Welcome to the panel session on Latin American Policy on Electricity Infrastructure, Interconnections, and Electricity Exchanges. Panelists focus on feasibility studies to interconnect power systems and energy resources, the present state of the electric power sector, participation of nonutility generators, future expansion of Latin American power systems, interconnections and power exchanges, and the impact of privatization on electricity supply. The following is a list of the panel session speakers and the topics of their presentations:

- Rafael A. Moscote (energy and regulatory advisor in the Technical Department for the Latin America and Caribbean Region of The World Bank, Washington, DC) reviews electric sector policy reforms of most countries in the Latin America and Caribbean region.
- Nelson de Franco (Latin America Infrastructure Development Department, The World Bank, Washington DC) reviews the role of the World Bank in electric power projects in Latin America.
- Ricardo Mota-Palomino (Instituto Politecnico Nacional Mexico D.F., Mexico) reviews the evolution of electrical interconnections between countries in the Central America isthmus and discusses perspectives of regional integration. He describes the characteristics and composition of generation and transmission networks in Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama. These systems were developed considering an autonomous power approach, a strategy which today has financial requirements that are difficult to meet.
- Tomas Gomez (associate director of the Instituto de Investigacion Tecnologica at the Universidad Pontificia Comillas (UPCO), Madrid, Spain) discusses feasibility studies for interconnection of power systems of the Central American Countries (the SIEPAC project) by means of a 1678 km, 500 kV ac line. The proposed project would link six electrical systems in the region using seven substations. All potentially exchangeable energy would be transmitted and distributed to participating utilities. This would give stability and reinforce-

This article includes summaries of presentations made at the 1994 PES Winter Meeting panel session on Latin American Policy on Electricity Infrastructure, Interconnections, and Electricity Exchange. The session was sponsored by the PES Energy Development and Power Generation Committee and was chaired by T.J. Hammons, University of Glasgow, Scotland.

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electric power industry in Argentina has undergone restructuring, from 100 percent government ownership in 1990 to an industry with more than 70 free agents: generators, transmission companies, and distribution companies today. He reviews initial milestones in restructuring the industry: the conception and settling down of the wholesale electric power market, its pricing system, the regulations for purchasing and selling energy both hourly and future, the drafting of concession contracts, and planning of efficient operation and investment.

- Luis V. Sbertoli (SIGLA SA, Buenos Aires, Argentina) presents "Interconnections Revisited: The Network as an Image of the Electric Market (the Argentinian Case)."
- Hugh Rudnick (Pontificia Universidad Catolica de Chile, Santiago, Chile) discusses the Chilean experience in restructuring the electric power sector. Its case merits particular analysis as Chile is a pioneer in deregulation of electricity supply. Although the Chilean system is small (70 percent installed capacity is hydroelectric with peak demand of 2,800 MW in 1993), restructuring of the industry has been observed with interest by many institutions, particularly by The World Bank, and more recently by the Latin American countries.

The following are summaries of the panel session presentations.

**Power Sector Policy Reforms**

Rafael A. Moscote, Energy and Regulatory Advisor, LAC Technical Department, Latin America and the Caribbean Region, The World Bank

The findings, interpretations, and conclusions expressed in this paper are entirely those of the author and should not be attributed in any manner to The World Bank, its affiliated organizations, members of its board of executive directors, or the countries they represent.

I will start by reviewing very generally some of the policy reforms of most countries in the Latin American and the Caribbean region. I believe this to be necessary to illustrate how the new legal and regulatory frameworks being developed are much more than a passing fad and that the changes now being implemented in many places have a very good base for sustaining the reforms for a long time. These reforms will no doubt provide a new driving force towards economically attractive international electric power transmission line interconnections and energy exchanges.

The electric power sector is characterized by the existence of technical or natural monopolies, due to economies of scale. The traditional view in most Latin American countries has been that this requires public production and financing. The resulting reliance on public monopoly providers led to a focus on centralized planning of investments, rather than on ensuring that the services to be provided from the facilities would be sustainable and responsive to changing demands. It also led to politicizing and inefficient pricing of public utilities and poorly targeted subsidies that have further contributed to patterns of demand that in many cases have been harmful to the environment, and reduced the access of the poor to an acceptable level of service. In the particular case of interconnections of power systems (both within national boundaries and internationally), this environment led to decisions being made on a political basis rather than on technical and economic grounds.

The relative emphasis of public sector entities on new investment has also been a major factor in the readily apparent lack of attention to proper maintenance of existing facilities. This latter consequence completes the often-cited vicious circle of inadequate operations and maintenance, poor quality of service, low cost recovery, deterioration of existing assets, and ever increasing investment needs solely for their replacement. Another, sometimes little noticed fact is that any discussion on the power sector has had the tendency to focus on the technical aspects of the sector.

Nowadays, discussions on electric power sector issues have moved away from this type of discussion to a more commercially oriented focus. The reason for this is that in order to address the investment requirement and improve the quality of electric services most Latin American countries have adopted fundamental policy changes. These respond to recent thinking and developments that have revealed a broader range of alternatives for public and private sector involvement in the power sector.

New ways of thinking as well as recent innovations in technology (especially metering and communications) have facilitated new institutional arrangements for production and commercialization as well as an increase in the demand for differentiated electricity supply. Many countries are therefore creating a market orientation to the provision of electricity by actively promoting competition where feasible and attempting to establish sound regulatory frameworks and institutions where there are market failures.

There is a growing realization that there is a need to attract the private sector with the expectation that this will both increase the total amount of capital available to the sector and increase the efficiency of supply. To make this possible, it is necessary to retain and increase investor confidence by offering an improved regulatory regime, transparent market processes, adequate pricing to the ultimate consumer, and efficient clearing and settlement arrangements. Most Latin American and Caribbean countries are moving in this direction.

The trend is clearly for increased private sector participation and less government provision of electric services. These changes in outlook towards ownership are occurring in parallel with an even more profound change: a structural change in the sector. More and more countries are questioning the need for vertical integration of the industry; there has been a recognition that the electric power sector can be separated into four major segments: generation, transmission, distribution, and commercialization. Many are separating the sector on a functional basis and, at the same time, moving towards competitive generation with unrestricted access to transmission, and, in some cases, also to distribution services and pricing of these services separately.

Government regulation (in some cases newly established) naturally follows the electric power sector structure. The trend here is clearly for concentrating price and quality regulation on transmission and distribution, leaving generation and sales, at least to the larger consumers, to the marketplace.

Nowhere are these trends more evident than in Chile and in Argentina. In Chile, the process started in the early 1980s. At the present time, the sector has been fully restructured (along the lines just mentioned) and is largely in the hands of the private sector. Government retains only about 15 percent of the installed generation capacity of the country and there is free entry and exit in this segment of the industry under a competitive regime and open access transmission.

The Chilean experience is being studied by many other countries and is being used as a guide; this does not mean that all Latin American countries are doing the same as Chile. There are important differences among the reforms enacted.
World Bank's Role in Electric Power Projects in Latin America

Nelson de Franco, World Bank, Washington DC

Following Rafael Moscote's overview of electric sector policies in Latin America (LA), I would like to make a few remarks on actual and possible implications of these policies for the development of electrical infrastructure, interconnections, and electrical exchanges (Figure 1).

Energy as a Commodity

It seems initially, based on the previous presentation, that electricity in Latin America could become a tradable commodity in its direct form, as opposed to its indirect presence in products, whose production is electrical energy intensive (e.g., aluminum). This would add a new dimension to the concept of energy as a commodity, which currently holds almost exclusively to tradable fuels. Discovery of gas fields in Latin America enhances gas as a flexible energy vector because of its trading potential as a fuel for industrial and residential uses, as well as for electric power generation through increasingly efficient, combined-cycle, thermal plants.

Let me pose a general question: Does the trend towards privatization, and in some cases breaking the vertically integrated utility structures, help or hinder the development of remote generation, extensive transmission and interconnections, as well as electricity exchanges?

The answer will certainly depend on the characteristics of private utilities, meaning their role in the national system, market aggressiveness, and the like, and the role the state is willing to play. It may well be that private utilities, exclusively on the basis of sound economic analysis, feel free to pursue new energy developments with more resolve than state-owned utilities. It is noteworthy that some states, including their foreign affairs offices, have been very supportive of private enterprise in undertakings abroad. On the other hand, in many cases the same foreign affairs office may be a hindrance to state-owned utilities, because their actions have

About the Speaker

Rafael A. Moscote, a Panamanian national, received his BSEE from the Massachusetts Institute of Technology in 1958, and his MSEE from the University of Wisconsin in 1963. He began his career in 1958 by working as an electrical engineer with the Panama Power and Light Co., Panama. In 1959, he joined Panama's National Regulatory Commission for Power, Telephone, and Gas; in 1961 he moved to IRHE (Panama's national electric utility); and in 1963 he was promoted to chief of Operations and Maintenance. In 1965 he was promoted to deputy general manager, and in 1967 he was appointed head of the Planning Department at IRHE. In 1968 he worked as a power engineer with the Panama Canal Company. Starting late 1968 through mid-1974 he was general manager of IRHE.

Moscote joined the World Bank in 1974, in the Power and Telecommunications Division, Latin American and Caribbean Projects Department. He was promoted to deputy division chief of the Energy Division I, Latin American and Caribbean Projects Department in May 1978, and to division chief in October 1979. In 1985 he became division chief of a newly formed Energy Division for Latin America and the Caribbean.

Following reorganization of the World Bank in 1987, Moscote was appointed chief of the Infrastructure and Energy Division, Country Department III, Latin America and the Caribbean Region. He became division chief of the Infrastructure Division, Technical Department, Latin America and the Caribbean Region in 1988. In January 1993, he was appointed Energy Advisor for the newly formed Advisory Group in the Technical Department, Latin America and Caribbean Advisory Group.
to be framed to meet complex geo-political goals, which are often volatile or even not clearly defined or wholly accepted.

Interconnections frequently derive from propositions that are not clearly justified in economic terms or which entail financial restrictions due to the massive investment outlays involved. State-owned utilities can be charged with developing such projects on grounds of national interest (whether correct or not). In fact, large binational projects have been driven mainly by geo-political concerns.

**Hydroelectric Potential**

Large hydro projects, usually remote from major load centers, considerably increase the size and boundaries of the transmission network and may support national, regional, and international interconnections. Examples include Itaipu, Yacyreta, El Cajon, Guri, and large undertakings in the Amazon region.

There are enormous possibilities for hydro development around the world. Recall that Latin America is endowed with considerable hydro resources, most of which have not yet been harnessed. Installed capacity in 1992 amounted to some 155 GW, representing nearly 6 percent of world capacity. In terms of hydro, the region fared better, with over 15 percent for an installed capacity approaching 100 GW. In fact, hydro represented almost two-thirds of the total installed capacity in Latin America. Table 1 shows the situation of hydro potential (expressed at a reference capacity factor of 50 percent) and development in Latin America.

Table 1. Hydro power potential and developments (NW South America includes French Guyana, Suriname, Guyana, Venezuela, Colombia, Ecuador, and Peru. SE South America includes Brazil, Bolivia, Paraguay, Uruguay, Argentina, and Chile.)

<table>
<thead>
<tr>
<th>Area</th>
<th>Total Potential GW</th>
<th>Developed GW</th>
<th>Development Potential</th>
</tr>
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<tbody>
<tr>
<td>Central America</td>
<td>50</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Mexico</td>
<td>54</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>NW South America</td>
<td>250</td>
<td>22</td>
<td>9</td>
</tr>
<tr>
<td>SE South America</td>
<td>373</td>
<td>66</td>
<td>18</td>
</tr>
<tr>
<td>Latin America Total</td>
<td>727</td>
<td>99</td>
<td>14</td>
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</table>

The power market has good potential for growth. This stems from a very low per capita electric consumption (about 1,200 kWh per year) and an electric supply coverage of nearly 70 percent of the population, while prospects for economic development, starting from a baseline GDP of $2,500 per capita, are reasonable, and the population of 450 million is still growing at a rate of about 2 percent per year.

**Growth and Investment**

The Latin American Energy Organization (OLADE) and the World Bank organized a Latin America Power Sector Conference in Mexico in September 1991, where estimates for growth during the 1990s were presented. Projected yearly growth was some 2.5 percent for GDP and nearly 8 percent for electric power consumption. On those bases, and considering the 1992 electricity production prepared by OLADE in May 1993, the following increments for generation capacity during the next 12 to 15 years are derived and shown in Table 2 against hydro potential available for development.

This demonstrates that there is a tremendous market for private investors and great potential for development of interconnections and exchanges. Even if one takes these additional generation requirements with a grain of salt, it would not affect the basic conclusion. The horizon in which these figures will be reached may be longer, or, conversely, the additional installed capacity may be somewhat smaller in that 15-year horizon. However, this should not be a serious drawback for a sector in which investments are somehow modulated by updated demand forecasts and are amortized over long periods of time (at least 20 years). To ensure that the basic growth trend is what matters most, the rules of the game ought to be clear, consistent, and stable, if massive private investment is sought.

The 1991 Latin America Power Sector Conference in Mexico demonstrated that power sector investment would average nearly $20 billion a year, within a framework of continuous growth. The belief that governments alone could raise such large volumes of capital is not commonly accepted today. This is one of the main reasons for the changes in policy. It is therefore necessary that a strong capital market be in place in Latin America. The foundations for this are being established in Mexico, Brazil, Chile, and Argentina.

**Natural Gas Reserves**

Since natural gas is another key variable of the power equation, let us review its current use and reserves in Latin America. In 1992, gas as a primary source of energy amounted to about 700 million barrels of oil equivalent (MBOE), which in electric terms translates approximately into some 1,120 TWh or, at a 50 percent reference capacity factor, some 255 GW of equivalent generation capacity. The reserves amount to 42,000 MBOE, which means they would last 60 years at the current consumption level.

This ratio of reserves to consumption is highly favorable when compared to the 15-20 prevailing in the petroleum sector, which seems to indicate a good scenario for substantial growth in gas consumption. It is also interesting to compare the magnitudes of gas as a primary energy source (255 GW equivalent electric generation capacity) with the installed electric generation capacity (155 GW).

**Regional Interconnections**

It is hoped that this background information will facilitate elaboration by subsequent panelists or during the ensuing discussion on some economic and institutional aspects of prospective electric transmission interconnections in Latin America, such as:

- Venezuela-Colombia (intra and toward Central America and Mexico, and from there into the United States)
- Central America
- Southern Cone, propped up by gas developments in Argentina and hydro in Brazil, including some sites in the Amazon where the prospects for environmental mitigation seem to be favorable.

As to the latter, I see the concept of energy as a commodity as an interesting prospect to bring about integration in the Andes and Southern Cone: a Bolivia-Brazil-Argentina-Chile
compact, linked by gas pipelines, which has been enhanced initially by occasional
electric interconnections (basically origi-
nating from binational hydro plants) and
eventually by gas-fired power plants in
territories of either gas exporters or im-
porters (the latter including end users in
households and industries) as well as
strengthening regional transmission sys-
tems.
Uruguay and Paraguay are bound to
be part of the compact because of their
geographic proximity, and Peru may join
the group in view of its huge jungle gas
reserves. Gas transactions and use of dc
lines or back-to-back schemes will help
further overcome the issues of long dis-
tances and relatively weak systems, as
well as frequency difference between
Brazil and its neighbors.
Finally, let me highlight the fact that
interconnections involving many coun-
tries may require some kind of supranor-
tional coordination to attain greatest
economic efficiency, whether in the form
of traditional committees composed of
the national utilities (or future private
utilities) or a special company in charge
of its development and/or management.

Acknowledgment
Throughout this presentation, basic
figures have been given in power rather
than in energy or both (as would be more
common and even more appropriate in
some cases) for the sake of easier refer-
ence and comparison. However, this has
caused no loss of accuracy because refer-
ence and actual capacity factors are
sufficiently close for purposes of this
presentation.

About the Speaker
Nelson de Franco received his BSEE
from the Federal University of Rio de
Janeiro, Brazil, in 1984, and his MSEE
from the Illinois Institute of Technology
in 1988. He completed advanced studies in the application
of computers in electrical systems at Purdue University in 1988,
and the management development program for the electrical
sector at the University of Sao Paulo in 1977.

