Energy Market Integration in South America

A panel session titled Power and Natural Gas in Latin America: Towards an Integrated Market was held on February 3, as part of the 1997 IEEE Power Engineering Society (PES) Winter Meeting in New York. The session was sponsored by the IEEE PES Energy Development and Power Generation Committee, chaired by Thomas J. Hammons, and cochaired by Nelson de Franco. Presentations included:

- Energy Market Integration in the Mercosur by Luis Victorio Sbertoli, SIGLA S.A., Argentina
- Overview of the Gas Industry in Latin America by Chakib Khelil, The World Bank
- Interactions Between Gas and Electricity Markets by Hugh Rudnick, Catholic University of Chile
- Transport of Gas or Electricity Transmission? by Alessandro Clerici and A. Longhi, Asea Brown Boveri SpA, Italy.

Panelists focused on the gas and electric power industry in Latin America in terms of the following:

- Transport of gas or transmission of electricity
- Energy market integration in the southern cone of South America
- Issues on gas use for electricity generation in South America countries.

Countries such as Argentina, Bolivia, and Peru will export natural gas to Brazil, Uruguay, Paraguay and Chile, and the energy matrices of these countries will change.

Energy Market Integration in the Mercosur

Luis Victorio Sbertoli

The challenge facing integration is a global one, not only related to the physical infrastructure required for trade, but, most importantly, the required business and regulatory framework that would foster trade within the region.

Mercosur Economic Market

The Mercosur is an economic common market project undertaken by Argentina, Brazil, Paraguay, and Uruguay. It covers an area of 12 million km² with a total population of some 200 million people (Table 1).

The regional integration began back in 1991 and involved a number of defined stages. At the present time, it implies mainly the unification of foreign exchange procedures and taxes, along with an increasing growth of the regional trade. The existing cross-border and domestic barriers are indicative of the maturity problems faced by all multicityoungs of this type.

The initial Mercosur member countries (Argentina, Brazil, Paraguay, and Uruguay) have been recently joined by Bolivia and Chile, two new participants that are expected to become full common market members in the near future. These countries are deeply involved in the energy connection projects within the region. For the purposes of this article, the Mercosur region is synonymous with what is known as the Southern Cone Region in Latin America, and energy integration of this region is our focus.

Areas for Integration

Electricity and gas are the most dynamic areas of the current energy integration process. Nonetheless, as the continent is the natural reference, the energy balance of each country sets the local conditions for energy integration projects. The oil industry interacts supplying derivative commodities that become gas and electricity substitutes. This commodities trade does not require large infrastructure links, as conventional overland and sea transport are used.

Electric Power Generation and Delivery. Power generation in each country of the region is presented in Table 2, and the existing network is shown in Figure 1. All power generation in Brazil and Paraguay is produced by hydroelectric plants, and Bolivia's generation is fully based on natural gas and oil fueled thermal plants. Power generation in all other countries is produced by a balanced combination of hydro and thermal plants. Argentina's power transmission grid is already linked to those of
<table>
<thead>
<tr>
<th>Country</th>
<th>Area (Mill. Km²)</th>
<th>Population (Mill. Hab.)</th>
<th>Density (Hab./Km²)</th>
<th>Consumption (MTEP/year)</th>
<th>Consumption (TEP/Hab.year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>2.8</td>
<td>34.0</td>
<td>12.1</td>
<td>42.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Bolivia</td>
<td>1.1</td>
<td>7.5</td>
<td>6.8</td>
<td>3.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Brazil</td>
<td>8.5</td>
<td>154.0</td>
<td>18.1</td>
<td>133.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Chile</td>
<td>0.8</td>
<td>14.0</td>
<td>17.5</td>
<td>16.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Paraguay</td>
<td>0.4</td>
<td>4.7</td>
<td>11.8</td>
<td>4.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Uruguay</td>
<td>0.2</td>
<td>3.2</td>
<td>16.0</td>
<td>3.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>13.8</td>
<td>217.4</td>
<td>15.8</td>
<td>201.0</td>
<td>0.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Production</th>
<th>Installed Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TWH/year</td>
<td>Total GW</td>
</tr>
<tr>
<td>Argentina</td>
<td>62.7</td>
<td>17.8</td>
</tr>
<tr>
<td>Bolivia</td>
<td>2.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>280.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Chile</td>
<td>25.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Paraguay</td>
<td>4.5</td>
<td>7.0</td>
</tr>
<tr>
<td>Uruguay</td>
<td>6.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Total</td>
<td>381.1</td>
<td>89.0</td>
</tr>
</tbody>
</table>

Paraguay and Uruguay by strong 500 kV interconnections associated with hydroelectric projects. The Brazilian and Paraguayan electric systems are strongly interconnected at the Itaipu hydropower plant. An interconnected transmission system is already in place in the Mercosur region. The use of the grid's capacity for additional transmission is limited by technical conditions and also by regulatory constraints in force in each country. Because of a very fluent integration between Argentina and Uruguay, the system can be said to have, in practice, a unified dispatch.

