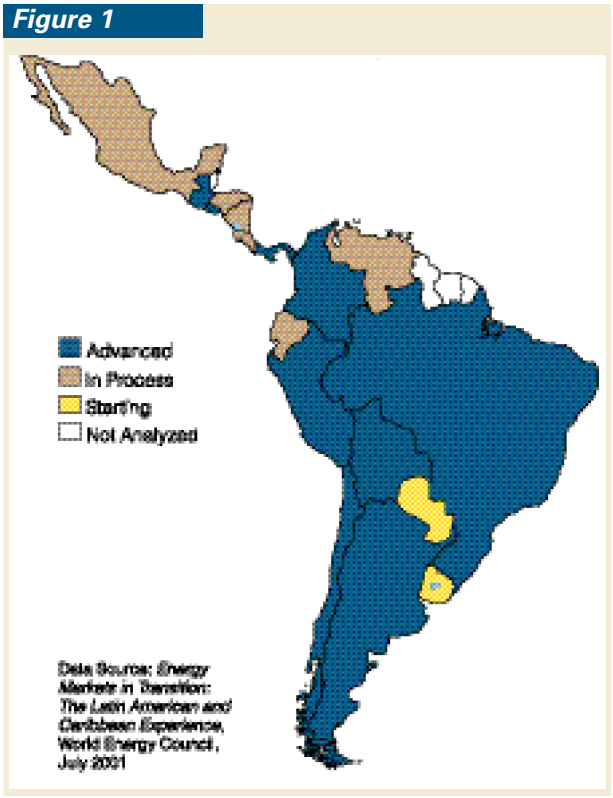
other duties, the agency approves international interconnection and stipulates the quantity of exports and imports, and supervises the National Committee of Load Dispatch, the body responsible for the coordination and administration of transactions on the privatized national grid, the Sistema Interconnectado Nacional (owned by Union Fenosa of Spain). Based on approval from the Superintendency, construction began in 2000 on an export facility that will connect Bolivia to the Brazilian grid, providing for an efficient exchange of power with the large neighbor.

During the late 1990s, Uruguay began positioning itself for international trade in electricity. In 1997, Uruguay and Brazil signed an agreement to allow the interconnection of the power grids of both countries. A similar interconnection with Argentina had been in place since 1974. In normal water years, Uruguay provides for its own electricity needs with four hydropower projects, but has begun promoting transmission and fossil-fueled generating plants intended to make Uruguay a key link in the growing trade in electricity between Brazil and Argentina. Another late 1990s law created Administracion de Mercado Electrico (ADME) to control the country's electrical wholesale market and the expanding grid.

In September 2001, Peru, Colombia, and Ecuador signed an agreement to integrate their power grids, establishing the future possibility of a region-wide market. Though Ecuador is not advanced in either privatizing its electric sector or in creating a competitive marketplace, efforts are un- der way in those areas. Peru, however, is advancing fast; under former President Alberto Fujimori, distribution was privatized, but the government decided to maintain state control of important hydroelectric plants; however, when Fujimori left office, Economy Minister Pablo Kuczynski, within the administration of President Alejandro Toledo, announced that Peru in 2003 would sell off state power generators, distributors, and transmission companies, including the 1,200-MW Mantaro hydro plant, which supplies 35 percent of Peru's electricity. Privatization in Colombia had progressed rapidly throughout the late 1990s, but has been brought to a virtual halt by the war with rebel separatists.

Argentina has electricity interconnections with Brazil and Uruguay. During 2001, Argentina increased its exports to Brazil substantially, owing to Brazil's electricity shortage. A new transmission line between Argentina and Brazil from the Argentina/Paraguay 2,700-MW Yacyreta Dam project is expected to be completed in mid-2002, increasing Argentina's total capacity of exports to Brazil to 2,000 MW (1,000 MW have been in operation since 2000). The trading of electricity on these transmission lines is the focus of proposed changes to Argentina's market in the future. Market administrator Compania Administradora del Mercado Mayorista Electrico S.A. (CAMMESA) hopes to coordinate regulatory differences country-to-country, and integrate the market into a regional market, generally including the Mercosur (regional trade pact) countries of Bolivia, Brazil, Chile, Paraguay, and Uruguay. Other market alterations that have sparked interest include creation of an energy futures market, transferring electricity price reductions to end consumers, and unrestricted access to price negotiation by mid-sized consumers.