In Brazil, de Franco worked for General Electric and, more
importantly, for Eletrobras for 15 years, where he became
assistant director for Planning and executive secretary for the
National Planning Coordination group. Since 1983, de Franco
has been with the World Bank and has been in charge of
electrical projects in Central America, the Caribbean, and
South America. He is currently task manager for the bank’s
electrical projects in Argentina. Since 1974, de Franco has
been a member of the Study Committee of CIGRE in the areas
of operations, planning, and development of electrical power
systems.

Central American Isthmus: Evolution and
Perspectives of Regional Electric Integration

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This summary is a brief description of the evolution of a
regional interconnection in the Central American isthmus.
National electric systems have evolved autonomously in
every country. The improvement of the coordination in the
operation and planning of the regional systems has been
recognized as a route to better usage of the regional re-
sources. The physical characteristics of the Central American
electric power sector makes it necessary to consider its
limitations for a rational development of this sector. After
strengthening the Electrification Council for Central America
(CEAC), the regional organization of the electric power sec-
tor, a decision was made to promote the integration of the
regional interconnected system. Some of the experiences
regarding the regional integration are described.
Technical Characteristics of the Electric Power Sector

The electric power sector of the Central American isthmus is formed by the national interconnected systems of Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama. The installed capacity by the end of 1992 was 4,462 MW and the noncoincident demand peak was near 3,014 MW. This installed capacity is composed of roughly 61 percent of hydro plants, 4 percent geothermal, 12 percent thermal, and 23 percent of small internal combustion and gas turbines. The mean value of hydroelectric production is about 12,000 GWh a year, while the geothermal production reaches up to 850 GWH (including the production from El Salvador and Nicaragua, the only two countries with geothermal plants in service).

The demand in 1992 was 15,900 GWh, of which 17 percent were losses. The other 13,200 GWh sold were consumed in such a way that residential and commercial consumption was 58 percent of the total. The electrification level is heterogeneous among the Central American countries, with a peak 92 percent in Costa Rica and ranging from 33 percent to 60 percent among the other five countries. At the regional level, only 46 percent of the population use electrical energy.

Regardless of the transmission network, the highest level of 230 kV exists in all the countries. In El Salvador, this level is used only in the interconnection to Guatemala.

There are 230 kV links among the other four countries, forming two interconnected systems: the north block (Guatemala and El Salvador) and the south block (Honduras, Nicaragua, Costa Rica, and Panama). The geographic distance from the north of Honduras to the southeast end of Panama is roughly 1,700 km. The main generation sources are scarce and located very far from the main load centers. The longitudinal electrical system configuration causes difficulties in the operation of the Central American system, mainly problems of dynamic and voltage control. In the operation of these systems it is not common to find transmission system limitations due to thermal capacity, but rather the limitations are due to voltage or stability margin limits.

As a result of the oil crisis of the 1970s, Central American countries increased their efforts to develop their own natural resources (hydro and geothermal) for producing electric power. As a result, except for Nicaragua, all the other countries built big projects that were commissioned in the early 1980s. These projects were also justified on the basis of a demand rate of increase of nearly 8 percent. However, due to economic limitations, the load growth slowed down. The rate of increase of demand in the 1980s was sustained, although at a lower value. From 1980 to 1985, the generation increased 4.4 percent per year, while, from 1985 to 1990, this rate was 5.9 percent per year. In the decade (1980-1990), the average rate was 5.2 percent.

Evolution of Interconnections

Due to the oil crisis, the Central American countries conducted studies to achieve a more efficient use of the energy resources available within the region. The name of the project, which was conducted from 1975 to 1979, was the Regional Study for the Electric Interconnection of the Central American Isthmus (ERICA), and it was developed in the Economic Commission for Latin American and the Caribbean (CEPAL) office in Mexico. The main results of the project were as follows:

- Identification of bilateral and regional actions required to reach a complete integration among the six countries.

Although the end of ERICA coincided with the political and economic crisis in the region, several benefits were obtained regarding the integration of the electric power sector by following the recommendations of the study.

In 1976, the transmission link between Honduras and Nicaragua started operating (136 km long, constructed and insulated for 230 kV, but operating at 138 kV). In 1982 the transmission link between Nicaragua and Costa Rica started operating (224 km long, 230 kV construction), allowing the export of hydroelectric power from Costa Rica to Nicaragua and Honduras. By 1985 the hydroelectric station Francisco Morazan (El Cajon) in Honduras, allowed the export of surplus energy to Nicaragua and Costa Rica. By that time, Costa Rica had already exhausted its export capability.

In 1986, the link between Costa Rica and Panama (42 km long, 230 kV construction) started operating, as well as the link between Guatemala and El Salvador (120 km long, 230 kV construction). The exports from Honduras to the southern and central countries continued, although water spills occurred in the Tacana project. This could have been avoided if the link between Honduras and Nicaragua had been operating at 230 kV, which finally occurred in 1990.

The interconnection process is not over yet. The link between El Salvador and Honduras is to be built (160 km long, 230 kV construction). From the technical point of view, the interconnected operation has been affected due to the weakness not only of the interconnected system but of the national systems themselves.

Operating problems have moved the electric utilities to improve their own technical abilities and start working to overcome these problems. In spite of the existence of the interconnections, utilities still plan their expansions without taking them into consideration, pursuing the self-sufficiency of every national system.

This approach is due to the uncertainty derived from the political turmoil in the region, and it produces larger financial requirements than would be necessary if a coordinated development strategy were followed.

In spite of the way the planning and development of the regional system is carried out, there have been significant transactions in the last decade that have reached as much as 3,232 GWh.

Current Difficulties in Developing the Regional Electric Power Sector

Since 1985, there have not been significant additions to the installed capacity in the region, and the systems in the region are still mostly hydroelectric in nature.

In these systems, the risk of energy shortages are the main design criteria, as opposed to mostly thermal systems where it is important to consider the reliability of the thermal units. During the last few years, planning proposals in the region have been delayed, producing large energy shortages with a significant impact on the national economies. In 1991, due to a severe drought, roughly 230 GWh were not served, affecting four countries. This impact lasted until the beginning of 1992.

Although from 1983 to 1991 there was hydroelectric surplus that was exchanged among countries due to the increase in demand, this surplus has already disappeared and for some time the interchange possibilities will be minimal and of short duration. However, it is possible to pursue a coordinated operation to replace diesel generation in one country for thermal generation produced in another. A number of technical, administrative, and legal problems have to be solved to get this form of operation going. The largest
problems are related to payment and cash flow to the selling utilities.

It is also necessary to consider that, due to the hydroelectric nature of the system and to the existence of large interannual capacity dams, it is very important to optimize the coordinated operation of the interconnected system (mid-term and long-term operations planning).

It is desirable not only to have a reliable energy supply but also to have it in the most economical way. An important problem that El Salvador and Guatemala have to face every rainy season is the limited size of the dams of the main hydro stations. They have to wait for the rainy season with almost empty dams, but, if the season is retarded even for a few days, expensive shortages might occur. In the other hand, if they keep high levels to ensure the energy supply, they might spill a large amount of energy.

The expansion plans, defined separately by every utility, require over US$700 millions a year. Even considering government, multilateral bank loans and the utilities own resources, it is not possible to acquire this amount. This financial shortfall produces delays in the construction of new plants even though the expansion plans consider thermal units costly to operate for the utilities (internal combustion and diesel units).

Technical Problems in the Networks

The transmission networks of the Central American countries consist of a reduced number of long transmission lines connecting remote generation sites to the main consumption centers, which are usually large urban areas. These systems, which have been named longitudinal power systems, are characterized for their radial structure and low short circuit capacities as compared with robust or network systems that are a characteristic of developed countries. The weakness of the longitudinal systems is shown through wide voltage variations when a configuration change occurs or even with normal load variations during the day. For these reasons, in both planning and operation of longitudinal systems, it is very important to consider their technical characteristics to support the decisions taken during the process of system development and integration.

The financial crisis and the privatization wave occurring worldwide is exerting pressure to change the property structure of the national utilities. However, even with an aggressive privatization policy, it is hard to think that this financial problem will be solved. So, it is very important to consider the financial costs involved in financing the electric power sector development to obtain reasonable unitary costs for the intended new energy sources and to avoid a massive extraction of economic resources from the Central American countries.

The growing and so far unsolved financial needs of the national utilities have encouraged the integration of the regional electric sector and the consideration of this integration as a valid option to promote development.

But, it is also clear that this integration will pose several problems of a legal, administrative, and technical nature that should be considered and confronted by all of the parties involved in the process. The next paragraphs briefly describe several of the typical problems that will appear when the six interconnected systems are considered. In spite of these problems, which are technically solvable, the benefit of a coordinated operation will encourage the strengthening of the interconnected operation. We are speaking about an economic operation of the regional hydro-thermal system that will be obtained through engineering training and improvement of the transmission system reliability.

Reduced Transmission Limits. The maximum transmission capability for a line or set of transmission lines (i.e., transmission line loading) is related to the line length. This limit has been reported in a curve, known as Clair’s curve, which can be found in transmission line handbooks.

By knowing the length of the line, it is possible to determine a transmission limit as a function of the transmission line surge impedance loading (SIL) and with a steady state stability margin (say 30-35 percent) and a given voltage drop (say 5 percent).

However, it should be pointed out that Clair’s curve was defined concerning high values of short circuit capacities at the line ends that correspond to 50 kA, or 20,000 MVA in a 230 kV level. In the Central American networks, some 230 kV nodes may have as low as 500 MVA short circuit capacities.

This is why it is not possible to use the standard Clair’s curve to define the loading of transmission lines in longitudinal systems.

In longitudinal systems, the transmission limit is generally defined by voltage drop problems or stability margins. It is important, however, to know the considerations involved in the determination of Clair’s curve to use it properly.

Voltage Control. This problem is associated with the loading of the transmission system. It is common in the Central American systems to have long lines to transfer power to load centers that have a limited reactive power support. Usage of the transmission network can be improved if appropriate compensating devices are installed to reduce transmission losses and improve loading. In these systems, it is very common to have excessive reactive power in light load conditions and deficient reactive power in heavy load conditions. So, it is very important to consider switchable shunts or compensating devices when adding new transmission lines.

The dynamic characteristics of the compensating devices must be considered also in the design of the transmission system, since, in these systems, severe voltage variations might occur that could produce loss of synchronism.

Dynamic Performance. In longitudinal power systems, it is very common to have transmission limits due to dynamic problems. It is also very common to have loss of synchronism of important machines due to single contingencies. In this case, it is important to consider discrete supplementary controls to improve the usage of the transmission networks. In the case of weak interconnections, when a perturbation occurs, electro-mechanical oscillations are introduced to the interconnected system. This phenomenon requires a careful adjustment of speed and voltage regulating systems. Although it is technologically feasible, it is not common to install supervisory devices to monitor the dynamic behavior of the system. By knowing this behavior, it is possible to design automatic separating strategies and to avoid the uncontrolled propagation of a disturbance.

Regulatory Aspects of Interconnected Operation

In 1958, the Economic Cooperation Committee of the Centroamerican Isthmus formed the Centroamerican Subcommittee for Electrification and Hydro Resources (SCERH) to promote studies of the integrated development of the electric power sector and hydroelectric resources of the region.

In 1963, SCERH founded the Regional Group for the Electric Interconnection (GRIE), which was responsible for supporting and promoting the integration of the electric power sector. GRIE was formed with planning and operations managers from every national electric utility. The Secretariat of the SCERH and GRIE was ECLAC, a United Nations organization. From 1979, the national electric utilities started organizing the Electrification Council for Central America (CEAC), which nowadays is the organization in charge of proposing, coordinating, and developing regional cooperation programs for the benefit of the six Central American electric
utilities. During 1994 and 1995, CEAC will be based in Guatemala.

**PARSEICA Project**

The Program of Regional Activities in the Electric power sector of the Central American Isthmus (PARSEICA) was a project developed in the region from 1989 to 1993. The project was financed by the InterAmerican Development Bank (IDB) and the six national electric utilities. The objectives of the project were to:

- Improve the technical capabilities of these utilities to operate their systems in a more secure, economical and coordinated manner
- Promote the integrated operation of the regional hydrothermal system.

For this purpose, over 24 engineers (6 per country) were trained in different aspects related to power system analysis, power system dynamic behavior, and operations planning. During 3 years, more than 10 courses, seminars, and workshops were organized in Mexico, Central America, and Brazil, for a total of over 600 hours of training for this select group of Central American professionals. The topics covered in the training program were power system analysis, transient stability, real power and frequency control, reactive power and voltage control, small perturbation analysis of power systems, basics of operations planning, advanced topics in operations planning, speed and voltage regulation system adjustments, and appropriate planning of system expansions.

Besides this training effort, computer systems were installed in every control center of the electric utilities. These systems consist of two interconnected personal computers. Programs were installed in these computers to develop studies of electrical and economic nature. These programs were transferred by the Federal Commission for Electricity (CFE) of Mexico and a Brazilian consulting company. The set of models provided in the program were:

- Power system simulator: transmission line modeling, load flow simulator, short circuit simulator, power system dynamic analyzer (time domain), and power system dynamic analyzer (frequency domain)
- Operations planning: demand analysis and forecasting, hydrology analysis and synthetic series generator, and simulation and optimization of hydrothermal systems.

During the project, besides the technical training and model transfer, other system aspects related to operational problems were analyzed, including diagnosis and recommendations regarding maintenance practices, control centers, and telecommunications infrastructure.

It is important to point out that, during program execution, all the important characteristics of the Central American systems were taken into account to customize the transferred computational tools. Also, common databases for system security analysis and operations planning were developed.

As a final activity of the project, different levels of operation coordination were analyzed. For 4 years of simulation and consideration of the actual transmission limits in the interconnection lines, savings of US$64 million were found. In considering the link between Honduras and El Salvador, additional savings for US$11.8 million were observed. For an integrated optimization of the regional hydrothermal system, US$13 million more could be saved.

These preliminary results have encouraged Central American utilities to promote the coordinated operation of their systems. To accomplish this, working groups in system security and operations planning are being formed to produce integrated operations plans and recommendations to improve the electric network reliability. These groups are being formed with the professionals that were trained in the PARSEICA project.

**Toward Coordinated Operation**

The evolution of the electric power sector in the Central American isthmus shows that, in the short and medium term, the financial shortfall existing for considering autonomous national expansion plans will be hard to overcome, even with an aggressive privatization policy.

An alternative way to cope with this problem could be to improve the integration of the regional electric power sector by promoting joint or coordinated operations and planning. The physical improvement of the regional interconnection has to take into account the weakness of the existing national and regional networks.

The electric utilities of the region have gained a valuable experience in terms of developing regional projects. They are working towards a coordinated operation of their systems as a continuation of regional efforts that have provided them with well trained engineers and analytical tools.

**About the Speaker**

Ricardo Mota-Palomino gained the BSEE and MSSEE degrees in from Instituto Politécnico Nacional, Mexico, in 1974 and 1978, respectively. In 1984, he earned a PhD degree from the University of Waterloo in Canada.

From 1975 to 1984, he was with the Federal Commission for Electricity (CFE), Mexico, where he was responsible for short-term operations of the Mexican interconnected system; from 1986 to 1988, he was chairman of graduate studies at...
Feasibility Studies of a Power Interconnection System for Central American Countries: SIEPAC Project

T. Gomez (presenter) and J.C. Enamorado, Instituto de Investigacion Tecnologica (IIT) Universidad Pontificia Comillas (UPCO), Madrid, Spain, and A. Vela, Empresa Nacional de Electricidad, SA (Endesa), Madrid, Spain

The electrical systems of the Central American countries are linked by 230 kV ac weak border interconnections forming two separated subsystems. The first one includes Guatemala and El Salvador, and the other one comprises the systems of Honduras, Nicaragua, Costa Rica, and Panama. As a consequence, unrestricted energy exchanges among all countries are not possible.

Since 1987, the following electric utilities have been promoting the SIEPAC project: INDE from Guatemala, CEL from El Salvador, ENEE from Honduras, INE from Nicaragua, ICE from Costa Rica, IRHE from Panama, together with the ENDESA Group from Spain.