**Natural Gas Production and Delivery.** The integrated natural gas market presently covers Argentina, Bolivia, and Chile. A breakdown of natural gas production and consumption by country is shown in Table 3, and Figure 2 presents the existing and projected gas pipelines.

Bolivia and Argentina are strong natural gas producers, while the other countries in the region are net gas importers. In recent years, there has been a relatively strong substitution of oil derivatives by natural gas as a result of natural gas ease of use and significant environmental advantages. Indicative of this trend is the recent emergence of new markets with little or no gas consumption culture. Natural gas network expansion is determined to a large extent by the use of natural gas to fuel combined cycle power plants. This new system accounts for the recent technology revolution that allows cost-efficient production.

**Institutional Situation**

The region has not escaped the worldwide process of public services restructuring.

**Structure of the Electric Power Industry.** As far back as 1982, Chile pioneered the unbundling of the former integrated utilities into different business units for generation, transmission, and distribution.

In Argentina, this process began in 1991, providing for a vertical division of activities and the establishment of a wholesale electricity market. Major activities, with the exception of bina
tional and nuclear plants, have been transferred to private owners.

The organizational structure adopted by Bolivia back in 1994 was very similar to that of Argentina. Unlike Argentina, privatization in Bolivia was implemented through the "capitalization" of power generation companies, which had, in fact, the effect of transferring the control to private groups.

State-owned monopolies are still in place in Brazil, both at the level of the federal government and of the states. Recent privatization steps have been taken in the area of power distribution (with Light and Escelsa at the federal level, and Cerrj at the state level). The federal government is studying a global restructuring plan to demonopolize the industry and introduce incentives for competition.

Government-owned monopolies run the electricity sector in Paraguay and Uruguay. In both countries incipient restructuring efforts have taken place, but the final structure is still being discussed.

**Structure of the Oil and Natural Gas Industries.** The oil and gas industry in Argentina differs greatly from the rest of the countries in the region. While Argentina shows an increasing trend toward free market, in the rest of the region this sector continues to be dominated by government-owned monopolies.

Brazilian Petrobras is the largest oil and gas company in the region and, with the exception of state-owned PDV in Venezuela, the largest in South America. The Brazilian government has expressed its intention of placing limitations on this monopoly, but how this will be achieved has yet to be defined.

Bolivia has initiated the privatization process of YPFB, the state-owned oil and gas company, through the capitalization of business units.

**Competitive Approach**

Regional integration seeks to reduce energy costs in front of stand-alone national systems. Therefore, the base for successful projects is to allow the use of cheaper resources by increasing market integration, thus enhancing the scale and the feasibility.

Because of the large water resources of the region, hydro generation gained immediate leadership in the electricity industr-

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![Electric power network](image)
Table 3. Mercosur natural gas (as of December 31, 1994)

<table>
<thead>
<tr>
<th>Country</th>
<th>Consumption (10^9 m^3/year)</th>
<th>Production (10^9 m^3/year)</th>
<th>Reserves (10^9 m^3/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>30.2</td>
<td>28.0</td>
<td>700.0</td>
</tr>
<tr>
<td>Bolivia</td>
<td>3.7</td>
<td>5.9</td>
<td>119.0</td>
</tr>
<tr>
<td>Brazil</td>
<td>7.5</td>
<td>7.5</td>
<td>166.0</td>
</tr>
<tr>
<td>Chile</td>
<td>0.4</td>
<td>2.2</td>
<td>117.0</td>
</tr>
<tr>
<td>Paraguay</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Uruguay</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>41.8</td>
<td>43.6</td>
<td>1,102.0</td>
</tr>
</tbody>
</table>

Table 4. Mercosur electricity demand forecast

<table>
<thead>
<tr>
<th>Country</th>
<th>2000 (TWh/year)</th>
<th>2005 (TWh/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>70.0</td>
<td>80.0</td>
</tr>
<tr>
<td>Bolivia</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Brazil</td>
<td>318.0</td>
<td>419.0</td>
</tr>
<tr>
<td>Chile</td>
<td>32.0</td>
<td>43.0</td>
</tr>
<tr>
<td>Paraguay</td>
<td>7.7</td>
<td>11.0</td>
</tr>
<tr>
<td>Uruguay</td>
<td>5.4</td>
<td>6.0</td>
</tr>
<tr>
<td>Total</td>
<td>436.1</td>
<td>563.5</td>
</tr>
</tbody>
</table>