Figure 1



This map shows the level of progress in electricity supply market reform in the countries of Latin America.

Detailed look at Brazil

The following section describes electricity sector deregulation and the status of energy markets in Brazil, which was selected for detailed discussion because of its large hydropower generating capacity and advanced state of deregulation and market competition.

The nation of Brazil has the fifth largest territory in the world, the fifth largest population, and its gross domestic product is the ninth largest in the world. In terms of energy resources, Brazil is hydro dominated, characterized by large reservoirs capable of multi-year regulation arranged in complex cascades over several river basins.

Power sector reform started in 1996. The basic objectives were to ensure necessary investments for energy supply expansion and that the sector would be economically efficient. To achieve these objectives, sector reform was designed to encourage competition when possible (i.e., in generation and trading) by the introduction of a free market; and by maintaining price regulation wherever competition was not feasible (i.e.,

As more countries create competitive markets for electricity in Latin America, hydropower stations such as the newly commissioned 1,140-MW Machadinho in Brazil (shown above) gain in value, owing to the special services they can provide to the grids.

in transmission and distribution of electricity).

Operation of Brazil's interconnected system is very complex, owing in large measure to the dominance of hydropower generation in the system (about 93 percent of the total), and the resultant presence of storage reservoirs. As a consequence, operational decisions taken today can significantly change the system's condition in the future. For instance, a decision to generate more hydroelectricity and shut down a thermal plant to save fossil fuel involves the risk of rationing in the future if the depleted reservoir has not been replenished. On the other hand, to turn on a thermal plant and save water for use in the future may result later in the need to spill water (i.e., to dump free fuel).

The need to coordinate the operation of generating plants led to the creation of a centralized dispatch carried out by an independent system operator. The dispatch of generation is computed with the aid of optimization computational models, involving calculations that consider the state of the system's reservoirs and represent possible future streamflows through statistical models. One important feature of this procedure is that it clearly identifies the short-run marginal costs for the system, which are the main component of market clearing prices.

Predominantly hydro systems such as Brazil's present fairly low short-term price volatility but an extremely high mid-term price volatility. The reason for reduced short-term volatility is that system reservoirs can easily transfer hydro energy from off-peak to peak hours, thus modifying load supply and equalizing prices. The reason for mid-term volatility is that predominantly hydro systems are designed to ensure baseload supply under adverse hydrological conditions, which rarely occur. Consequently, most often there are temporary energy surpluses that imply very low prices. However, if a very dry period occurs, spot prices may increase sharply, and even reach system-rationing prices.

The main driver for spot price variations in Brazil is the overall reservoir system storage level. There is a negative correlation between storage and spot price: if the reservoirs are full, the opportunity cost of water is very low; conversely, if the system is at low levels, the rationing risk increases steeply, leading to a corresponding increase in the expected opportunity cost. One consequence of this negative correlation is that the economic benefit of selling excess hydro production to the spot market tends to be smaller than expected.

One of the main objectives of Brazilian power sector reform in 1996 was to promote private investment in new generating capacity. Load growth (demand) rates in Brazil had achieved fairly high levels in the mid-1990s, fueled by economic expansion, but load growth was not matched by an increase in actual supply, owing to the length of time required to bring new power plants — mainly hydroelectric stations — on line. In fact, by the end of 1999, construction of many projects was delayed because of uncertainties concerning important aspects of the new regulatory framework. With the creation of new capacity slowed, the risk of energy rationing in future years increased, and became a major source of government concern.

The government tried to alleviate the problem by promoting the emergency thermal plant program, in which gas prices would be guaranteed for 20 years for those plants starting operation before 2003. Plants would still have to negotiate their supply contracts and project financing. However, only a few projects were started. During 2000, it became increasingly clear that the avoidance of rationing in 2001 and 2002 would depend essentially on the occurrence of a favorable hydrological situation. Unfortunately, this did not occur.

In June 2001, Brazil started energy rationing in southeastern, northeastern, and northern regions of the country, with a target level in the range of 20 percent (see Table 1). These markets correspond to roughly 80 percent of the country's gross domestic product and population. Rationing lasted for eight months, and

Table 1

Results of electricity rationing in Brazil from June 2001 to February 2002 as a percentage reduction in consumption from the base period.