The SIEPAC project consists of a 1678 km long 500 kV ac power transmission line that would link the six electrical systems of the region through seven power substations (one for each country and two in Panama), installed close to the highest demand national centers and six control centers of energy (one for each country) to allow coordinated operation of the interconnection. This project also considers a set of complementary assets (230 ac power transmission lines into some countries and the border transmission line between El Salvador and Honduras, and various other equipment).

The power transmission line will greatly reinforce the actual border interconnections, which have a reduced capacity of exchange and technical problems associated with the stability of a weak longitudinal system. On the other hand, economic savings for the region would be achieved, coming from a higher coordination level in the operation and planning of their systems.

Analysis Outline

Feasibility studies have been carried out in order to determine the optimum installation program and the capacity of the interconnection, analyzing the economic and technical convenience of the interconnection, taking into account the power and energy exchange requirements expected for the short (1993-1997), middle (1997-2000), and long (2000-2004) terms among all the countries from the Central American Isthmus.

General Scheme. The general scheme of the analysis is based on three consecutive studies:

- Determination of generation expansion plans with different hypothesis on the coordination level among the countries
- Determination of the power and energy exchanges among local systems and the optimum interconnection capacity development required
- Economic evaluation of the different generation-interconnection plans obtained, comparing their benefits versus a reference plan.

Studies of the interconnection design and the security evaluation of the coordinated operation (voltage profile, transient and dynamic stability, and electromagnetic transients) correspond to another set of the studies.

Scenarios. Different scenarios have been defined for the feasibility analysis based on:

- Different hypothesis of estimated load growth: low (scenario 1) and medium (scenario 2).
- Different coordination levels in generation planning (autonomous and coordinated plans): autonomous generation expansion of each national system keeping present individual criteria of generation reserve margins (plan A); coordinated generation expansion from 1998, keeping positive power and energy reserve margins in each country and assuming average hydrology in the whole region (plan B). Both plans consider coordinated operation of the whole system from 1997. All facilities projects planned up to 1997 are considered to be committed and excluded in the economic evaluation of the studies.
- Different expansion alternatives in the coordinated generation planning: optimum plan based on hydro, thermal, and geothermal combination (without large hydro plants), including 350 MW thermal plants as alternative projects (plan B.1); optimum plan similar to B.1, but taking into account large hydro plants, such as the 1520 MW Borucu hydro project in Costa Rica (plan B.2).

Main Criteria. The feasibility studies were carried out under the following main hypothesis. The horizon study covers the period 1997 to 2012. The coordinated plan provides positive power and energy reserve margins in each country every year under average hydrology conditions. This overall cooperation in potential undesirable situations. Under dry hydrology conditions, the non-supplied energy must not exceed 1.7 percent of the total energy demand.

Coordinated operation "economic dispatch for the global system" is implemented starting on 1997 in all the scenarios. The expected load growth of the whole system ranges between 5 percent (scenario 1) and 6.4 percent (scenario 2).

Fuel prices are considered: 47 and 54 $/MT coal, 14.82 and 17.68 $/bbl Bunker C, and 22.52 and 27.09 $/bbl diesel for 1993 and 2003, respectively. The installation costs (without capitalization) of the most relevant thermal generation alternatives are: 1,200 $/kW Bunker 100 MW; 1,500 $/kW coal 350 MW; and 450 $/kW gas turbine 30 MW. The installation costs (without capitalization) of the geothermal alternatives range from 1,890 $/kW (Hoyo Montegalan in Nicaragua) to 2,617 $/kW (Costa de la Islita in El Salvador). The installation costs (without capitalization) of some hydro alternatives are: 866 $/kW Borucu in Costa Rica, 2,300 $/kW Changuinola in Panama, 1,731 $/kW Brito in Nicaragua, and 1,482 $/kW Angosta in Costa Rica. The installation costs (without capitalization) of the power transmission line alternatives are: 0.13 M $/km (230 kV) and 0.20 M $/km (500 kV).

Methodology: Generator Expansion Plans

The EGEAS generation expansion model has been used to determine the different generation expansion plans. Considering average hydrology conditions in all the countries, the autonomous expansion plans for each country (autono-
nous plan A), as well as the coordinated plans B.1 and B.2 for the whole system were obtained, on each load scenario (1 and 2).

The obtained expansion plans were reevaluated under dry hydrology conditions, commissioning some projects at earlier dates and/or incorporating new gas turbines. The study enables determination of the optimum generation expansion plan in every scenario, investment costs associated, year-to-year operation costs without constraining economical exchanges, and also the yearly energy exchanges among the countries.

Development of the Interconnection. The interconnection development program is done according to the optimum power exchanges obtained from the coordinated operation of the countries. The JUANAC generation-transmission simulation model, which performs a security-economic dispatch of the overall system, has been used to determine these exchanges.

The power transmission line alternatives considered are:
- Building and operation at 230 kV, which is the highest voltage existing in the region
- Building in 500 kV, initially operated at 230 kV, in order to be operated later at 500 kV
- Building and operation at 500 kV

The interconnection requirements were analyzed in three different years of the horizon (1997, 2000, and 2004).

The optimum schedule for development of the interconnection is determined for each of the generation expansion plans.

Economic Analysis. The actual costs are present value, with a discount rate of 12 percent. Different generation-interconnection plans developed in each load scenario are computed. The total cost of each plan consists of:
- Investment cost of new generation plants plus fixed O&M associated cost
- Investment cost of power interconnection lines plus fixed O&M associated cost
- Annual operation cost, including fuel costs, variable O&M costs, and energy nonsupplied costs.

According to their present value, the different generation-interconnection plans are economically comparable with respect to the reference plan.

Results of the Studies
In all analyzed scenarios the studies carried out show the interest of building an interconnection. Even under autonomous planning scenarios, savings derived from coordinated operation justify a new interconnection.

SIEPAC Project Formulation. For each one of the generation plans, different optimum developments of the interconnection were obtained. These results lead to a practical formulation of the SIEPAC project with the following characteristics:
- Homogeneity in the voltage level of the whole interconnection
- Simultaneity with regard to the building time program
- Profitability similar to the different optimum developments of the interconnection.

According to these criteria, under coordinated planning scenarios, the SIEPAC project has been basically formulated in two stages:
- Stage 1: construction of the complete power interconnection line at 500 kV, initially operated at 230 kV. The deadline for this stage is the year 2000. The construction of the local transmission system reinforcements should be considered in the period 1997-2000. This construction and finance must be compatible with the national development programs now underway.
- Stage 2: construction of seven 500/230 kV substations to operate the power interconnection at 500 kV. The expected deadline for this stage is the year 2004.

**Required Investments.** The required investments for the SIEPAC project are shown in Table 3.

<table>
<thead>
<tr>
<th>Country</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guatemala</td>
<td>16.3</td>
<td>9.4</td>
<td>25.7</td>
</tr>
<tr>
<td>El Salvador</td>
<td>90.1</td>
<td>12.7</td>
<td>102.8</td>
</tr>
<tr>
<td>Honduras</td>
<td>47.8</td>
<td>13.2</td>
<td>61.0</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>57.5</td>
<td>14.2</td>
<td>71.7</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>108.4</td>
<td>15.2</td>
<td>123.6</td>
</tr>
<tr>
<td>Panama</td>
<td>86.7</td>
<td>26.5</td>
<td>113.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>406.8</strong></td>
<td><strong>91.2</strong></td>
<td><strong>498.0</strong></td>
</tr>
</tbody>
</table>

Expected Benefits. In order to determine the expected benefits of the coordinated plans, a comparison was made between autonomous plan A (reference plan which is used to assess the savings and the profit of SIEPAC), and coordinated plan B.1 and coordinated plan B.2. These results are presented in Table 4.

<table>
<thead>
<tr>
<th>Scenario &amp; Plan</th>
<th>Gen Invest</th>
<th>Net Invest</th>
<th>Operation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan A</td>
<td>1,505</td>
<td>1,062</td>
<td>2,567</td>
<td></td>
</tr>
<tr>
<td>Plan B.1</td>
<td>1,373</td>
<td>273</td>
<td>869</td>
<td>2,515</td>
</tr>
<tr>
<td>Plan B.2</td>
<td>1,366</td>
<td>275</td>
<td>905</td>
<td>2,446</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan A</td>
<td>2,214</td>
<td>1,876</td>
<td>4,090</td>
<td></td>
</tr>
<tr>
<td>Plan B.1</td>
<td>2,013</td>
<td>280</td>
<td>1,600</td>
<td>3,892</td>
</tr>
<tr>
<td>Plan B.2</td>
<td>1,856</td>
<td>281</td>
<td>1,583</td>
<td>3,720</td>
</tr>
</tbody>
</table>

From these results, it is concluded that the expected benefits of the project rise when:
- Expected load increases (scenario 2 vs scenario 1)
- Coordination in planning reaches higher levels (coordinated vs. autonomous)
- Borrica project is included in the coordinated planning (plan B.2 vs plan B.1).

Sensitivity Analysis. The following sensitivities were performed in order to test the project robustness:
- Relaxation of the constraints of positive generation reserve margin per country (increment of the energy dependence among countries)
- Increase in fuel prices (20 percent)
- Borrica project cost increment (25 percent) and 1 year of delay in Borrica's start date of operation
- Financial discount rates of 10 percent and 14 percent, respectively
- 400 kV transmission line versus 500 kV
- 230 kV transmission line versus 500 kV.

The results show that the project continues being profitable in all of these situations.

Feasibility Study Findings
A methodology to evaluate (technical and economic) international interconnections among electrical systems has been presented. Its application to the SIEPAC project shows the savings and reliability improvements derived from better
coordination in the planning and operation of the systems, even keeping energy independence in case of necessity (positive reserve margin in each country).

Also, the SIEPAC project would provide important advantages to the Central America region:
- Regional integration given the compromises assumed by all participants countries in the financing, construction, and operation of the interconnection
- Regional natural resources, such as large hydraulic projects, will become more attractive and feasible, decreasing external energy dependence
- Investment reduction in generation and transmission equipment as a result of coordinated planning
- Operation cost reduction by using the least expensive generation facilities because of the coordinated economic dispatch
- Uncertainties in future load growth, generation plant allocation, and local dry hydrology periods would be more manageable
- Improvement of global and local reliability, giving a better quality of service to users.

About the Speaker
Tomas Gomez obtained his PhD in electrical engineering in 1989 from the Universidad Politecnica, Madrid, Spain, and his bachelor's degree in electrical engineering in 1982 from the Universidad Comillas, Spain. He is the associate director at the Instituto de Investigacion Tecnologica, Universidad Pontificia Comillas, Madrid, Spain. He is working on several projects related to transmission planning, protection systems, reliability of distribution networks, and voltage control. His areas of interest include analysis and design of electric power systems, nonlinear dynamic systems, control of large scale systems, and optimization techniques.

Electric Energy Sector in Argentina
Carlos Manuel Bastos, Secretary of State for Energy, Ministry of Public Works and Services, Republic of Argentina

The organization of the electric energy sector in Argentina has changed dramatically from a sector in which state-owned companies worked under a central planning to one in which private companies make their own decisions.

The way that the electrical system used to work can be shown by these statements:
- Demand growth estimated by central planning team
- Projects to be developed and the timetable determined by the same team; unit operations ruled by central dispatch, and under state-owned companies responsibility
- Integration with neighbor countries focused on physical projects, such as Salto Grande with Uruguay and Yacyreta with Paraguay.

Today the electrical system works under these rules:
- The system has been vertically separated and the companies cannot be integrated.
- Electric energy is considered as an ordinary wealth and the value that consumers give it is taken into account. (The distribution companies pay consumers a penalty for the energy that they cannot supply. The penalty is worth the economic damage consumers suffer due to its lack.)
- Producers have to compete for demand. They can sell in two ways: sell under private agreements or sell to the system. Both ways of selling compete with each other because the system buys giving priority to lower costs and, as a consequence, some of the producers do not sell at all.

Transportation and Interconnections
In the new organization, the transmission network is a key issue, because, as you know, the producer and the consumer share it, and they do not have any other way to transmit energy to each other.

There are three main goals in energy transportation:
- Transmission network is open access
- Transportation companies do not buy or sell energy, they only transport and receive a toll for it
- Future developments in transport should obey market forces.

To achieve these three main goals was the greatest difficulty that we faced in all the transformation from public to private operation. I'm not going to give more details about it, because other panellists (engineers Caruso and Sbertoli) will provide additional information.

Interconnections are the way to exchange energy between different systems. The relevant point of this energy exchange for us is, because in a system that works under rules as outlined above, the prices and investment decisions depend on the future scenarios and the perception that different players have of those scenarios.

These scenarios can be determined mainly by:
- Demand growth
- Petroleum prices
- Discount rates.

The various combinations of these parameters will lead to different decisions; probably, high oil prices with low discount rates give more hydroelectric development than the inverse, while low oil prices with high discount rates mean more thermal plants. But there is another cause that is important too to make investment decisions, such as capacity excesses, natural gas prices, competitors behavior, and the scope of analysis.

Capacity Excesses. This is related to the place to build a new generating plant. If there is excess capacity in the transmission network, it is better to build near the source of fuel. If the excess capacity is in the pipeline, it may be better to build the plant near to the location of the demand.

Natural Gas Prices. Natural gas is not a commodity, and its price will be fixed by the relationship between reserves, production, demand, and transportation costs.

Competition's Behavior. Wrong decisions by some players do not always mean benefits for the others. A big hydroelectric power plant or a nuclear generating station may not be able to recover the investment cost, but, as their operation costs are lower than a thermal power plant, the output would be dispatched in place of some thermal plant output resulting in a marginal price that would be lower for all.

Scope of Analysis. The players need to know with precision the limits of the demand and the details of the offer to make their decisions. For example, the future energy scenario in Argentina is completely different if we think of Yacyreta as selling energy only to Argentine markets or if we think of Yacyreta as selling to Brazil as well.

Energy Exchange Policy
Before taking a position on this subject, I want to show you the obligations governments have in two very opposite possibilities.

First, think of an isolated country (meaning that we are going to look only at national energy markets).
- The government has to approve energy import and/or export. In these cases, the government has to be sure that the prices for that are based on marginal cost.
The energy export and import has to be announced long before it is performed, otherwise it would be changing the rules of the game. Remember that different private players are making risk decisions looking at internal market only.

Second, think of a country completely integrated (national and international energy markets). In this case, the rules for the exchange have to be:
- Equity, producers and consumers should be able to buy and sell in all the region.
- Rates and prices have to be based on marginal cost, otherwise factories that means demand will move for noneconomic reasons.
- Networks and pipelines have to operate under open access and toll prices.
- If in some place there are state owned companies, they cannot sink capital cost at the moment of selling energy.

It is important when privatization is in process, because if at this moment governments sink costs, it would imply unfair competition.

Of course, as Argentina has reorganized all of the electric energy system with new ideas based on competition and private risk taking, it is looking forward to integrating its energy system with neighboring countries as much as possible.

About the Speaker
Carlos Manuel Bastos, an Argentine electrical engineer, did his graduate studies at Cordoba National University, Argentina. He began his career as a researcher in IEERAL (Institute of Economic Researches), Fundacion Mediterranea, in the area of economy of public services and energy. Later, he was appointed associate chief of the Electrical Planning Division, Electrical Company of the Province of Cordoba, and consultant in the area of electric energy of institutions at the Intramericano Development Bank and the Harvard Institute for International Development. He has played a key role in the transformation and in the restructuring of the electricity supply industry in Argentina.

Venezuelan Energy Resources and Electric Power System
Juan Altimari, Executive Director, Foundation for the Development of the Electric Service, Electric Regulatory Commission, Venezuela

Venezuela is located in the north of South America, has an area of almost 1 million square kilometers, and has a population of nearly 21,000,000. One of Venezuela’s outstanding characteristics is its great abundance of energy resources. Two of the largest industries in the country are in the energy field: the oil industry and the electric industry. The availability of energy makes Venezuela very attractive for electro-intensive industries, and the location of the country greatly facilitates trade with North America, Central America, South America, and Europe.