Table 5. International electricity interconnection projects

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Description</th>
<th>Length (km)</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>Chile</td>
<td>Mendoza</td>
<td>200</td>
<td>500</td>
</tr>
<tr>
<td>Argentina</td>
<td>Chile</td>
<td>Salta</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Argentina</td>
<td>Brazil</td>
<td>Garabi - Ita 500 kV</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>Argentina</td>
<td>Brazil</td>
<td>Garabi - CEEE 230 kV</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Argentina</td>
<td>Paraguay</td>
<td>Yacyreta - Itaigu 500 kV</td>
<td>300</td>
<td>1,500</td>
</tr>
<tr>
<td>Brazil</td>
<td>Uruguay</td>
<td>Rivera - Santana</td>
<td>10170</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>Uruguay</td>
<td>PTE Medici - San Carlos</td>
<td>200</td>
<td>300</td>
</tr>
</tbody>
</table>

Outlook for the Electric Power Industry

The extent to which a regional electricity market is likely to be developed will depend on physical integration links and on how a cross-border regulatory and business framework is phased in.

The expected energy consumption by country in years 2000 and 2005 is shown in Table 4. Major changes in demand structure are unlikely. The modulation of these values will depend largely on the region’s economic development, which can be expected to be fairly positive after the recent stability and economic adjustment periods. The stronger the growth, the greater the increase in the demand for supply availability. The largest electric integration projects in the region are shown in Table 5.

The outlook for each country is as follows.

Argentina. Increasing electricity exports as a result of higher thermal generation capacity based on locally produced gas. Location of power plants next to load centers. Prospects of major firm electric energy exports to Brazil. Increasing integration with Uruguay and Paraguay. Prospects for an interconnection with Chile. Water resources shared with Brazil, Paraguay, Uruguay, and Bolivia. Significant local water resources. Market mechanisms for pricing. Probable long-term unification of the two interconnected systems (MEM and MEM Patagonico).


with specialized private players. High potential for growth with the currently unmet demand. Connection of small stand-alone networks to the interconnected grid.

**Chile.** Supply/demand balance. Thermal generation projects based on gas from Argentina. Own water resources. Prospects for limited imports from Argentina. Possible connection of the Norte Grande system to the central interconnected system. Operation of a wholesale electricity system with private players and freely agreed contracts. Indicative state planning with some effect on business (node pricing).

**Paraguay.** Net electricity exporter (from Itaipu and Yacyreta). Possible new binational hydropower plants. High potential for demand growth by the addition of currently unsatisfied demand. Incipient revision of ANDE, the state-owned electric monopoly. Centralized expansion.


### Outlook for the Natural Gas Industry

The expected production and consumption of natural gas by country are shown in Table 6. In the future, the region may receive gas from the Camisea gas fields in southern Peru. This would reinforce the reserves that support the market supply. Table 7 summarizes the main gas pipeline projects in the region.

The outlook for each country is as follows.

**Argentina.** Increasing natural gas exports to Brazil and Chile and, to a lesser extent, Paraguay and Uruguay. Development of power plants in load centers. Pricing rules: unregulated pricing system at wellhead, highly regulated transmission and distribution.

**Brazil.** Strong growth in the demand for natural gas. Project for massive gas imports from Bolivia in the immediate future and from Argentina in the medium term. Development of gas-fired power plants. Completion of the current revision of the Petrobras monopoly. Association with companies in Bolivia and Argentina to explore and develop natural gas reserves.

**Bolivia.** Increasing discovery of large natural gas reserves. Natural gas exports to Argentina and Brazil. Completion of the capitalization of YPFB, the state-owned oil and gas monopoly.

**Chile.** Increasing demand for natural gas. Development of industrial and residential customers. Power generation based on natural gas from Argentina. The government has an important role in the exploration and operation businesses through ENAP with private distribution companies.

**Paraguay.** No gas consumption at present. Probable connection to the Argentine northeast. Oil and fuels monopoly run by Petropar.

**Uruguay.** No gas consumption at present. Natural gas supply from Argentina under negotiation. Gas-fired power generation projects. Oil and fuels monopoly run by ANCAP.

### Price Considerations

It is important to discuss some economic considerations in order to provide a way to measure the feasibility of initiatives at the national and regional levels. For this purpose, we have calculated the break-even price of electricity from gas-fired combined cycle power plants consuming natural gas at different prices. This price takes into account all the costs involved, including operation and taxation (reference frame as in Argentina). The results should be adapted to the features of each local system. The analysis was undertaken for real rates of return (i.e., net of US$ inflation) ranging between 8 and 12 percent. Gas prices of US$1-3/MBTU were used, representing a typical wellhead location and a very long distance transmission, such as Bolivia-Brazil, with light flow, respectively. The results of these calculations are shown in Table 8.
Acknowledgment

Information on energy consumption is from own files and from “Integracion Energetica en el Cono Sur,” BID, INTAL, Mario Wiegens, 1996.