	North Region	*Northeast Region*	*Southeast Region*
Load reduction in relation to May/June/July 2000	*	15.7	15.6
Load reduction in relation to the base period 2000-2001	18.3	19.5	19.8
Load reduction in relation to the initial estimates for 2001-2002	24.6	20.7	21.2

* The base period for the North Region is 2000 to 2001

widespread consumer opposition to electricity sector reform developed. Why? Because Brazil's generating system is dominated by hydropower, the gap between supply and demand did not create immediate scarcity. The reason: a hydro system can meet demand even in unfavorable hydrological situations, provided inflows are average, by allowing reservoir levels to drop. Because the past few years have not been very dry in Brazil, rationing has not been needed. What happened, however, was that, each year, the system's reservoirs reached levels that were lower than the previous year's levels. This situation changed in 2001 because the wet season (November to April) was much drier than usual, and the reservoirs started the wet season at unusually low levels due to emptying in previous years. Electricity rationing had to be declared to avoid the risk of emptying the system's reservoirs before the end of the dry season, in which case supply would depend almost solely on dry-season inflows, resulting in unpredictable and possibly much harsher cuts.

In 2001, the Brazilian government created a "Revitalization Committee of the Power Sector Model," aimed at revising the regulatory framework and restructuring the Ministry of Mines and Energy. In early 2002, the committee announced a range of measures aimed at increasing competition in the power sector by reinforcing market practices in parallel with a higher intervention on the regulatory side.

The measures are organized in the following topics:

- Resuming market operation;
- Reinforcing market-based mechanisms (including a proposal to move from a cost-based dispatch to a bid-based dispatch);
- Ensuring adequate expansion of supply;
- Monitoring supply reliability;
- Improving interface between market and regulated segments; and
- Stimulating fair competition, realistic tariffs, and consumer benefits.

In parallel, a plan to improve functioning of institutional agents, such as the federal regulatory agency — Agencia Nacional de Energia Eletrica (ANEEL) and Ministry of Mines and Energy — is being carried out. (A detailed discussion of all proposals can be found on the Internet: http://www.energiabrasil.gov.br.)

An important decision involved postponing the previously announced privatizations of large state-owned utilities, such as Companhia Paranaense de Energia (COPEL) and Companhia Hidreletrica de Sao Francisco (CHESF), owing to little interest from international investors and strategic planning by the government.

While uncertainty exists over what actually will happen — the measures are not yet implemented and may be altered during public hearings — there is a general agreement that government proposals go in the correct direction: to maintain market-based schemes in parallel with a stable and consistent regulatory structure.

The reality for Brazil's electricity sector is that the reforms already in place make a return to the pre-reform structure — involving state ownership and control — impossible. Therefore, the only option is to move forward to a better designed market, achieving a balance between market incentives for generation expansion on one hand and the strengthening of planning institutions on the other. Energy rationing will be the "stress test" for the new electricity sector structure in the Brazilian system. The country must wait and see how the new market will behave. ▲

Dr. Hammons may be contacted at IEEE, 11 C Winton Drive, Kelvinside, Glasgow G12 0PZ United Kingdom; (44) 141-3397770; E-mail: t.hammons@ieee.org. Dr. Rudnick may be contacted at Department of Electrical Engineering, Pontificia Universidad Catolica de Chile, Vicuna Mackenna 4860, Casilla 306, Correo 22, Santiago, Chile; (56) 2-6864289; Fax: (56) 2-5522563; E-mail: h.rudnick@ieee.org. Mr. Barroso may be contacted at Mercados de Energia, Rua Voluntarios da Patria 45/1507, Botafogo, Rio de Janeiro 22270-000 Brazil; Telephone/ Fax: (55) 21-25392073; E-mail: luiz@gmercados.com.br.

References:

Energy Markets in Transition: The Latin American and Caribbean Experience, World Energy Council, July 2001.

Millan, Jaime, Eduardo Lora, and Alejandro Micco, "Sustainability of the Electricity Sector Reforms in Latin America," delivered at the annual meeting of the Board of Governors, Inter-American Development Bank and Inter-American Investment Corporation, Santiago, Chile, March 16, 2001.

Rudnick, Hugh, "Pioneering electricity reform in South America", *IEEE Spectrum*, August 1996, pages 38-44.