The availability of energy in Venezuela also opens the possibility of exporting electric power to other Latin American countries, but, in this respect, it is important to take into account that in some cases there are thousands of kilometers between generation and load centers.

Power Industry
In Venezuela, the electric systems were established by private companies over 100 years ago, and electrical service was quickly extended to all main Venezuela cities. Nowadays, Venezuela is over 90 percent electrified.

Among the original private companies, La Electricidad de Caracas stands out as one of the largest private power companies that has survived the decades of state socialism in Latin America, becoming one of the leading enterprises in Venezuela. La Electricidad de Caracas serves the city of Caracas and its metropolitan area. It generates, transmits, and distributes power with the reputation of good service and efficiency.

Besides La Electricidad de Caracas and its subsidiaries, there are three minor private utilities in Venezuela and four medium to large publicly owned companies. The two medium public companies, Enelven and Enelbar, used to be owned by Canadian investors until 1976, when they were bought by the Venezuelan government. These companies serve the cities of Maracaibo and Barquisimeto, respectively, and they are vertically integrated. Cadafe and Edelca are the two large publicly owned companies. Cadafe covers most of the Venezuelan territory and generates, transmits, and distributes electric power. Edelca is in charge of developing the large hydroelectric projects in the Caroni river, and, therefore, is the largest producer of electric power in Venezuela. It also owns and operates most of the bulk transmission network in the country.

Venezuela is undertaking a large reformation of its electric power sector in order to make it more competitive. Enelven and Enelbar privatization processes are in the final stages. Cadafe is under deep restructuring in order to improve its effectiveness and efficiency, and to make its privatization feasible in the short to medium term. From the regulatory point of view, some reforms were introduced, like a consistent tariff system and a basic set of rules for the business; but, a lot of work needs to be done and is being done in this area.

Generation Resources
The most important resource for generation of electric energy in Venezuela is the Caroni river, where 70 percent of the energy consumed in the country is produced in two plants: Guri and Macagua I, with a combined capacity of 10,000 MW. The Caroni river, located in the southeast part of the country, has in its last 100 km a drop of over 250 meters, which represents over 16,000 MW of power in a relatively short distance; it has an average flow of 4,700 m³ per second.

In order to take advantage of this unique situation, a plan was conceived over 30 years ago, which called for the construction of Guri Dam to regulate the river and store energy in a lake over 4,000 km² and the construction of several power houses in the lower Caroni: Guri and Macagua I are already in operation; Macagua II (2,500 MW) and Caruachi (2,000 MW) are under construction, scheduled for 1995 and 2001 respectively; and Tocoma (2,000 MW) is in project stage. The steady execution of this plan by EDELCA, with the unique characteristic of the Caroni river and the support of all consecutive democratic governments, make these developments among the least expensive in the world: Guri 400 $/KW, Macagua II 600$ KW, and Caruachi and Tocoma 750$/KW.

The rest of the Venezuelan Generation (30 percent) comes mainly from thermo-electric generation, which is based on gas and fuel oil. The largest generation plants are Tacao (1200 MW) and Planta Centro (2000 MW), located in the northern part of the country.

Venezuela has had for many years a policy of favoring the use of hydroelectric energy instead of burning fuel that could be exported. This policy made hydroelectric energy the important source of energy for generation, with gas the favored alternative, and many of the thermal units in the system were simply displaced by the substitution energy.
from hydroelectric projects. But, in the next 10 years, even the most pessimistic forecasts point out that it will be necessary to put from 1,500 to 2,000 MW of additional thermal capacity online, along with Macagua II and Caruachi projects. This capacity could come in part from new plants, which most likely will be turbo-gas or combined cycle, depending on the gas price, which, given Venezuela's vast gas reserve is very competitive (US$ to US$ per mmbtu in the long term).

Finally, in order to optimize the use of generation resources, from the late 1960s to the present time, an extensive interconnected network was developed in Venezuela, with voltages of 230, 400, and 800 kV. This system allows the interconnection of the hydro-generation in the Caroni river, with the rest of the country. The interconnected network is continuously in expansion, but the next major expansion is planned after Carauchi and Tocoma are in service. The extensive transmission grid will play a crucial role in the future reorganization of the electric sector, as it might become part of a separated transmission company, whose mission will be to give transmission access to large electric customers and the large producers of energy.

**Load Perspective**

In the past 20 years, Venezuela has been the largest per capita consumer of electricity in Latin America, and we used to be proud of it, as it represented a high level of industrialization and high standard of living. However, nowadays, the environmental considerations require us to rethink energy use in terms of industry efficiency and domestic electric savings. Almost two-thirds of our electric energy consumption is industrial, with the system load factor near 80 percent for the last 10 years and with all of the economic consequences that this has for planning and system operation. Hence, in our system, all new expansion was dictated by energy requirements rather than power, and high priority is put on the availability of generation and transmission lines. This system expansion has required the installation of appropriate reserves.

The load forecasts to year 2010 indicate that the load will grow at a rate of at least 4 percent a year, which is less than one-third of the load growth rate observed in the 1970s. However, it is important to note that even in the years of very little growth of the GNP, the load increase rate has never been under 4 percent. In the last 10 years, including 1993, the load growth was 5 percent, despite a contraction of 1 percent in the GNP and a large adjustment in tariffs, particularly for the residential sector.

It is expected the load growth will continue to have a heavy industrial component for the next 7 years, as the oil industry will depend more and more on the electric utilities, as the isolated self-generation scheme that this industry used to have, became impractical and obsolete. It is also expected that two new aluminum smelters will be installed in the country before the year 2000. A large residential load increase is not expected, as the tariffs will continue to adjust for this sector.

Two international interconnections with Colombia are in service at 230 kV with 150 MVA capacity and 115 kV with 50 MVA capacity. This later interconnection will be expanded at 230 kV to increase the capacity to 200 MVA. Other international interconnections under study in Venezuela are interconnections to Brazil (Manaos), Trinidad Island, and Aruba. But, in order for these interconnections to prosper, not only must technical problems be solved, but it will be necessary to appropriately solve the political issues that these interconnections raise. Other issues need consideration, like whether it is not better to export energy in the form of carbon, oil, or oil derivatives, instead of building a large and long transmission line. Nevertheless, as in the case of Colombia, all these problems can be overcome and great profit derived from interconnections for all parties involved.

**Conclusion**

In this brief presentation, an overview of the Venezuelan electric power sector was given. It was observed that in Venezuela both private and public utilities have coexisted for many years and the electric sector is headed for further privatization. The abundance of energy resources and the expected load growth make Venezuela a very interesting place for investments in both the electric business and in electro-intensive industries.

**About the Speaker**

Juan Altimari was born in 1941 in Maracibo, Venezuela. He gained his first degree from the Central University of Venezuela in 1963, and a MS in electric power systems from Illinois Institute of Technology, Chicago, Illinois, in 1965. He has been a member of the faculty of the Central University and Simon Bolivar University, Venezuela, since 1965. He has been a member of the board of directors of the Electric Utilities Cadafe and EDELCA in different capacities since 1969.

He was director of planning at EDELCA from 1987 to 1993, and recently became executive director of Fundelec, the Electric Regulatory Commission of Venezuela.

**Brazil and the Electrical Interconnections in the Mercosul Region**

**Jose Luiz Alqueres**, Chairman, Centrais Electricas Brasileiras SA, Eletrbras

This presentation describes the state of relations among the four countries that form Mercosul, the common market that is being formed by Argentina, Brazil, Paraguay, and Uruguay, and the prospects for expansion of international electric energy commerce and exchanges in that region.

The first part presents the main supply facilities already available, including hydroelectric power plants, power stations, frequency conversion stations, and transmission lines. It should be noted that some borders between Mercosul's countries are already crossed by highly significant electric energy flows, at binational hydroelectric developments such as Itaipu (Brazil and Paraguay) and Salto Grande (Argentina and Uruguay), where one party sells to the other the surplus of its share in the plant's generation.

The second part focuses on the status of the Brazilian electric power sector and analyzes some of its features that are considered to be an incentive to the expansion of the electric energy international commerce in the Mercosul region. Among such features that may foster interchange are:

- Large binational hydroelectric potential to be developed by these countries
- Foreseen growth rate of the regional power market made accessible to all parties by the interconnection of their power systems
- Hydrological diversity among different countries' river basins
- Diversity of energy resources, including oil, gas, coal, and hydropower. Some significant examples of such aspects are the final works now under way at the Yacyreta power plant (Argentina and Paraguay) and at the Uruguaiana frequency conversion station (Argentina and Brazil).
Recent agreements for the exploitation and sale of Argentine and Bolivian natural gas.

*Effects of the operation of Sintrel (the open-access system to Brazilian power transmission network) and privatization progress in Argentina.

Recent governmental initiatives in the Mercosul region demonstrate that, besides the commercial convenience, electric energy interchange effectiveness also has the support and the manifest interest of the intervening governments, from the standpoint of their international policy.

This presentation reviews the spirit and guidelines that resulted in the conception and implementation of the present binational developments, within a bilateral logic and scope, and compares that outlook with the present rhetoric and integration practice. This takes into account the well-known implementation difficulties and points out the advantages of bilateral optimization, an approach that may accelerate market integration within the Mercosul region.

The concept of bilateral optimization is based on the knowledge of the potential energy and capital gains that can accrue because of an optimized, integrated operation of supply facilities, both those currently available and those to be developed.

The distribution of the benefits from this integration should be proportional to the dimension of the markets to be supplied, so as to contemplate the customers that sign contracts for guaranteed energy supply from the integrated system.

Full consideration of these aspects will lead to the revision of some projects in the region, besides affecting the evaluation their economic and financial attractiveness. Such is the case of transmission lines to carry nonguaranteed hydroelectric energy to be commercialized. That energy, sold as interruptible power, should be adequately priced so that the investment in these transmission lines can be duly paid off from the energy sales revenue, and it should be realistically estimated.

**Brazilian Electric Power Interconnections in Mercosul**

In the mid-1970s, the first electric power interconnections were installed between Brazil and its neighbors, primarily benefiting the small localities on Brazil’s borders with Paraguay and Uruguay.

Most of these townships are not yet linked to the large national electric power systems of their respective countries. They are supplied by small diesel-electric groups and are beset by many operational problems, particularly the availability of fuel and spare parts.

By interconnecting these localities, it became possible to implement an exchange of electric power in emergencies and to effect contractual supply when one of the parties was not equipped to generate the capacity needed.

It must be stressed that international electric power interconnections between Brazil and neighboring countries in the southern cone (Argentina, Paraguay, and Uruguay) usually face technical problems caused by differences in voltage standards and frequency (in Brazil 60 Hz, and everywhere else 50 Hz). So far, the geo-economic conditions in other countries bordering on Brazil, including those in the Andean region (Bolivia, Colombia, Peru, and Venezuela) as well as Guyana, Suriname, and French Guiana, limited the development of major international power transmission interconnections in the past; although, some possibilities are under study now, especially regarding Venezuela, Peru, and French Guiana.

Brazil’s electric power integration with bordering countries really started with the implementation of binational hydroelectric projects. They are, so to say, a natural international electric power link. International electric power interconnections are acknowledged to be among the best methods for promoting integration between countries.

In this respect, the southern cone common market (Mercosul) is of major importance. It came into being as a result of a treaty signed in Asuncion, Paraguay, in March 1991, by the governments of Argentina, Brazil, Paraguay, and Uruguay. These countries have common borders and cover 67 percent of the South American continent.

With the signing of the Andean Pact, a similar market was established between Bolivia, Ecuador, Colombia, Peru, and Venezuela, countries that share extensive borders with Brazil.

Except for the electric power interconnection between Brazil and Paraguay in Itaipu, exchange capacities of Brazil with bordering countries (already operating or under construction) are very modest, as shown in Table 5.

Table 5. International electric power interconnection in existence and under construction

<table>
<thead>
<tr>
<th>Country &amp; Terminals</th>
<th>Voltage (kV)</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uruguay, Paso dos Libres (under construction)</td>
<td>230/132</td>
<td>50</td>
</tr>
<tr>
<td>Paraguay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Itaipu binational (operating)</td>
<td>500</td>
<td>6,330</td>
</tr>
<tr>
<td>Foz do Iguacu, Acary (standby)</td>
<td>132</td>
<td>70</td>
</tr>
<tr>
<td>Uruguay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chui, Chuy (operating)</td>
<td>23</td>
<td>1 MW</td>
</tr>
</tbody>
</table>

Over the period 1985-1990, electric power trade between Brazil and bordering countries developed as shown in Table 6.

Table 6. International electric power trade between Brazil and bordering countries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Import</td>
<td>2,779</td>
<td>10,342</td>
<td>16,785</td>
<td>17,960</td>
<td>22,014</td>
<td>24,666</td>
</tr>
<tr>
<td>Export</td>
<td>-</td>
<td>122</td>
<td>155</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Domestic Supply</td>
<td>189,700</td>
<td>211,859</td>
<td>219,053</td>
<td>231,919</td>
<td>242,663</td>
<td>245,984</td>
</tr>
<tr>
<td>Ratio % (1)/(3)</td>
<td>1.5</td>
<td>4.9</td>
<td>7.7</td>
<td>7.7</td>
<td>9.1</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Brazil’s electric power imports from bordering countries are rapidly increasing because of the purchase of Paraguay’s quota of electric power generated by Itaipu, and the corresponding revenues are used to pay down the debt due to the financing of the plant. The power imported amounted to about 10 percent of the power available for consumption in Brazil. Exports continue to be negligible. The net power imported by Brazil, calculated by deducting the amount of exported power, is among the highest in the world and second only to Italy’s 13 percent.

**Prospects for Expanding Integration**

Prospects for expanding Brazil’s electric power integration with bordering countries that will be part of the Mercosul and Andean Pact group common markets are good in the mid- and long-term. We consider that the transformation of the Brazilian power grid to an open-access grid could be a major factor to encourage the development of that integra-
tion, since it can motivate the private agents to participate in the electric power sector, and possibly aid progress towards private investments in Brazil.

Projects in the Mercosul Region

Argentina has fairly large fossil and hydroelectric energy sources. It has an electric thermal power generating plant structure with complementary hydrothermal production and has thermoelectric generation costs that are economically attractive for exchange in electric power priced by the cost of displacing fossil fuel consumption.

Tables 7 and 8 summarize energy resources and a percentile composition of the national generating plant structure of Argentina's and Brazil's national interconnected electric power systems.

<table>
<thead>
<tr>
<th>Country</th>
<th>Oil (10^9 bbl)</th>
<th>Natural Gas (10^12 m³)</th>
<th>Coal (10^11 t)</th>
<th>Hydro Potential (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>2,188</td>
<td>744</td>
<td>294</td>
<td>35,403</td>
</tr>
<tr>
<td>Brazil</td>
<td>2,801</td>
<td>115</td>
<td>10,176</td>
<td>213,000</td>
</tr>
</tbody>
</table>

Table 7. Energy resources, 1990

<table>
<thead>
<tr>
<th>Country</th>
<th>Hydro</th>
<th>Conventional</th>
<th>Nuclear</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>MW</td>
<td>5,774</td>
<td>6,274</td>
<td>1,026</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>44.2</td>
<td>48.0</td>
<td>7.8</td>
</tr>
<tr>
<td>Brazil</td>
<td>MW</td>
<td>45,041</td>
<td>3,128</td>
<td>657</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>92.3</td>
<td>6.4</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Table 8. Composition of the generating plant structure, 1990

Projects for Integration Between Brazil and Mercosul Binalational Hydroelectric Plants

Brazil/Argentina (Uruguay River)
- Garabi: installed capacity 1,800 MW; engineering stage is basic project; commissioning scheduled for the year 2001.
- Roncador: installed capacity 300 MW; engineering stage is feasibility; commissioning not scheduled.
- Sao Pedro: installed capacity 750 MW; engineering stage is feasibility; commissioning not scheduled.

Brazil/Uruguay (Jaguarao River)
- Talavera: installed capacity 6 MW; engineering stage is inventory; commissioning not scheduled.
- Paso Centurion: installed capacity 32 MW; engineering stage is inventory; commissioning not scheduled.