About the Panelist

Luis Victorio Shértoli is partner and director of SIGLA S.A., Buenos Aires, Argentina. He has held this position since 1978. He has managed projects and studies in the energy area for both the public and private sectors. From 1989 to 1991, he acted as National Director for Planning, Secretariat of Energy, which included negotiations with the International Development Bank and the World Bank. He was also a member of the Public Sector Deregulating and Restructuring Committee. This dealt with strategic planning with the regulatory framework, definition, and evaluation of business units within public sector utilities. From 1972 to 1977, he was an engineer in the Planning and Development Department, Agua y Energi, where he was company representative in planning groups coordinated by the Secretariat of Energy. Shértoli gained a degree in electrical engineering from the University of Buenos Aires in 1974, specializing in energy planning and economics, and in electrical transmission systems.

Overview of the Gas Industry in Latin America

C. Khell, The World Bank

During the last 10 years, the world has gone through major political and economic changes, especially in the formerly centrally planned economies of Eastern and Central Europe. Certain Western European and most Latin American countries also experienced big changes in the direction of establishing open and competitive market economies concerned as they were to reduce the government fiscal deficit and debt and to focus their resources on basic social infrastructure, health, and education.

This new direction implied limiting the role of the state to that of a policy maker and regulator and pulling away from the entrepreneurial role it held in the past through state enterprises demonopolizing commercial activities and even privatizing state-owned enterprises. While this is not happening in all countries and all sectors in Latin America with the same speed and depth, the trend is gaining momentum throughout the region, particularly in the energy sector. Suffice it to mention the movement towards a market economy and privatization in Argentina, Bolivia, Chile, and Peru, possible Brazilian constitutional amendment to eliminate state companies exclusivity, the association contracts in Venezuela, and the encouragement to private investors in the gas sector in Mexico.

The structural changes in the economies have also accelerated the globalization of the energy industry because of competition between countries for private capital and the multiplication of new activities where the private sector can invest.

The Latin American energy demand will reach 677 MTOE by 2010, a 50 percent increase over 1995. There will be a major shift towards use of natural gas in power generation. From 1995 to 2010, US$503 billion will be required over 1995–2010 to discover and develop hydrocarbon reserves, build the pipeline system, as well as generate and distribute electricity. US$19 billion will be required for gas pipelines and LNG projects in the region. Improvements in the policy, legal, and regulatory framework are required in many countries to attract the needed investments. Several major gas projects are being implemented or planned in the region: Colombia Enron-built pipeline, Peru Camisea project, Chile Nova gas pipeline from Argentina, the Bolivia-Brazil pipeline, and others. The World Bank group has been assisting countries in developing a competitive business environment and can provide, when needed, comfort to lenders in project financing through a guarantee scheme in several large complex cross border projects.

The World Bank Group

The World Bank Group (WBG) is owned by 176 governments and has as a general objective to reduce poverty and support sound and safe economic growth. The WBG consists of:

- The World Bank, which requires government guarantees for financing projects and technical assistance
- The International Development Agency (IDA), which provides credits at concessional terms to the poorest category of member countries for projects and technical assistance
- The International Finance Corporation (IFC), which does not require government guarantees to finance or take equity in private sector projects
- The Multilateral Investment Guarantee Agency (MIGA), which provides insurance against possible expropriations
- The Global Environmental Facility (GEF), which provides grants and concessional funding for projects and programs that protect the global environment.

Investment Requirements

The region would require about US$503 billion over the period 1995–2010 to meet the investment challenge for the primary energy and power demand requirements. This does not include financial resources required for certain countries to continue imports of crude oil and/or petroleum products, estimated at about US$100 billion, or the cost of conversion of users to natural gas, for which estimates are not available. Of the total investments, 27 percent would be for:

- Exploration and development of oil and gas resources, mainly in countries of Brazil, Mexico, Venezuela, Argentina, and Colombia, which constitute 84 percent of the total for the region
- Oil transportation and refining
- Oil products storage and distribution.

Another 5 percent of the total investments would be for:

- Natural gas transmission pipelines and LNG plants
- Natural gas distribution
- Compressed natural gas (CNG) distribution.

The remaining 63 percent of the total investments would be for power generation, transmission, and distribution. Out of the US$159.7 billion estimated for power generation, only about US$35.9 billion (i.e., about 22 percent) would be for oil and gas based power. The rest would be mainly for hydropower.

Legal and Regulatory Framework

There may be a need in many countries of the region to address the policy and legal, institutional, and regulatory issues not only for the development of natural gas reserves but also their transport, distribution, and possible export. A resolution of these issues is critical before the gas sector can develop along with the oil and power sectors. Such issues have already been addressed in Argentina and Peru within the framework of the reform of the hydrocarbon sector and the privatization program of the state owned companies, and they are now being addressed in Bolivia within the framework of the reform of the hydrocarbon sector.
and the capitalization program of the state oil company. In Brazil, Congress is discussing a new petroleum law that will amend the present constitution and that will address the issues of free import and export of natural gas, monopoly by Petrobras, regulation of prices of petroleum products and natural gas, and the set up of a regulatory entity in the sector. Mexico has recently issued a natural gas regulatory framework that will facilitate investments by private companies in natural gas pipelines and power generation. However, the maintenance of the national oil company PEMEX monopoly in upstream exploration and development and of the national power company CFE monopoly in the sale of electricity to the grid raise issues of reliability of gas deliveries by PEMEX and payments for sale of gas/electricity by CFE.

**Project Financing**

When the framework for the gas sector is not clear from the perspectives of the investor, the latter may require mechanisms to mitigate the risks inherent in such projects. They may include construction, operating, fuel, market availability of foreign exchange, and the political or country risks. Allocation and mitigation of risks make project financing an attractive option for the investor unless the latter considers that the state owned company financial strength and prospects may not warrant bringing in another player to mitigate, for example, the fuel purchase agreement, the take-or-pay contract, or the political or country risk. The World Bank participation through a guarantee scheme may provide the comfort necessary to the lenders in case of noncompliance by the state companies of natural gas supply contracts or electricity purchase contracts. The World Bank guarantee requires a counter-guarantee be provided by the government. The International Finance Corporation (IFC), another member of the WBG, can lend to the private sector without government guarantee, and can also take equity participation in the project.

Project financing is important for international companies for the following reasons:
- Joint venture (JV) partners may require funding because the project is highly capital intensive
- JVs want off-balance-sheet financing or corporate financing is not feasible
- JV partners may like risk sharing with others, especially the political or country risk.

For governments, project financing is important for the following reasons:
- Is not able to continue funding of the sector at the same scale as in the past because the state is focusing its resources on health, education, and infrastructure and may not want to increase its debt
- Would like to minimize impact on budget and official borrowing
- Would like to encourage capital flow into the country
- Wants project financing as part of a larger program of the sector reform, demonopolization and privatization.

**World Bank Role in Support of Project Financing**

The most important role for the bank is risk mitigation through:
- Helping countries establish an appropriate business environment such as energy and sector policy, petroleum and gas laws, regulations for safety and environment, common carrier or third-party access regulations, institutional organization, staffing and systems such as the natural gas regulatory agency or the petroleum agency in charge of promoting exploration, negotiations and supervision
- Providing guarantees at the request of government and private parties for political risk, foreign exchange convertibility, and government’s contractual obligations
- Participating in project financing.

The World Bank is working on several important projects in Latin America and Africa, where its risk mitigation role is considered critical by the private sponsors of the projects.

**Conclusions**

The general trend of demonopolization, sector reform and privatization is expected to expand in scope and depth in the energy sector in Latin America. Policy shifts in Mexico, Venezuela, and Brazil confirm this trend.

The governments of the region are focusing on new priorities (such as basic social infrastructure, health, and education) and are less inclined to call on the government budget and official borrowing to fund energy projects at the same scale as in the past. The governments are also watching experiences in Argentina and Chile, which show that the private sector could play an increasing role in areas that until recently were considered by many to be of a “strategic” nature.

The primary energy demand requirements for the region by the year 2010 will increase by 50 percent over the 1995 level, even though the per capita energy demand remains almost at the level of 1995. Mexico and Brazil would continue to absorb the largest (about 56 percent of the demand) percentage of energy in the region. The energy and power demand are required to support the economic growth of the region, expected to be one of the highest in the world after that of Asia.

There will be a major shift towards more use of natural gas, hydropower, and coal, and less on oil as a percentage of energy demand. In absolute values, the region will continue to rely very heavily on oil and hydropower by 2010.

The investment requirements for the development of primary energy and power demand by 2010 are estimated at about US$503 billion, not counting about US$100 billion that would be required for oil imports during that period. A large portion will be required for power generation and infrastructure (69%) and another for oil and gas exploration and development (32% percent). About US$36 billion would be required for oil and gas based power generation, US$19 billion for gas pipelines and LNG plants, and US$2.2 billion for gas distribution.