Natural Gas Supply from Argentina for Electric Power Generation

Since 1986, when the presidents of Brazil and Argentina signed a Cooperation and Integration Act, a gas pipeline (Protocol B) has been negotiated for the supply of natural gas from Argentina to the Rio Grande do Sul market. Also under discussion are possibilities for extending the gas pipeline to other states in southern Brazil.

Represented by Eletrobras, Brazil’s electrical sector has been taking part in meetings held at a diplomatic level with a view to converting existing thermoelectric installations (Alegrete and Nutepa) in Rio Grande do Sul to natural gas utilization. This would enable the consumption of about 0.3 million cubic meters per day, at a 40 percent capacity factor. This volume is much lower than the minimum initial sales volume of 1.8 cubic meters per day proposed by Argentina, and yet is supposed to increase to 4 million cubic meters per day over 5 years. To assess the feasibility of this project, it is necessary to involve industrial and government sectors in the negotiations.

Another critical point of these discussions is the gas price offered by Argentina, approximately US$2.1 per 10^9 btu, against a maximum price of US$1.61 per 10^9 btu, which, according to estimates by the electric power sector, could be paid if Argentina's natural gas had to be consumed in existing thermoelectric plants.

Electric Power Interconnections

Garabi. An installation of two converting units of 450 MW each, 50/60 Hz, associated to the future binalational hydropower plant of Garabi. Operation of the first conversion unit is to start before the plant is constructed. This installation will connect the interconnected Argentine system to the south-east and center-west of Brazil and thus enable electric power exchanges of the economic and reserve provision (for maintenance and improved supply reliability) types.

UTE. The Brazilian Candida thermoelectric plant (the state-owned Uruguayan Electric Power Utility) consists of a project for sharing the development of part of the coal reserve pool of Candida. This plant would also supply Uruguay's electric power market through an interconnection at 500 kV, extending from the Candida Plant to alternative points of the UTE electric power system.

Projects in the Andean Area and Guyana Group

Although emphasis in the present study is centered in the Mercosul region, electric power sector integration possibilities between Brazil and bordering Andean Pact countries are quite promising, since this block of countries has plenty of energy resources that could be developed at prices competitive with those foreseen for the expansion of the Brazilian electric power system.

Table 9 shows the energy potential Brazil shares with the countries of that region that can contribute to the supply of power market Brazil, thus enabling eventual surplus in the

<table>
<thead>
<tr>
<th>Country &amp; River</th>
<th>Individual MW</th>
<th>Remaining MW</th>
<th>Total MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Madeira</td>
<td>8,492</td>
<td>1,788</td>
<td>10,280</td>
</tr>
<tr>
<td>Abuna</td>
<td>616</td>
<td>36</td>
<td>652</td>
</tr>
<tr>
<td>Acre</td>
<td>72</td>
<td></td>
<td>72</td>
</tr>
<tr>
<td>Xipamanu</td>
<td>80</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>Subtotal</td>
<td>9,108</td>
<td>1,976</td>
<td>11,084</td>
</tr>
<tr>
<td>Colombia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traira</td>
<td>80</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>Icana</td>
<td>132</td>
<td></td>
<td>132</td>
</tr>
<tr>
<td>Papuri</td>
<td>88</td>
<td></td>
<td>88</td>
</tr>
<tr>
<td>Uaupes</td>
<td>500</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>Subtotal</td>
<td>800</td>
<td></td>
<td>800</td>
</tr>
<tr>
<td>Peru</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breu</td>
<td>36</td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>S. Rosa</td>
<td>92</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>Subtotal</td>
<td>128</td>
<td></td>
<td>128</td>
</tr>
</tbody>
</table>

IEEE Power Engineering Review, June 1994
south and southeast regions, enabling the country to study exportation to the Mercosul region.

The availability in that region of a fuel called Orimulsion is also worth mentioning. It is considered to be similar to fuel oil and is obtained from the huge heavy-oil reserves (API below 8.5) in Venezuela, in the region of the Orinoco River. Presently identified reserves are sufficient for Orimulsion production of 28 x 10^8 bbl. Prices for this fuel are set 5 percent higher than for coal, yet their energy content is the same.

It can be seen that most of this hydroelectric potential is evaluated at the remaining stage, whereas utilization is at the individualized level, basically concentrated in the international (Bolivian border) sector of the Madeira and Abuna Rivers, and amounts to a total electric power of about 9,000 MW. It is, therefore, much more power than that needed for the loads of isolated electric power systems adjacent to the border zone between these two countries.

There have also been agreements made for generation of electric power by natural gas. Two projects are contemplated for this area: one involving Bolivia, and the other Peru.

The governments of Brazil and Bolivia exchanged Guaranteed Letters of Intent in August 1988, which allowed Brazil to use Bolivian natural gas in several ways that included the generation of electric power by a thermoelectric plant to be installed in Puerto Suarez on the border between the two countries near Coiruma. This plant was to have six gas turbines of 75 MW each, totaling 450 MW, and was scheduled to come into operation in the second half of 1993. The project had to be discarded, however, due to feasibility problems mostly related to raising funds.

On the other hand, the negotiations dealing with Bolivian natural gas for Brazil led to a more wide-reaching project that included building a gas pipeline connecting Bolivia with Sao Paulo, with branches to Belo Horizonte and Curitiba. The agreement signed by Brazil and Bolivia in 1992, valid for 20 years, permits participation of private companies of both countries. It allows for a volume of gas to be imported by Brazil varying between 8 and 16 million m^3 per day. This agreement will result in more intensive utilization of natural gas in Brazil’s energy structure, also for use in thermoelectric.

Due to this progress in the gas pipeline project, the Bolivian government canceled the installation of the Puerto Suarez thermoelectric plant. The final contract for the supply of Bolivian natural gas to Brazil, also stipulating the respective price, is supposed to be signed by the presidents of both countries.

Another project, somewhat similar, covers the possibility of Brazil acquiring electric power from Peru to supply the Acre-Rondonia electric power system by means of an indirect purchase of natural gas. It is intended to use the natural gas of the Camisea field, located in the municipal area of Cuzco, Province of La Convención.

The explorations carried out by Shell under a risk contract with Petroperu resulted in the discovery of major gasified and condensed product volumes. The field is estimated to contain about 10.8 x 10^12 cubic feet of natural gas and 725 x 10^9 bbl liquid natural gas, equivalent to approximately 2,500 x 10^9 bbl crude petroleum, i.e., six times Peru’s proven oil reserves.

Peru made private enterprise responsible for this project, which entails the installation of a 200 MW thermoelectric plant in the Quilabamba region, which will use Camisea’s natural gas. It is Perú’s intention to supply the domestic market as well as to penetrate the Brazilian market.

Brazil has, at times, had contacts in regard to energy matters with countries of the Guyana Group (Guyana, Suriname, and French Guiana) that share its borders.

Information on energy resources in these countries is scarce. Suriname has available a proven small oil reserve of 26 x 10^6 bbl for production and domestic use. Guyana’s hydroelectric potential is 4484 MW, and Suriname’s is 2320 MW.

An electric power exchange agreement between Brazil and this group of countries, which is presently being negotiated by Eletrobras and Electricité de France (EDF) in French Guiana is worthy of mention. It refers to a project for developing the binational hydroelectric plant Salto Mariposa (Sault Maripa) on the Oiapoque River by the installation of about 200 MW. Output to be shared by the two countries.

**Sintrel**

The Brazilian electric system comprises two large interconnected systems: north/northeast and south/midwest. It is made up of federal companies that, besides hydroelectric power plants, own EHV transmission systems to transport the energy generated and to allow its use by the state companies, most of which are in charge of the electric energy distribution. Eletrobras is responsible for about two-thirds of the country’s installed capacity, presently around 60,000 MW.

In the southeast/midwest region, bordering the Mercosul countries, there are two federal companies that operate a large transmission network with 230, 345, 500 and 750 kV voltages.

To make better use of the available financing resources and to attract new partners to enlarge the electric system, it became necessary to restate the electric power sector organization structure, a process initiated by the Presidential Decree 1009, issued in December 1993, creating the Sintrel electric energy national transmission system.

Sintrel, which will be managed by Eletrobras, represents a cut in the vertical structure of the federal companies and sets apart the transmission services so as to create a network made up of the transmission installations of such companies, thus allowing the access of new agents and inducing competition among producers, resulting in lower energy costs for the final consumers.

It is anticipated that this structural change will set forth important improve-

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**1994 International Conference on Power System Technology**

**Beijing, China**

**October 18-21**

The 1994 International Conference on Power System Technology (94 ICPST) will be held in Beijing, China, October 18-21, 1994. The conference is sponsored by the IEEE Power Engineering Society and CSEE, with cooperation from the Electric Power Research Institute, Beijing, China.

To date, more than 180 papers have been submitted for the conference, 98 of which are from outside of China. The conference is shaping up to be extremely interesting and informative.

ments in the electric energy services sector, owing to the following advantages:

- Requires a more aggressive entrepreneurial attitude in energy commercialization
- Stimulates competition, mainly among generators
- Stimulates partnerships in the generating area, bringing on resources to make new projects feasible and to expand the electric power sector

**From Binational Agreements to Market Integration**

The introduction of Mercosur is an important economic and political landmark. It cannot, by itself, provide the tools required to ensure more open commercial transactions in all possible fields.

Concerning the energy area and, more specifically, electric energy, those tools will require comprehensive work to equalize the legal aspects of public service concessions, the use of natural resources for generating electricity, the contract forms to buy and sell energy, and, from the technical standpoint, the criteria to deal with frequency conversions, and the interconnected operation of differing electric systems.

Historically, the electric energy projects in the region originated from binational thoughts. The best interest of the parties and the projected economic benefits were evaluated within the limits of the economies of the markets involved.

This approximation policy matched the existing political situation, where national sovereignty, strategic considerations, areas of influence, borders untractability, and the country interest could influence or even overcome any rational technical or economic criteria.

The signing of the Mercosur agreement brought a more open context to a series of ongoing initiatives:

- **COMIP studies**, Comissao Mistia Argentina Paraguai in charge of studying the Corpus hydroelectric power plant in the Paraguay River, between Yacyreta and Itaipu, which will have an installed capacity around 3,000 to 4,000 MW
- Brazil and Uruguay electric systems interconnection protocol
- Brazil and Argentina electric systems interconnection protocol
- Renewal of the Eletrobras/Aguas y Energia protocol about the Garabi hydroelectric power plant (1,800 MW) and others in the international stretch of the Uruguay river.

It became quite clear that the fast privatizing process that has occurred in Argentina increased the complexity of the international negotiations to discuss possible electric energy buy/sell interchanges, owing to the great number of parties that have to agree upon the many aspects of such an operation.

**Table 10. National electric energy markets in accordance with official update forecasts from each country**

<table>
<thead>
<tr>
<th>Country</th>
<th>Elec Sales 1990</th>
<th>Elec Sales 2010</th>
<th>Mean Yearly Growth Rate</th>
<th>Yearly Added Inst Cap MW*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>43.1</td>
<td>151.0</td>
<td>6.5</td>
<td>947</td>
</tr>
<tr>
<td>Brazil</td>
<td>189</td>
<td>501.5</td>
<td>5.0</td>
<td>3,240</td>
</tr>
<tr>
<td>Paraguay</td>
<td>2.3</td>
<td>10.8</td>
<td>8.0</td>
<td>97</td>
</tr>
<tr>
<td>Uruguay</td>
<td>4.7</td>
<td>9.5</td>
<td>3.6</td>
<td>42</td>
</tr>
<tr>
<td>Mercosur</td>
<td>239.1</td>
<td>812.2</td>
<td>6.3</td>
<td>4326</td>
</tr>
</tbody>
</table>

* Based on power plant capacity factors suitable to each production area

Other aspects to consider, to achieve market integration, are the relative size and growth dynamics of the countries involved, as shown in Table 10.

The differing growth dynamics and relative strength of these partners makes us think about the desirable total market integration as a controlled process ensuring the best economic conditions for investors allied to maximum energy benefits and the sharing of these benefits.

This process, which we are calling *bilaterals optimization*, would initially keep to the existing ongoing relations, but encompass a more comprehensive scenario.

The Corpus hydroelectric project, for instance, if developed just for the Argentine market, would cover a 4-year growth period and become rather difficult to justify. On the other hand, if the Mercosur market is taken into consideration, the Corpus project corresponds to less than a year growth and becomes quite attractive.

Besides this *project matching* to the integrated markets, we should also have in mind the great energy benefits coming out of the joint operation of the binational hydroelectric power plants, to which we should add the benefits resulting from the Brazil/Uruguay and Brazil/Argentina interconnections.

The working out of the *bilaterals optimization* would create the adequate and necessary legal documents to give those projects a supranational character, resulting in other benefits such as better conditions, lower capital cost, and the attraction of foreign investors.

This new strategy can create an approach to ensure the development of a new, sound, economic, political era in the relations of the various countries' power sectors and one that should produce progress and results in the short term.

**About the Speaker**

Jose Luiz Alqueyes became president of Eletrobras in March 1993 and president of the Brazilian committee of the World Energy Council in 1991. From October 1992 to February 1993, he was a director of BNDES-Par-BNDES (National Economic and Social Development Bank); from September 1992 to October 1992, he was national secretary of Energy, Ministry of Mines and Energy; from January 1989 to October 1992, he was director of Planning and Engineering, Eletrobras; and from January 1988 to December 1988, he was president of Companhia de Eletricidade do Rio de Janeiro (CERU), a state power utility serving 1.0 million customers Rio de Janeiro.

Since 1972, he has worked in the power sector carrying out activities that include studies, coordination of interdisciplinary task forces, and management in the fields of general planning, market analysis, supply expansion, energy pricing, selection of investment alternatives, engineering and operation of distribution systems energy conservation, commercial management and consumer relations, power generation engineering, bidding and contracting, utility organization, and institutional organization of the energy and power sectors.

Within the Brazilian power sector, his responsibilities have included the establishment and management of an electricity supply program for slums in Rio de Janeiro (250,000 new consumers in 4 years), the preparation and negotiation with the World Bank of the Power Sector Rehabilitation Plan, coordination of the National Power Sector's Long-Range Plan 2010 (1987) and 2015 (1992), and coordination of the Basic Project of the Garabi Hydroelectric Plant (a 1,800 MW Argentine Brazil plant).

His international activities include negotiation of loans with suppliers, commercial banks, and with the Interamerican and World Bank; participation in Brazilian government technical assistance missions to Mozambique, Senegal, Kenya, Algeria, Tunisia, and Egypt; and representation of the
Brazilian power sector in negotiations with Mercosul countries for the establishment of policies and operational procedures favoring power interchange within the region.

Alqueres has also received the following distinctions: "Ao Livro Técnico" prize for first place in Civil Engineering Course 1966; City of Tiradentes medal for relevant services in historical preservation in 1989; and Personality of the Year prize given by ABRACE, an association which congregates the largest consumers of electricity in the country.

Electric Power Sector in Mexico: Past, Present, and Future Developments

Eduardo Arriola, Vice President of Planning, Comision Federal de Electricidad, Mexico City, Mexico

Comision Federal de Electricidad (CFE) was created in 1937 by the government of Mexico, with the basic objective of organizing and directing the development of a national system for the generation, transmission, and distribution of electric energy, based on technical and economic principles, and oriented to serve the public interest as a nonprofit organization.

In 1960, the government began the process of acquisition of stock of the then existing investor-owned electric utilities, initiating at the same time the project for integrating the legal, financial, administrative, and operational processes and assigning to CFE the responsibility of providing electric energy as a public service.

In the technical area, two major steps were taken to build a national interconnected system:

- Unification of frequency at 60 Hz, completed in 1976
- Interconnection of the central electrical system, accomplished in 1978.

Today, only the Baja California Peninsula remains isolated from the main electric network that spans the rest of the nation with high-voltage transmission lines of 400 and 230 kV.

In December 1992, the Electric Public Service Law was modified to create the appropriate legal framework for the participation of the private sector in the process of generation of electric energy. With the new law, it is expected that most of the generating capacity additions required to provide for the future demand growth will be met by nonutility generators.