New opportunities have developed for the private investors in the world in new areas (Russia, Eastern Europe, China, and India) and in new activities (upstream in Venezuela gas pipelines in Colombia and Argentina, etc.). The energy industry is becoming global (Gas de France, British Gas, Enron, BHP, Tenneco, and others from Argentina, for example, have become important new players), sometimes as a consortium, seeking high return opportunities for investments. The governments in turn are competing amongst themselves to attract new capital. Both the international companies and the government objectives and strategy favor the project financing scheme.

Project financing of gas and power projects involves various risks that require mitigating before the project moves ahead. It is possible that the investors find mechanisms where they are provided the necessary comfort without the involvement of a party such as the World Bank. In large complex and cross border projects, the experience has shown that the industry may require World Bank assistance in dealing with the political, contractual, and convertibility risks. IFC can also provide equity and/or fi-
nancing. The Bank group is involved in several important projects financing in Latin America and Africa, where the World Bank group may provide financing and guarantee.

While The World Bank will continue lending to the oil and gas sector at the rate of US$1 billion a year in the foreseeable 5 years, the lending is shifting towards more assistance to the countries to help them establish an attractive enabling environment for private investments and financing of gas pipelines and rehabilitation of other facilities.

About the Panelist

Chakib Khellil is at The World Bank, Washington DC. He has 30 years experience in the petroleum industry, 15 years of which have been with The World Bank, dealing with policy, legal, regulatory, institutional, and specific project implementation issues. His experience has been in many countries in Africa, Asia, and Latin America. During the last 10 years, Khellil has focused on projects dealing with energy; more particularly with hydrocarbon sector reform and privatization in Argentina, Peru, Bolivia, and Ecuador. Prior to joining the Bank, he worked in the United States with major oil companies in the oil and gas production area and with an international consulting company dealing with oil and gas field studies throughout the world. Khellil has also worked in Algeria with SONATRACH as a manager in charge of production, reservoir engineering studies, the development and implementation of the natural gas master plan, and as technical advisor in the presidency of Algeria. He has a PhD from Texas University, speaks five languages, has published extensively, and is a member of several professional societies.

Interactions Between Gas and Electricity Markets

Hugh Rudnick

South America has been a world pioneer in the deregulation of electricity markets. Chile started a process in the late 1970s that finally gave birth in 1982 to a new conceptual framework for the electricity sector, where generation competition and transmission open access were the key elements. Argentina followed in the late 1980s with a new electricity law in 1992. Peru came next in 1993 and Colombia and Bolivia in 1994. Finally, Brazil and Venezuela are making initial regulatory changes in 1997. In parallel with this deregulation evolution, an economic integration process has been taking place among South American countries. Furthermore, the growing need for additional energy resources to support economic growth is forcing a globalization of the electricity and gas markets throughout the region, economic growth and integration leading to energy integration.

Of particular importance in the economic integration is the Mercosur market, extending over 12 million square km and involving over 200 million people. Argentina, Brazil, Paraguay, and Uruguay, as the core members, have been joined by Bolivia and Chile. International natural gas and electricity exchange initiatives have been taking place in what many see as the birth of an integrated energy network. Figure 3 illustrates what is seen as a future natural gas pipeline network throughout the region.

Energy Market Integration Issues

The integration process and the growing energy exchanges raise different issues for the private parties and governments involved, where new economic, political, and regulatory matters need to be faced.

Economic issues that need to be dealt with include the matter of import duties and how they impact producers and consumers, the need for coherency among the different economic signals (as they impact use and investment in competitive energy resources), and the existence or not of cross-subsidies in prices (providing protection of one energy producer against another producing a different energy product, like, for example, oil derivatives against coal, electricity against natural gas).

Among the political issues, it is not easy to deal with a history of border conflicts between countries, which have even caused wars. The old concept of energy as a "national security" resource is still present in many nations, mainly among the military hierarchy, with a deep fear of energy dependence. These fears are being overcome through the signing of bilateral and multilateral agreements, supported by a return of democracy and political stability to the region. The globalization of the markets in what some call the "diplomacy of economics" is also supporting a change of the political atmosphere. International energy consortiums with complementary partners that support each other across political boundaries are developing everywhere and furthering the cause of energy integration.

Among the regulatory issues that arise in the integration process, concern arises on how differently each country has structured its energy markets (mainly gas and electricity), allowing or not vertical integration. Although most countries have chosen similar paths for restructuring the energy industry, introducing competition where feasible, questions remain on the treatment of the monopolistic activities. Should the international transportation service (gas or electricity) develop through exclusive concessions? Should transportation open access be imposed? Should public service duties be imposed? Should prices be regulated? Should there be a price differentiation? These are just a sample of the questions faced.
### Table 9. Gas and electric projects

<table>
<thead>
<tr>
<th>Project</th>
<th>GasAtacama</th>
<th>Norgas</th>
<th>ElectroAndes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main shareholders</td>
<td>Endesa (Chile), GMS (USA)</td>
<td>Electroandina (owned by Tractebel from Belgium, Iberdrola from Spain, and Enagas from Chile), Edelnor (Chile), Techint (Argentina)</td>
<td>Norgener (owned by Chilgener from Chile)</td>
</tr>
<tr>
<td>Main project characteristics</td>
<td>926 km gas pipeline from Jujuy, Argentina to Mejillones, Chile, 8 million cubic meters daily. Three natural gas combined cycle plants in Chile with total capacity 720 MW</td>
<td>880 km gas pipeline from Salta, Argentina, to Tocopilla, Chile, 7 million cubic meters daily. Three natural gas combined cycle plants in Chile with total capacity 690 MW</td>
<td>Generate electricity with three natural gas combined cycle plants in Salta, Argentina, transmit 625 MW through 408 km 220 kV transmission line to northern interconnected Chilean system</td>
</tr>
<tr>
<td>Projected investment</td>
<td>400 million dollars for pipeline, 100 million for secondary pipelines, 308 million for generating plants</td>
<td>330 million dollars for pipeline, 300 million for generating plants</td>
<td>160 million dollars for transmission line, 300 million for generating plants</td>
</tr>
</tbody>
</table>

### Interaction Between Markets

Interesting developments are taking place in the energy exchanges between Argentina and Chile, illustrating the different issues involved as well as how competition can link both the gas and electricity businesses. Two examples make the point.

From 1994 to 1996 a “war” developed between two natural gas pipeline projects that were to transport natural gas from southern Argentina to central Chile. It was locally known as “the war of the gasducts.” The main actors were two Chilean privately owned generating companies, Chilgener and Endesa. Chilgener developed the GasAndes project with NovaCorp, the Chilean Gasco and others, for a 465 km pipeline crossing the Andes directly to Santiago, with $1 billion to be spent in transport and distribution. Endesa developed the Gasoducto Transandino project with Tenneco, British Gas, the Argentinean YPF and others, for a 810 km pipeline crossing the Andes directly from the gas fields in southern Argentina. The pipeline would then travel from southern Chile to Santiago, with $1.7 billion to be spent in transport and distribution. Wide and bitter discussions developed, state intervention was requested, the house of representatives resolved to favor the Endesa alternative. It was always clear that both projects would provide overcapacity; therefore both were not economically feasible. It did not help that there was no available regulation for gas exchanges between countries. Finally, agreements were signed between Argentina and Chile, lifting all limitations for exchanges, in practical terms governments stayed aside the competition, favoring market decisions. At the end, only the GasAndes project was built, and it will be bringing natural gas to Santiago on August 1997. It ensured contracts with several new combined cycle gas turbine generating plants, the first one starting operation at the end of 1997.

Soon after, a new war started, “the gasduct-electric war.” The same actors were involved, but new ones arrived. The matter at hand: northern Chile flourishing with mining developments that are thirsty of electric energy, demand growing at a pace of 12 to 15 percent a year. Opportunities arise with abundant natural gas in northern Argentina. Two projects are formulated initially, the first one by ElectroAndes, lead by Chilgener, to provide an international electric transmission line and a second one by GasAtacama, lead by Endesa, to provide an international gas pipeline. Again, both are not economically feasible given the overcapacity they would provide. A third project is formulated later, Norgas, lead by Electroandina and Edelnor, also to provide a gas pipeline between the two countries, increasing uncertainty in the energy sector. The main characteristics of the three projects, all projecting a start of operations by mid 1999, are summarized in Table 9. Bidding stages are taking place, success of each project dependent on contracts with major generators and large consumers. Again, governments are challenged as there is no available regulation for electricity exchanges between Argentina and Chile.

These examples demonstrate that gas and electricity markets are increasingly interacting within countries and through international boundaries. Competition is the rule, and the final consumer the beneficiary of price reductions and more reliable energy supply.

### About the Panelist

Hugh Rudnick was born in Santiago, Chile, and graduated as a civil electrical engineer from University of Chile, later obtaining his MS and PhD from Victoria University of Manchester, UK. He is a professor of electrical engineering at the Catholic University of Chile. His research activities focus on the economic operation, planning, and regulation of power systems. He has been a consultant with utilities and regulators in Argentina, Bolivia, Chile, Colombia, Peru, and Venezuela, and he has written and lectured at length on South American deregulation. He is a Senior Member of the IEEE. His E-mail is h.rudnick@ieee.org.

### Transport of Gas or Electricity Transmission?

**A. Clerici, A. Longhi**

Today's world energy market is characterized by two main factors:

- Growth in the per-capita primary energy consumption, mainly in some developing countries (peaks up to around 10 percent per year)
- Ever-increasing electricity penetration rate: today 37 percent of the total primary energy resources are converted into electricity compared to 27 percent of 1973.