Present Situation

CFE and Luz y Fuerza del Centro distribute electric energy to more than 18 million customers. Today, 92 percent of the population of Mexico has the benefit of electric energy, the remaining 8 percent of the population live in small communities located far from the electric energy distribution lines. Most of these communities have less than 100 inhabitants.

At the end of 1993, the installed capacity in Mexico was 29,204 MW. Of this capacity, 55.9 percent is generated by conventional steam units, combined cycle units, and gas turbines, which use fuel oil, natural gas, and diesel respectively. Of the installed capacity, 28 percent is hydroelectric, most of which is located in the southeastern Mexico, 6.5 percent is capacity that uses coal as fuel, 4.8 percent of the capacity is constituted by dual units designed to burn fuel oil or imported coal, 2.5 percent is geothermal and the remaining 2.3 percent is nuclear (Table 11).

As shown in Table 12, electric energy sales in 1993 amounted to 104 TWh, of which 53.2 percent were sales to industrial and other high voltage customers, 24.8 percent were sales to residential customers, 9.1 percent sales to commercial customers, 5.9 percent was used for agricultural irrigation, 5.1 percent for municipal services such as street lighting and water pumping, and the remaining 1.9 percent was sold to U.S. and Belize utilities.

<table>
<thead>
<tr>
<th>Source</th>
<th>Capacity (MW)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric</td>
<td>8,170</td>
<td>28.0</td>
</tr>
<tr>
<td>Fuel oil and gas</td>
<td>16,316</td>
<td>55.9</td>
</tr>
<tr>
<td>Coal</td>
<td>1,900</td>
<td>6.5</td>
</tr>
<tr>
<td>Dual</td>
<td>1,400</td>
<td>4.8</td>
</tr>
<tr>
<td>Geothermal</td>
<td>743</td>
<td>2.5</td>
</tr>
<tr>
<td>Nuclear</td>
<td>675</td>
<td>2.3</td>
</tr>
<tr>
<td>Total</td>
<td>29,204</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use</th>
<th>TWh</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>55.3</td>
<td>53.2</td>
</tr>
<tr>
<td>Residential</td>
<td>25.7</td>
<td>24.8</td>
</tr>
<tr>
<td>Commercial</td>
<td>9.5</td>
<td>9.1</td>
</tr>
<tr>
<td>Agricultural</td>
<td>6.1</td>
<td>5.9</td>
</tr>
<tr>
<td>Services</td>
<td>5.3</td>
<td>5.1</td>
</tr>
<tr>
<td>Export</td>
<td>2.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Total</td>
<td>103.9</td>
<td>100</td>
</tr>
</tbody>
</table>

Electric Energy Exports and Imports

The electric power system of CFE is interconnected with the electric systems of various utilities along the Mexico-U.S. border. In Baja California, CFE and San Diego Gas and Electric (SDGE) have two 230 kV interconnections that were built for the purpose of exporting 220 MW to SDGE and Southern California Edison. This 10-year contract is associated with geothermal capacity from the Cerro Prieto power plants and was signed in 1986.

In the Ciudad Juarez area, CFE imports 150 MW from El Paso Electric Co. (EPECO), using two 115 kV interconnections. For stability reasons, CFE and EPECO cannot operate in synchronism, and, therefore, the import of electricity is accomplished by a load blocking scheme.

Along the border with Texas, CFE and Central Power and Light (CPL) have four 138 kV and one 69 kV interconnections that are normally open. These ties have been basically used for emergency assistance and short-term energy sales by using load blocking schemes.

At the southern border, CFE exports 6 MW through a 34.5 kV interconnection with Belize. Studies are being conducted to increase the level of export by building a new 115 kV transmission line.

Expected Growth and Generation Projects Under Construction

In the last 10 years, the average growth of electric energy sales has been 5 percent. The forecast for the next 10 years is based on two scenarios:

- Low scenario with an average annual growth of 3.8 percent
- High scenario with an average annual growth of 5.4 percent

To face the expected future demand, CFE has 20 generating units under construction, which amount to 5,835 MW of
additional capacity. These units are scheduled to begin commercial operation in the years 1994 to 1997. Table 13 shows the amount of capacity under construction by type.

<table>
<thead>
<tr>
<th>Source</th>
<th>Number of Units</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric</td>
<td>9</td>
<td>1,840</td>
</tr>
<tr>
<td>Fuel oil and gas</td>
<td>6</td>
<td>1,720</td>
</tr>
<tr>
<td>Coal</td>
<td>2</td>
<td>700</td>
</tr>
<tr>
<td>Dual</td>
<td>2</td>
<td>700</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1</td>
<td>675</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>5,635</td>
</tr>
</tbody>
</table>

In addition to these units, the construction of the Sama-yuca combined cycle plant with three 173 MW units will be initiated in 1994. Also, in the same year, CFE will request proposals for the construction of what is to be the first independent power production project in Mexico. This project is known as Merida III and will consist of two combined cycle units of 220 MW each.

**Future Development of the Electric Power Sector Under the New Law**

The Electric Public Service Law, approved in December 1992, creates the appropriate framework for the participation of private investors in the electric generation process, via the following schemes:

- Self supply
- Cogeneration
- Small power production
- Independent power production.

The new law also allows private entities to:

- Import capacity and electric energy for self-supply purposes
- Build a power plant to export electric energy.

All of these new projects need a permit which, if requirements are met, will be granted by the Secretaría de Energía, Minas e Industria Paraestatal (SEIMP).

In accordance with the new law, CFE will provide the following services, when appropriate:

- Transmission services
- Backup services
- Supplementary capacity and energy sales
- Excess capacity and energy purchases.

**Conclusions**

The Electric Public Service Law in Mexico creates a positive environment for private sector participation in the generation of electric energy. It is expected that the future additional capacity required by CFE to meet the expected demand growth will come mainly from nonutility generators. The transmission and backup services provided by CFE will provide the feasibility and flexibility of operation to these privately owned projects that, in most cases, will be selling capacity and/or energy to CFE.

A recent study conducted by SEMIP and the U.S. Department of Energy concluded that there are various points of interconnection between U.S. and Mexican electric systems, where electricity exchanges could be mutually beneficial. Further studies are required on a case-by-case basis, but, with the new law, there will be incentives to build stronger electric ties between the two countries.

**About the Speaker**

Eduardo Arriola was born in Mexico City in 1945. He received his BSEE degree in 1970 from Universidad Nacional Autónoma de Mexico (UNAM). He gained the MS degree in electrical machines and power systems in 1973, and the PhD degree in electrical engineering in 1977, both from Imperial College of Science and Technology, University of London, UK.

Dr. Arriola joined the Faculty of Engineering, Universidad Nacional Autonoma de Mexico as a part-time professor in 1970, and since then has taught various courses in electrical engineering and power systems analysis and optimization to both undergraduate and graduate students.

He joined Comision Federal de Electricidad as a research assistant in 1970, and was awarded a scholarship for post-graduate study in England in 1972. On completion of his PhD, he was made head of a group responsible for developing computer models for power system planning. He was appointed vice president of Planning, Comision Federal de Electricidad, Mexico, in 1991.

Dr. Arriola has been PES Mexican Section Chair, Mexican Section chair, and Latin American Region director of IEEE. He was awarded the IEEE Centennial Medal in 1984.

**Restructuring the Electric Power Sector in Colombia**

**Manuel I. Dussan**, General Coordinator, Commission de Regulación Energetica, Ministerio de Minas y Energie, Republic of Colombia

A major restructuring of the Colombian electric power sector is being implemented based on the improvement of sector efficiency through the promotion of a competitive energy market and the participation of private investment. This short presentation highlights major events and difficulties in the restructuring process.

The national interconnected power system has an installed generation capacity of about 10,000 MW, of which 80 percent is hydro and 20 percent is fuel-fired thermal. The current generation expansion plan calls for the installation of about 4,000 MW during the next 10 years, of which 60 percent is in thermal plants.

The present institutional structure shows 8 major generation companies and about 23 distribution companies, all of them state-owned enterprises (national and municipal governments). There are two vertically integrated municipal companies (generation transmission and distribution), serving 40 percent of demand.

The development of the power sector has faced major problems, common to many countries in Latin America, related to centralized planning, poor regulation, pricing distortions, monopoly power over regional markets, and state participation as the major owner of energy enterprises, with a subsequent lack of efficiency incentives, the virtual disappearance of accountability, and deterioration of finances. The problems were exacerbated by a prolonged power rationing during 1992 and 1993.

Since the early 1990s, the government has been developing a power sector reform strategy based on the following key elements:

- Introduction of indicative planning
- Establishment of competitive wholesale market, as a major instrument for improving efficiency
- Creation of independent and transparent regulation of the sector
- Promotion of private sector participation
- Financial rehabilitation of state-owned enterprises.
Progress in Implementing Sector Reform

Progress has been made in implementing sector reform. The government submitted to Congress two bills related to the electric power sector, which were approved by senate and will be considered by the lower chamber during the first semester of 1994. These bills, among other things:

- Enable any private or public agent to develop generation projects
- Separate utility businesses in generation, transmission, distribution, and supply
- Deregulate wholesale prices for transactions between generators and suppliers
- Guarantee free access to transmission and distribution networks by third parties, at regulated use of system charges
- Create a new company responsible for the national transmission grid and dispatch.

In late 1992, the government created an Energy Regulatory Commission (ERC), responsible for sector regulation, with the participation of three independent experts and three secretaries of state. ERC is developing, with the assistance of international consultants, the key instruments and rules for sector regulation based on the principles outlined above, including the commercial arrangements for the wholesale market, the use of system charges for transmission and distribution, and the regulatory controls. In late 1993, ERC issued a directive for the deregulation of prices for sales to industrial consumers with loads above 2 MW, as of April 1994. During 1994, the new rules for sector regulation will be gradually implemented.

The government decided to offer to private generators under build/operate/own (BOO) arrangements the development of about 1,280 MW in thermal power plants by year 2000. So far, 250 MW in private projects have been commissioned, and bids for additional 630 MW are underway.

The government implemented a major financial restructuring of the power sector. During 1991 and 1992, the government contributed about US$1.5 billion to the sector through capitalization and debt swap schemes. As a result, about 1.000 MW in generation assets are now in the hands of the government, and the Ministry of Finance has initiated the process to privatize about 700 MW.

Difficulties in Achieving Efficiency Improvements

Notwithstanding the progress made, the restructuring program faces some difficulties in achieving efficiency improvements through competition. These are cross-subsidies, vertical integration, and government's role.

Subsidies. Presently the pricing system includes substantial cross-subsidies. For example, generators sell energy under contract at about 80 percent of their cost, residential tariffs on average cover 35 percent of the cost of supply, and high-voltage industrial customers pay on average 135 percent of the cost of supply. Obviously, competition and cross-subsidies cannot live together. The government is implementing a 4-year tariff adjustment program that will eliminate cross-subsidies. Therefore, in the meantime, cross-subsidies are a major constraint to the introduction of a competitive market.

Vertical Integration. About 40 percent of the market is presently served by munical companies which provide generation, transmission, and distribution services. In order to introduce a competitive market and reduce the regulatory burden, it would be necessary to separate these businesses. However, at present, there are no legal instruments to enforce this requirement. Therefore, as a last resort, it has been necessary to settle for a separation of accounts.

Government Role. By law, the government is responsible for ensuring a reliable electricity supply in the country. Due to the 1992 power shortages, the government has become risk averse and is taking actions to ensure that new generation is commissioned on time to meet an adequate reliability criteria. If the market is not driving the development of new generation, the operation of the wholesale market would be at risk, because the spot prices may collapse under a situation of excess capacity and it would not guarantee enough revenues to generators to pay for expansion costs.

In summary the Colombian government is committed to the implementation of an ambitious restructuring program of the power sector to improve efficiency through competition and participation of private capital. The program is now entering into a critical phase of introducing new rules and regulations for the operation of the sector, and of overcoming problems inherent of changing the status quo.

About the Speaker

Manuel I. Dussan was born in Bogota, Colombia in 1944. He obtained a BSEE from the Universidad de los Andes in Bogota in 1966 and an MSEE from Northwestern University in 1968. From 1968 to 1970, he was a member of the faculty of engineering at the Universidad de Los Andes, where he became head of the Electrical Engineering department.

In 1970, he joined Interconexión Electrica SA. For 10 years, he was responsible for operational planning and dispatch of the national interconnected system, and was also responsible for power interchange negotiations.

From 1980 to 1992, he was a staff member of both the Interamerican Development Bank and the World Bank, where he was responsible for preparation, appraisal, and supervision of power projects in Latin America, and also acted as a consultant for 4 years.

Dussan is currently commissioner and general coordinator of the Energy Regulatory Commission in Colombia.

Transformation of the Argentine Wholesale Electricity Market

Luis Maria Caruso, Director, Mercados Energeticos SA, Buenos Aires, Argentina

The electricity industry in Argentina has undertaken a very deep restructuring in recent years, from a 100 percent state-owned, integrated activity to a true market of electricity, in which more than seventy free private agents (generators, transmission companies, distribution companies, and big customers) operate in a framework of rules completely different from those in force at the beginning of the transformation.

Today, almost 3 years later, an observer can notice a number of changes already in place. As a consequence, there is an increased interest from companies and government as well, in old and new issues such as electrical markets integration, or global business.

The purpose of this presentation is to examine this emergent market, its rules, and its players, and to assess which of the patterns associated with the integration of business, markets, and culture are for the benefit of final users.

Beginning the Transformation

At the time of the electrical industry restructuring, Argentina had a very extensive 500 kV transmission grid, covering most of the domestic territory and providing for 90 percent of the wholesale trading of electricity. The grid, 90 percent of the generation installed capacity, and 50 percent of the distribution business was in the hands of three federal government owned integrated companies (Segba, Hidronor, and...
Agua y Energia), while the rest of the industry was in the hands of 18 provincial governments.

Since Argentina is embedded in a geographical area (the southern cone of South America) and is involved in an ambitious plan of economic integration called the southern common market (Mercosul), Argentina enjoys very strong commercial links with the six countries in the southern cone. In the electric power sector, the different countries have always had a long tradition of integration, as demonstrated by big enterprises such as the hydroelectric power plants of Salto Grande, Itaipu, and Yacyreta, are binational efforts. As a federal country, Argentina faces, in this field as well as in many others, the challenge of integration.

There was, therefore, a specific goal when writing down the new rules. Argentina wanted to encourage and facilitate a smooth and easy integration among the different electric power markets inside the country borderlines, and as well as among the national markets of the southern end of the continent.

**Transformation**

The objective of the government when initiating this transformation was to set the basis for a new, strong electric power industry, and in doing so, introduce a new culture (not only managerial but also technical) capable of supplying the necessary power at prices compatible with the economic cost of maintaining and expanding the power systems.

The framework for this transformation, a substantial change in the role of the government regarding industrial activities and utilities, resulted in clearly separating administrative functions from regulatory ones.

The means chosen to achieve this transformation in the shortest time were:

- Clear segregation between functions subject to market conditions and those activities demanding regulation
- Establishment of a market price system as a set of consistent signals to encourage efficiency, quality, and security
- Reorganization of the preexistent, vertically integrated, state-owned companies, creating a number of new, specialized, privatized ones
- Implementation of concession agreements for activities demanding regulation (distribution, bulk transmission, and hydroelectric generation) as a complement to the pricing system
- Creation of new institutions as required by the transformation model: the Wholesale Electric Market Administration Company and the National Regulatory Agency
- Privatization of the newly created business units within the framework of the new rules.

The Argentine electricity industry transformation was not merely a privatization. On the contrary, before privatizing, there was a great deal of work and effort invested in restructuring the preexistent companies and in engineering the appropriate regulation.

Most of this transformation has been successfully performed, and it is possible to make some assessments about the main issues of this success:

- Clear ideas and a good execution plan
- Strong executive team plus good experienced consultants

- Full political support along the whole process
- Trade unions that understood and participated in the transformation
- Decrease of country risk and increase in international banking confidence.

**Creating Competition**

The new industry has been organized to encourage competition where possible, and to introduce regulations where there is no chance to get competition or where the latter should still be developed.

A competitive system in which producers are forced to resign a piece of their desired profit as a condition to having access to a fraction of the market means reduced costs for industrial and residential users, provided that the new rules enable the transfer of reduced costs to customers.

The rules put into practice in the Argentine market to encourage competition were the following:

- Ownership in the generation activity was segmented, limiting the cap participation in this industrial segment to a 15 percent of the capacity to be privatized by the federal government. This policy gave way to more than 20 independent power producers born from the preexistent government-owned monopoly.
- A system of pricing signals, based on the practice and procedures of centralized operation and economic dispatch. During actual operation, the available units are requested to generate following a priority list based on increasing variable costs, until the demand is fulfilled. The marginal cost of the last unit accepted by the demand represents the price that purchasers are ready to pay at a given time. In this way, cheaper units always displace expensive ones from the market, driving agents towards efficiency in operation and investment.

In the Argentine electricity market, there is a reference price (the Market Price), that reflects the present short run marginal cost of the system in each hour. In the absence of contracts agreed to by parties, every transaction is performed at that price. The Market Price comes from the centralized operation activity; there is no bidding process involved.
Key Elements in the Organization of the Argentine Wholesale Electricity Market

The Market. Three different kinds of companies are accepted as agents for operations in the wholesale electricity market: generators, distributors, transmitters, and large customers.

Each one has access to two different ways of selling and/or purchasing electricity: through direct contracts freely agreed to by parties, and through the pool, at the hourly market price.

While the contract price arises from a free negotiation, the market price basically reflects the short run marginal cost of the system (generation plus bulk transmission costs), and three different payments in exchange for services needed for reliable operation: contribution to frequency and voltage control, and disposition to start and to stop thermal units as requested by the economic dispatch.

There are two basic kinds of contracts: supply contracts, in which a load curve is committed between parties, in general with a delivery-or-pay clause given by the seller; and cold reserve contracts, in which some units remain in standby at the disposal of the contract holder for a fee.

The contracts are commercial relations between agents and are compiled regardless of the actual generator program issued according to the economic dispatch principle. The differences between both give room to trading in the spot market.

Prices and Concession Agreements. The joint action of market prices and obligations enforced by concession agreement is the key issue of the regulatory strategy chosen for the Argentine electric power market. The system works as follows:

- The distributors’ concession contract provides the most important element for the development of the electric power market, the obligation to supply. This forces the distributor to look for a reliable source of the power supply needed for subsequent distribution. The tool provided by the electric power market to achieve this goal is the use of forward contracts for quantities, conditions, and prices freely agreed to by parties.
- The need for distributors to “get the supply guaranteed” is the essential incentive for the development of the future supply contracts market. Through contracts, generators ensure the supply requested by the client in conditions and prices agreed to in advance for long periods. Contracts are, therefore, the actual price stabilizer for the wholesale electricity market.
- The need for generators with contracts in the forward market in order to have access to the demand is the essential incentive for the expansion of the transmission capacity.
- The transmission concession contract should provide complementary incentives to complete the cycle, the obligation to give open access to any user requesting transmission capacity to carry out the transportation. The prohibition to trade electricity, the obligation of independence from distribution and generation companies, is enforced by law.
- A last condition was to be met by regulation. Both key elements (pricing system and concession agreements) should facilitate the integration of neighbor electric power domestic markets among countries of the southern cone, as long as their pricing system reflects the same criteria regarding economic costs as the one adopted by the Argentine wholesale electricity market.

Other Key Decisions

An important strategic regulatory decision taken by the government was the creation of an independent company for the administration of the wholesale electricity market, Cammesa. This company has a number of characteristics to be mentioned:

- The partners in Cammesa are the five different players in the wholesale electricity market: generation companies, transmission companies, distribution companies, large customers, and the government. Each party has 20 percent of the votes on the board.
- Its functions are to perform a centralized, real-time operation subjected to the economic dispatch principle, to document transactions among agents in terms of physical units, transforming these transactions in economic results.
- The kind of organization created pursues efficiency and transparency, giving nondiscriminatory service to every agent in the system.

Cammesa is a regulated company; government is present but it is not dominant, and the same applies to industry. In particular, the management of the company is not dependent on the generation industry.

The second key decision was to organize a separate transmission activity. Consider the following important issues:

- In opposition to what had been done in the generation business, the restructuring here had the objective of concentrating the bulk transmission function in a single company (Transener) created from the merging of functions and assets present in the three preexisting government-owned transmission companies.
- Additionally, several regional transmission companies were organized and given the responsibility to connect one to the other and to the national grid, all large users, generation and distribution companies in the same geographical area.

Besides these regulated companies, independent transmission companies are admitted. They can build, operate, and maintain new lines under the operational authority of the transmission concessionaire of the area. They are not agents of the market, but as far as construction of new lines are concerned, they can compete with existing concessionaires for the expansion.

While operation is a monopoly, construction of new lines is open to competition.

The transmission activity is under federal regulation down to the level of 132 kV. That means that every node in the system, regardless of ownership of assets there, has an associated cap price. These nodes are, therefore, the access to the market and to the market price for every agent, and particularly for the regulated agents (customers of installed capacity above 1 MW by now).

This activity, in which prices are regulated in the concession agreement and the concessionaire receives the obligation to give open access to every request at that price, presents two significant issues:

- These specialized companies represent the border of application of the principle of vertical separation.
- The transmission system translates the market price deeply inside the network, to every node involved in the transmission regulation.

We are convinced that these basic rules of transmission pricing, access, and expansion are a practical contribution to solving the problem of integration among neighboring domestic markets in the region.
Towards Global Industry and Market Integration

From the Argentine experience, it is possible to draw some conclusions about which of the conditions inside the model are pushing towards globalization (and finding it unavoidable), and how the adoption of certain rules of the game facilitates the process of integration.

In terms of the push towards globalization, consider the following:

- Opening to foreign investors in nondiscriminating conditions
- Legal framework, giving enough stability to the rules of the game and to the policy of foreign investments
- Efficiency oriented pricing system allows for the appearance of excellent companies worldwide
- Familiar regulatory environment encourages the presence of global companies
- Global business ends up making room for a global culture in the specialized electricity business management and in the technical operation of it.

In terms of market integration:

- Compatible wholesale (at least) pricing concepts across state borderlines
- Consistent regulation and pricing for the bulk transmission activity
- Necessary institutional framework (federal laws, provincial laws, international agreements)
- Satisfactory solution for the administration, both technical and commercial, of the system and market under an integration process is in progress.

How the New Industry Looks. There are now 74 independent agents in the Argentine wholesale electricity market: 26 generation companies, 26 distribution companies, 3 transmission companies, and 19 large customers. New private companies born from restructuring of prior government owned monopoly are shown in Table 14.

Conclusions

The Argentine wholesale electricity market and its new rules have enabled the gathering of a large number of excellent companies of the world in a competitive environment, and this is actually a key element of the Argentine process. We can appreciate the importance and the variety of this contribution. The degree of acceptance relies on some main issues:

- Kind of rules enforced in the Argentine wholesale electricity market
- Nondiscriminatory opening to new investors
- Clear government role in the new business structure.

Experience shows that:

- Success in obtaining enough competition depends on the effort in the restructuring and in the careful design of the market price system, and the writing down the set of obligations and rules for regulated activities.
- The way of organizing the transmission activity is the key for a fast and easy integration of neighboring markets, both inside and outside the countries’ borderlines.
- The change does not merely consist of a privatization of what existed before, but of a sound transformation of the principles on which the whole industry is based.
- The transfer of responsibilities in the supply from government to third parties does not deprive these activities of their character or public interest. The exclusion of government from industrial or commercial activities does not mean it has no place in the new order. The presence of government is essential to enforce the new rules, and to build up the necessary regulatory bodies.
- Consequently, there is a sustained interest from foreign investors to enter the Argentine wholesale electricity market and a new interest from several companies born from the transformation, to intervene in the privatization of electricity business abroad, to join the global business. And, the is a renewed interest in restructuring the industry following similar principles as a way towards market integration from provincial governments inside Argentina as well as from national governments across the South American continent.

About the Speaker

Luis Maria Caruso was chairman of the National Coordination and Regulation Board, Energy Secretariat, and a member of the Electric Sector Privatization Committee from 1991 to April 1993. From these appointments, he had primary responsibility for the organization and launching of the Argentine Wholesale Electric Market (WEM), the creation of Compania Administradora del Mercado Mayorista (Cammesa) of which he has been executive vice president, and in drafting regulations that enforce the market.

He has also been responsible for the Executive Unit created by the Energy Secretariat to guide the organization of companies specialized in electric power transmission, formulate regulations for their activity, and for their privatization.

Between 1987 and 1991, he was manager of the National Dispatch Center, a predecessor of Cammesa, that was responsible for centralized operation and economic dispatch in the Argentine national interconnected system. Between 1984 and 1987, he was director of the Working Group for Planning the National Transmission Network, which had the

### Table 14. New private companies

<table>
<thead>
<tr>
<th>Company</th>
<th>Activity</th>
<th>Size</th>
<th>Partners from Abroad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alicura SA</td>
<td>Hydro generation</td>
<td>1,000 MW</td>
<td>Southern Elec. Int.</td>
</tr>
<tr>
<td>Cerros Colorados SA</td>
<td>Hydro generation</td>
<td>450 MW</td>
<td>Dominion</td>
</tr>
<tr>
<td>Chocoon SA</td>
<td>Hydro generation</td>
<td>1,320 MW</td>
<td>Endesa (Chile) CMS</td>
</tr>
<tr>
<td>Piedra de Agulla SA</td>
<td>Hydro generation</td>
<td>1,400 MW</td>
<td>Duke Chilener Transalta</td>
</tr>
<tr>
<td>Transener SA (UK)</td>
<td>Transmission</td>
<td>7,000 km of 500 kV lines</td>
<td>Duke Entergy National Grid (UK)</td>
</tr>
<tr>
<td>Alto Valle SA</td>
<td>Thermal generation</td>
<td>100 MW</td>
<td>Dominion</td>
</tr>
<tr>
<td>Guemes SA</td>
<td>Thermal generation</td>
<td>245 MW</td>
<td>Duke Iberdrola (Spain)</td>
</tr>
<tr>
<td>San Nicolas SA</td>
<td>Thermal generation</td>
<td>650 MW</td>
<td>AES</td>
</tr>
<tr>
<td>Central Puerto SA</td>
<td>Thermal generation</td>
<td>1,000 MW</td>
<td>Chiligen</td>
</tr>
<tr>
<td>Costanera SA</td>
<td>Thermal generation</td>
<td>1,260 MW</td>
<td>Endesa (Chile) Entergy</td>
</tr>
<tr>
<td>Edenor SA</td>
<td>Distribution</td>
<td>10,000 GWh/yr</td>
<td>EDF (France) Endesa (Spain)</td>
</tr>
<tr>
<td>Edesur SA</td>
<td>Distribution</td>
<td>10,000 GWh/yr</td>
<td>Endesa (Chile) PSI</td>
</tr>
<tr>
<td>Edelap SA</td>
<td>Distribution</td>
<td>3,000 GWh/yr</td>
<td>Houston Ind.</td>
</tr>
</tbody>
</table>
task of designing the future extra-high-voltage bulk transmission system. Between 1977 and 1987, he was head of the Operation Department in Hidrocor SA, participating in the commissioning and operation of the Comahue hydro power plants and associated transmission system.

Reorganization of the Electric Transmission System in Argentina

Luis V. Sbertoli, SIGLA SA, Buenos Aires

The Argentine electric system was developed from isolated local services, and, as the years went by, it became a well-integrated grid. Except for some services in the southernmost region, the national interconnected system supplies electric power to final users throughout the country.

Argentine Interconnected System

The Argentine national grid includes over 7,000 km of lines at 500 and 220 kV, and about 30 transformer stations. System Demand. Electric power demand in the Argentine interconnected system is 49,000 GWh, with a peak load of 9,000 MW. The geographical distribution of the energy demand is as follows: Gran Buenos Aires (GBA), 45 percent; Buenos Aires Sur, 14 percent; Litoral, 13 percent; Centro, 9 percent; Cuyo, 6 percent; Noroeste Argentino (NOA), 6 percent; Comahue, 4 percent; and Noroeste Argentino (NEA), 3 percent. Isolated systems, mainly those in the southern Patagonia, demand about 5,000 GWh. Demand is expected to grow at a rate of 6 percent per year. By 1994, SIN will add 1,000 GWh from presently isolated systems.

Hydro Plants. Hydro plants installed capacity is 7,000 MW with an average production of 16,000 GWh per year. The Comahue region in the south provides 4,300 MW and 63 percent of global production, and it was formerly operated by Hydroelectric Nuclear Patagonica (Hidronor). Salto Grande, with 900 MW, produces 22 percent of the total hydro power. The Comahue plants include a great capacity for regulation, and define the long range price of energy in the system. Main generators are Chocón SA (1,320 MW), Cerros Colorados SA (460 MW), Alícura SA (1,000 MW), and Piedra de Agüita SA (1,400 MW). A number of minor private companies will be formed from plants presently owned by Aguas y Energia Electrica (AYE). In the near future, it is expected to commission the Yacyretá plant, which will add 3,000 MW and 20,000 GWh to the market.

Thermal Plants. Thermal plant capacity is around 7,700 MW, with 5,000 MW conventional steam, 1,000 MW nuclear, 1,500 gas turbines, 100 combined cycle, and 100 diesel generators. Steam plants are mainly fueled by natural gas from the Comahue and the NOA regions. Main generators are Puerto SA (1,000 MW), Costanera SA (120 MW), both located in GBA, Eseba (1,100 MW), San Nicolás SA in the Litoral region (650 MW), and CNEA (1,000 MW).

In 1994, the thermal capacity in the Comahue will be increased by 500 MW in gas fueled gas turbines plants. CNEA is constructing a third nuclear power plant in the Litoral, 750 MW, that is expected to be commissioned by 1999.

Private Companies and Public Service

Private companies started the Argentine electric systems; however, the supply of electric power had become a public activity long ago, and a number of publicly owned electric utilities provided service.

Public service in the Greater Buenos Aires Area was performed by Segba, the greatest distributor and a big generator as well, with more than 4 million customers.

Widely spread Aguas y Energia Electrica was the national company covering the rest of the country, and shared the supply to regions other than the Greater Buenos Aires Area with the provinces. It was an integrated unit, devoted to final distribution and generation as well. Aguas y Energia Electrica was a pioneer in hydro resource exploitation.

Major hydro power plant construction in southern Argentina gave way to the creation of Hidroelectrica Norpatagonica (Hidronor). Remote hydro plants are linked with the market through a strong 500 kV transmission System.

The Comision Nacional de Energia Atomica (CNEA) built and operates two important nuclear power plants (about 1,000 MW), and has a third one under construction.

The hydro power plant of Salto Grande is shared with Uruguay, and is operated by a binational company, Comision Técnica Mixta de Salto Grande (CTM).

The Yacyretá hydro project (3,000 MW) is being commissioned by another binational company, Entidad Binacional Yacyretá (EBY).

The national interconnected system was developed to connect the regional systems and to route remote hydro and nuclear energy to the market. The national interconnected network includes overhead lines covering over 7,000 km and about 30 transformer stations, mainly at 500 kV. Some lines operate at 220 kV. The original major owners of the network were AYE and Hidronor. Regional systems cover the rest of the country, typically at 132 kV, with some lines at 220 and 330 kV.

Electric Power Sector Transformation

In mid-1991, the national government decided on the transformation of the electric power sector as part of a wider plan of public facilities privatization. The plan included:

- New definition for the role of the state in the electric power industry
- Plan for resizing and privatizing the national public-owned utilities
- Guidelines for the extension of these principles to the provinces.

This plan was carried out within the state reform defined by National Law 23696 and is almost completed. The scope of this section is to describe the main characteristics and results of the transformation process.