The need for energy transport systems suitable to satisfy the requirements of the market has to overcome the problems related to energy resources very concentrated in restricted areas (e.g., fossil fuels).

With respect to fossil fuels, land transport of oil and gas over long distances is a consolidated reality, with length limits imposed mainly by economics but also by social and political situations of the countries being crossed.

In the electric field, due to the development and to the continuous cost curtailment of high voltage ac/dc converter stations,
dc is improving its attractiveness for very long transmission systems involving large amounts of power.

The recent discovery of some huge natural gas reserves in areas far from main consumption centers, combined with the previously mentioned considerations, has generated the following questions:

- When natural gas is needed only for electricity generation, is the gas duct the most economic energy transport system?
- Is it economically reasonable compared with a system made up of generation plant near the gas field and a dc transmission system to the end user?

In order to avoid misunderstandings, the presentation is not considering a possible turf court substitution of gas ducts by means of electric lines: gas ducts are clearly the basic solution for multipurpose gas utilization (electricity generation, industrial and domestic uses, petrochemicals, etc.), particularly when very large gas flow rates are involved. What is considered is when a need for an increased availability of electricity arises in a country where the demand of natural gas for non electric purpose is already satisfied. In this case, being that electricity is the Kind of energy needed by the end user, it is of interest to make an economic comparison between gas transport (gas duct + electricity generation close to the user) and electricity transmission (electricity generation close to the gas field + electricity transmission to the user).

The presentation considers land transport without sea-crossing and with optimization of the transport systems aiming to minimize the final cost of electricity. The electricity transmission system was limited to the today’s commercial available values of the ac/dc converter stations (600 kV), even if higher values could lead to lower costs of delivered electricity.

The compared energy transport systems are the following:
- Gas transport: gas duct (single pipe + compression stations) + combined cycle generation plant
- Electric energy transport: combined cycle generation plant + ac/dc conversion station + dc overhead bipolar line (single for power up to 5,000 MW, double for larger powers) + dc/ac conversion station

The economic analyses refer to power values from 1,000 to 10,000 MW and distances from 1,000 to 5,000 km. Being the investments related to the type of route/logistics and to the availability/cost of local resources, for both gas pipelines and overhead transmission lines, the comparison considers two different situations: condition similar to those of western European countries (medium/high cost areas) and conditions similar to those of desert areas of northern Africa and the Middle East (low cost areas). For the gas price at the field, values in the range of 2 c$/m^3$ to 6 c$/m^3$ are taken into account. In first approximation, the costs of unavailability of delivered energy are not taken into account.

Electricity transmission, even showing a lower global energy efficiency, results more convenient for longer lengths, lower power values, higher cost areas for lines and gas ducts, low gas price at field and should therefore be more deeply analyzed to create a possible additional market for the exploitation of remote/cheap gas resources.

**Conclusions**

The main conclusions are that for power values from 2,000 to 8,000 MW and for distances from 3,000 to 5,000 km, the global cost of kWh at the receiving end with electricity transmission is in the range between 2-4 c$/kWh$, when considering gas price at field from 2 to 6 c$/m^3$ and construction condition both in low cost areas and in medium/high cost areas.

The gas transmission for the same lengths/powers gives over-cost in the range from 5 percent (8,000 MW, 3,000 km, gas cost 2 c$/m^3$) to 70 percent (2,000 MW, 5,000 km, gas cost 2 c$/m^3$).

**About the Panelist**

Alessandro Clerici is executive vice-president of Business and Technology at Asea Brown Boveri SpA, Milano, Italy. He was with CESI from 1961 to 1980, where he worked extensively on power system planning studies. As senior engineer and later as manager of the network analysis department, he provided consulting services in both Italy and to more than 30 countries abroad in the area of generation, transmission, and distribution systems. He became technical commercial director in 1978. From 1980 to 1988 he was general manager for Technology and Business Development of the SADE-SEDELM Group, a contracting company of GE, U.S.A. From 1989 to 1991, he was the technology manager of the new company (SAE SEDELM) resulting from the merging in ABB of the SAE Group with the SADE SEDELM Group. From 1991 to 1995, he was managing director of ABB Sistemi Transmissione Energia, the Italian subsidiary of ABB Power Systems. Since June 1995, he has been executive vice-president for Business and Technology Development, ABB, Italy; and president of ABB Corporate Research Center, Italy. He has wide international experience and has served on a number of committees and working groups of IEEE, CIGRE, and other international and national organizations. He has authored or coauthored more than 90 papers in the energy field. He is a Fellow of the IEEE.