With the reform, an in-depth transformation of the public sector began, with the aim of transferring productive and commercial activities to the private sector, and keeping the responsibility for system regulation with the government. A Regulatory Framework Law for the electric power sector was passed. This law states the main characteristics of sector activities, with two different types of regulation:

- Energy production in power plants, organized as a competitive matter under a well-defined pricing system based on production costs (short range marginal cost of thermal units) and capacity costs needed to ensure system reliability (capacity and loss of load probability).
- Transmission and distribution, established as public services, organized as monopolistic steps within an area and level, under specific regulation and subject to concession (license) contracts (transmission and distribution concessions).

In this way, the privatization of public-owned utilities was based on the segregation of production, transmission, and distribution activities. This vertical cut was performed by creating different business units as commercial corporations, the controlling stake of which was to be offered to public bid.
In order to achieve this, the former state-owned utilities (Segba, Agua y Energía Electrifica, and Hidronor) were split into several specialized companies. The government transferred to these companies the assets and functions, and the concession, when necessary. Then, the controlling stake and the managing of these companies was sold in public auction. A minority stake, generally 10 percent, has been reserved for workers, and the remaining shares will be offered on stock exchanges.

The privatization of the national utilities has been completed, except for some minor power plants and regional networks that are to be sold early this year.

The other key feature of the process was to set up a wholesale electricity market (WEM) that includes:

- A unified marketplace where producers and customers buy and sell electricity and where a wholesale price is defined.
- A transmission system that carries market prices and products, defining a nodal price for each delivery point (This is a monopolistic and federally regulated level).
- A distribution system as a monopolistic and federally regulated level in the Greater Buenos Aires area.
- A regulatory body (ENRE) in charge of overseeing the observance of laws and codes and judging cases of disputes between market actors.

ENRE is an autonomous body, its board of directors being appointed by the Executive Power. ENRE is responsible for sector regulations and also plays a major role in concessions and the definition of rates.

Electricity producers are selected according to location and production costs under a national dispatch program. This program and overall market operation is in charge of Cammesa, a company formed by the government and the different market players, generators, distributors, transmitters, and large users.

We can summarize the tasks of the state as follows: reorganize, create a market with private producers and customers, and regulate the whole system.

**Transmission Network Privatization**

Electric power networks in Argentina have developed from the beginning with two main goals:

- Connect services so as to reduce power production costs by increasing unit sizes, reducing reserve requirements and allowing for general scale economies.
- Link power plants, mainly remote hydro, with demand centers.

While monopolistic state-owned agencies were in charge of services, the grid implied the creation of a commercially integrated system in which the state was both the producer and the final distributor.

The vertical cut process produced a great number of new generation and distribution companies operating upon a previous matrix: the Argentine interconnected transmission system. Even the creation of the wholesale electricity market has been possible because that market was already in existence by means of the transmission networks.

The Regulatory Framework Law defines power transmission as a monopolistic activity, to be performed under a license contract. Power transmitters do not buy or sell energy and are paid as agents of a transmission service to the market.

This feature is intended to preserve open access to the different players, thus increasing global efficiency over market priorities and constraints.

With vertical cut, the transmission grid takes on a new function, namely to provide an open access to market players, making power production effectively competitive, and allowing distributors and final customers to buy energy from producers not even directly connected to them.

Transmission activity includes:

- Transener, a company with a concession for the national high voltage grid (500 and 220 kV).
- A network of regionally organized companies operating typically 132 kV grids, with a few transmission lines at 220 and 330 kV.

All these companies have been created from previous Segba, AYE, and Hidronor grids, and with the potential addition of the provincial assets. These companies operate under license contracts, the general regulation of the wholesale electricity market, and specific transmission regulation referring to grid utilization, expansion, connection, and information.

**Transmission Rates**

Transmission rates have been developed in such a way as to provide economic signals to grid users. Each point of the network (node) becomes characterized by a factor expressing the relative cost in relation to market; an export node with a poor link will receive an income reduced by that factor, while an import node will pay the energy increased by that factor.

This principle tries to take into account the inefficiency derived from insufficient transmission capacity, and should encourage players to build new facilities.

Economic theory indicates that in such cases, transmission should be paid according to marginal transmission losses. Because of the nature of electricity networks, some scale economies appear that make it impossible to pay for new lines only with that remuneration, and some special charges must be added to pay for the transmission service.

In the Argentine system, a mixed pricing method has been developed, based on marginal considerations and fixed costs as well. The variable charge takes into account the incidence of marginal losses through a nodal factor. Poor network reliability resulting in unsupplied energy and out-of-merit dispatch is taken into account through an adaptation factor. These factors cause the node price to change throughout the transmission grid and, with time, in accordance with power balance and network availability.

The fixed charge represents the operation and maintenance costs of connecting users to the grid (connection charge) and transmission facilities (transmission capacity charge).

All these charges are computed for each user and are managed by Cammesa.

Variable charges are calculated on an hourly basis for generators, but are stabilized each 5 months for customers. Thus, transmission charges are an essentially changing amount, according to the transmission network and power dispatching.

However, as the transmitter is an agent that does not have any influence on energy flows, the remuneration has been stabilized on a 5-year basis, according to the ex-ante mean value of charges for the period. The stabilized annual income of Transener for the first 5-year period is 95 MUS, including 55 MUS from variable charges and 40 MUS from fixed charges. This income will be reduced annually by a factor aiming to increase system efficiency, and will be adjusted every 6 months by a factor that takes into account dollar inflation. Every 5 years, annual income will be adjusted according to expected variable charges in the following 5-year period.

The remuneration of the transmission companies in the first period is based on 100 percent availability. Any time a facility is out of service, whether planned or accidental, a penalty will be applied to the company, its amount being computed according to outage duration and facility importance. From the second period on, a quality standard is to be established, based on previous system performance. Penal-
ties and bonuses will be applied to company income whenever a deviation from the standard occurs.

The pricing system is designed to maintain economic signals to users, and preserve system reliability as the transmission companies' main duty.

**Concession (License) Contract**

Electric transmission companies operate under federal concession contracts stating their rights and duties. The contract term is 95 years, with successive management periods, the first lasting 15 years and the following lasting 10. At the end of each management period, the controlling stake is to be offered in public auction, at which time the owner is asked to declare the value he or she assigns to the company. Should any other bidder offer a higher price, he or she will become the new owner, and the price will be paid to the former. Otherwise, the former owner will maintain the controlling stake.

The main duties of the company are to keep its facilities in normal service and to avoid discrimination between network users, so as to allow free access within its field of operation. Transmission companies will also comply with technical and environmental conditions.

As stated, transmission companies are not allowed to buy or sell power. They will not be allowed to own controlling stakes of generators or distributors or big customers.

The transmission company is not obliged to make investments, except for operation and maintenance needs. Network extensions are to be processed in a special way (described in the next section). However, the company will be in charge of overseeing construction, operation, and maintenance of its own network and the extensions being developed by third parties within its concession area as well.

**Extensions**

The electric power sector in Argentina is no longer subject to centralized planning. System design, operation, and tariffs are intended to promote economic decisions based on economic signals sent through prices. As a consequence, transmission companies will not be asked to make new investments or to supply demands beyond their electrical network capacity.

On the contrary, major extensions are to be promoted by interested agents and paid by those who benefit. Extensions will also require a need and suitability certificate issued by ENRE after an analysis and public hearings process.

Major extensions will always be the responsibility of an independent transmission company (ETI) through a Construct, Operate & Maintain Contract (COM contract). Transmission companies are allowed to act as ETI. The specific access and extension code states two ways in which major extensions can be performed:

- By agreement between a user or group of users and the ETI. In this case, third users will pay ordinary transmission charges.
- By public call for bids (auction) at the request of a group of users totaling 30 percent or more of those who will benefit from the extension, and barring opposition of 30 percent or more. In this case, a competitive bidding is called to select an ETI, and a COM contract is to be signed. The transmission company must give the ETI a technical license contract and oversee construction, operation, and maintenance. The COM contract will have an amortization period during which ETI will be remunerated through the canon that was offered. The rest of extension life, ETI will collect normal transmission tariffs.

The concessionaire will be in charge of overall supervision within its area, being allowed to collect fees for the same as stated in the concession contracts. This mechanism is already in operation for the Yacyreta hydro plant transmission system (1,500 km, 500 kV). In the case of regional networks, concessionaires are compelled to give ETI operation and maintenance services using the standard fixed remuneration index.

**Other Transmission Concessions**

The aim of electrical transmission regulation is to transmit an economic based remuneration from the wholesale market to final customer. Wholesale electricity market prices are established in points of demand, based on transmission rules.

This mechanism, referring to federal concessions given to new companies, is supposed to be completed by provinces that own a variety of transmission grids. The intention of general regulation is to encourage provincial utilities to perform a segregation process as done in connection with national assets.

In so doing, wholesale prices will reflect economic conditions throughout the country, and global supply costs will be reduced.

Such an organization will also provide services integration, with a great deal of operative decentralization and high regulatory consistency.

**About the Speaker**

Luis Victoria Sbertoli graduated from the School of Engineering, University of Buenos Aires, in 1974. For more than 15 years, he has codirected and managed technical projects undertaken by SIGLA SA, with particular emphasis on new business in both the public and private fields. He has been involved in many projects, including privatization of electricity transmission in Argentina (1992-1993) and electric distribution planning in Costa Rica (1993). In 1989-1991, he was national director of Energy Sector Planning, including both technical and institutional matters. In 1987-1989, he was associate director of the Argentine consulting group Distrelc for the Engineering Project for National Electrical Distribution Systems. In 1985-1987, he was director of the Energy Plan for the Province of Formosa and the organization of the Province Energy Utility. He has also codirected the study outlining residential areas for the Corpus hydro project, and codirected electrification studies and programs for the provinces of Catamarca, Tucuman, San Juan, La Rioja, Salta and Misiones.

**Chile: Pioneer in Deregulation of the Electric Power Sector**

Hugh Rudnick, Pontificia Universidad Catolica de Chile, Santiago, Chile

Chile was the leader in Latin America in the restructuring of the electric power sector, and its case merits particular analysis. Although a small system (70 percent of installed capacity is hydroelectric with 2,800 MW maximum demand in 1993), its development has been observed with interest by many institutions, particularly by the World Bank and most recently by other Latin American countries, and several countries have followed its steps.

The Chilean 1982 electricity law was a worldwide pioneer in deregulating the electric power sector to create market conditions where generators compete to provide electrical energy to large consumers, sharing a transmission system open to all and paying fees for that system. The law formalized what had taken place in the country since 1978, several
years before market approaches were formulated in the United States and implemented in the United Kingdom. [Margaret Thatcher published her white book, *Privatizing Electricity*, in March 1988; that lead to the restructuring of the UK electric power sector in April 1990, a development of worldwide interest. At the time, Chile was already publishing some of the results of actions taken in 1978 that had lead to the new legislation of 1982 (S. Bernstein, “Competition, Marginal Cost Tariffs, and Spot Pricing in the Chilean Electric Power Sector,” Energy Policy, August 1988, pp. 369-377).

**Energy Policies**

The policies applied to the Chilean electric power sector have been directly linked to the general energy policies, formulated by the National Energy Commission, the basic regulatory institution. The overall energy strategy aimed at maximizing the welfare of the community by establishing conditions of efficiency in the development and operation of the national energy system, and assigning the state a subsidiary role.

Within this strategy, efficiency is connected to the recognition that market forces represent a basic mechanism in the correct allocation of resources. The necessity of deconcentrating, decentralizing, and privatizing the activities and property of the energy sector companies was recognized as desirable for the stability of the system.

On the other hand, subsidizing energy basically implies state support for the more deprived sectors of the population through direct subsidies, without distorting the prices of goods and services. It also means that the state will perform entrepreneurial activities only when such activities cannot or will not be carried out by the private sector.

**Technical and Economic Characteristics of the Electricity Business**

The electricity law assumes that there are distinct technical and economic peculiarities of the business of electric generation, transmission, and distribution that condition their development and operation. Empirical information was used to demonstrate that there are no significant economies of scale in the generation business, nor in technology nor in organization. On this assumption rests the conclusion that for an electric power generator, full competition is possible. The distribution business, given present-day technologies, tends to develop through geographic monopolies, although the assumption is that there are no clear economies of scale. Transmission of electric power is seen as the single electric business in which important economies of scale are present and in which competition is not feasible, and natural monopolies develop, requiring government regulation.

**Specific Policies for the Electric Power Sector**

The policies applied to the Chilean electric power sector were aimed at establishing an appropriate framework for decentralization, efficiency, and the establishment of competition and private participation in the sector. The instruments designed to reach those objectives included:

- Design of a new price system on the basis of marginal supply costs. [The electricity law is based on the economic principle that the social optimum is achieved when in an economy, the goods and services are priced at marginal costs and systems are economically adapted. Marginal costing is believed to provide the correct economic signals to system users.] The system establishes explicit generation to distribution sale prices, transfer prices between generating companies, rates applicable by distributing companies to small end-users, and, finally, freedom of prices for large consumers (over 2 MW).

- Division of the large state companies and explicit separation between generation-transmission and distribution activities.

- Design and implementation of an Economic Load Dispatch Center ("a generators club") to coordinate the operation of the generating companies, to obtain the minimum overall operating cost of the system, and to assure equitable conditions in marketing the energy produced by the various generating entities (This Center was to be the key for competition in generation.)

- Design of an open access system for the shared use of transmission systems

- Establishment of a new generation planning scheme, with an indicative plan being developed by the regulatory agency

- New generation schemes to be undertaken by new companies by a consortia of the existing electric power facilities owners and the new private investors, plus state participation if necessary

- Clear definition of duties and rights of distribution companies

- Increased participation of consumers in financing the expansion of the electric power sector

- Full privatization of state-owned electric distribution companies and majority sale of state equity shares in the electric generating companies (actions were taken for a whole restructuring of the sector, with clear and stable defined rules and operational experience, before any extended privatization of the generating sector was achieved)

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*Figure 2: Evolution of energy prices (US$ cents per kWh) in the central interconnected system T*
Major Results of the Process

The Chilean restructuring process, with the framework provided by the electricity law, has proved to operate adequately. Electricity prices are relating closely to long run marginal costs, with what are thought to be correct market-based economic signals orienting the efficient decisions of participants. Private capital is actively investing in the electric power sector development.

Ownership of electric power sector companies is widely distributed across the population, and their stocks are traded daily on the local stock exchange. The market is very dynamic, and the legislation has allowed the market to resist government political and special interest group pressures.

Prices have remained relatively stable, with variations depending mainly on hydro availability and fuel prices. Figure 2 shows the evolution of energy prices (in US$ cents/kWh) in the central interconnected system, the residential tariff (100 kWh load), and the prices for large industry.

The process has promoted large investments by many private electric utilities with an annual average investment of US$400 million, with a system demand growing at a rate of 6 percent a year. This private investment allows the government to concentrate its investment resources in other economic areas of greater social urgency.

Private electric utilities are making reasonable profits. Endesa, with 2,500 MW installed capacity, has made enough profits to sustain a continuous investment process of US$150 million a year, with major investments in Argentinean generating plants, and plans to invest in the future privatization of the electric power sector in Peru.

The results of the restructuring process are perceived as successful for the consumers and for the generation and distribution businesses. The regulators and the electric utilities are looking for some improvements to the law.

A particular area in which problems have surfaced is that of the transmission business. Difficulties have been faced with the open access tariff scheme, particularly in the allocation of the payments among participating electric power generators. The difficulties have created uncertainty in the development of the transmission networks, with restricted investments taking place. The regulations dealing with transmission costs are being revised to deal with this matter.

Another area where the parties are looking for improvements, to avoid isolated conflicts, is that of energy pricing at the distribution level (where marginal generation and transmission costs are added to average distribution costs, assuming ideal model distribution companies). The incorporation of security and quality concepts in electricity tariffs is also being studied.

About the Speaker

Hugh Rudnick was born in Santiago, Chile. He graduated as a civil electrical engineer from the University of Chile and received his MS and PhD degrees from the Victoria University of Manchester in Great Britain. After a period of working for local utilities, he joined the Universidad Catolica de Chile, where he is a professor of electrical engineering.

His research interests include power system economic operation, dynamics and control, where he has published over 100 technical papers. He has been a consultant to the National Energy Commission, software development companies, industrial firms and several electric utilities in Chile, Argentina, and Colombia.