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The Potential of Regional Power Sector Integration

Argentina-Brazil | Transmission & Trading Case Study

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Economic Consulting Associates

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Contents

Tables and Figures

Tables

Figures

Abbreviations and acronyms

ABB GroupFormerly Asea Brown Boveri

AC	Alternating Current
ADI	Area of Direct Influence
AII	Area of Indirect Influence
ANEEL	Agencia Nacional de Energia Elétrica (National Agency for Electricity, Brazil)
CAMMESA	Compañía Administradora del Mercado Mayorista Eléctrico (Wholesale Electricity Market Administration Company, Argentina)
CCC	Capacitor Commutated Converters
CEPEL	Centro de Pesquisas de Energia Elétrica (Electricity Energy Research Center)
CIEN	Companhia de Interconexão Energética
COPEL	Companhia Paranaense de Energia
COSERN	Companhia Energetica do Rio Grande de Norte
CTEE	Comitê Técnico de Estudos Energéticos (Technical Committee of Energy Studies)
CTM	Compañia de Transmissión del MERCOSUR
EIA	Environmental impact assessment
GCPS	Grupo Coordenador de Planejamento dos Sistemas Elétricos (Electricity Systems Planning Group)
GW	Gigawatt
HVDC	High-Voltage Direct Current
Hz	Hertz
IAA	Immediately Affected Area
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis
IDB	Inter-American Development Bank
IIRSA	Initiative for the Integration of Regional Infrastructure in South America
IMF	International Monetary Fund

ISO	Independent System Operator
ITP	Independent Transmission Project
MAE	Wholesale Energy Market
MEM	Wholesale Electricity Market Agents, Argentina (Agentes del Mercado Eléctrico)
MERCOSUR	Mercado Común del Sur (regional trade agreement)
MIGA	Multilateral Investment Guarantee Agency
MME	Ministry of Mines and Energy
MW	Megawatts
OC	Ordinary Capital
ONS	Operador Nacional do Sistema Elétrico
ROW	Right of Way
RTA	Regional Trade Agreement
SADI	Sistema Argentino de Interconexión (Argentine Interconnected System)
TESA	Transportadora de Energia
TL	Transmission Line
TWh	Terawatt hour
UCTE	National Electric Power Generation and Transmission Administration, Uruguay

Preface

This case study is part of an Energy Sector Management Assistance Program (ESMAP) project on Regional Power System Integration (RPSI). The objective of the project is to facilitate and accelerate RPSI projects in developing countries around the world. The project will draw on international experience and theoretical analysis in this area to provide a framework to assess:

- the economic, financial and environmental benefits that can accrue to regional power trading;
- the institutional and regulatory arrangements needed to sustain and optimize regional projects; and
- the ways in which obstacles to integration have been successfully overcome.

The final output of the project will be an umbrella report, *Regional Power Sector Integration – Lessons from Global Case Studies and a Literature Review*. This review will summarize the 12 case studies and literature review undertaken and analyze common themes on barriers to RPSI and solutions to overcome them.

Economic Consulting Associates was contracted to execute the project. In doing so, we are working closely with ESMAP and World Bank staff, as well as government officials, utility, power pool, and regional economic community personnel, and others directly involved in implementing regional power schemes.

This and other 11 Case Studies are prepared as clear, factual presentations of the selected projects. The intent is to provide a direct, easily digestible description of each of the selected projects without imposing an analytic framework or making judgments about the degree of success. Such analysis will be undertaken at the global level, considering the entirety of experiences from the Case Studies, in the aforementioned umbrella report.

All 12 Case Studies follow a uniform structure to facilitate ease of comparison and reference from one Study to the next. Some sections are longer than others, depending on the specifics of the Study. Additionally, there is some cross-referencing within each Study.

1 Executive summary

1.1 Motivations/objectives for trade

The main focus of this case study is the Garabi interconnector between Argentina and Brazil, commissioned in the year 2000. The Garabi project was planned during the 1990s, when most of the Southern Cone countries were liberalizing their economies, reforming their electricity sectors and moving toward promotion of energy exchanges driven by market rules. The international economic crisis which started at the end of the decade precipitated a political and institutional crisis in Argentina in 2002, resulting subsequently in a sharp reversal of approach in economic and energy policies. The abrogation of Argentina's electricity and gas export commitments in 2004 has meant that the usage of the Garabi interconnector has been very different from what had earlier been planned.

The rationale for creating an energy trading scheme with an interconnector at Garabi was the imminence of power shortages in Brazil. These shortages were due to excessive reliance on hydropower generation and low hydrological flows at the time brought about by drought conditions. The Garabi project was designed around a contract for firm capacity imports of 1,000 MW by Brazil from Argentina, without committed amounts of related energy. The infrastructure also makes possible nonfirm energy trade, in particular the advantageous possibility for Argentina of substituting imported hydropower for gas-fired electricity during the winter months when demand for gas in Argentina is high. This is the same season when water availability is high in Brazil. During the remainder of the year when hydro supplies are more problematic, Brazil could import gas-fired power from Argentina.

At the time that Garabi was planned, Argentina deliberately restricted the import capacity of the line, fearing that imports of cheap non-firm hydropower would undermine the viability of generation plants in the Argentine market. In fact, Argentina quickly turned from a gas and electricity surplus country to one seeking imports. Over the life of the project thus far, power flows through Garabi have thus been predominantly from Brazil to Argentina rather than the other way around as had originally been planned.

1.2 The trade solution put in place

In order for the two countries to exploit their electricity trade potential, it was necessary not only to build a transmission interconnector linked to the national grids of the two countries, but also to build a frequency converter station. Brazil's electricity system operates at 60 Hz, while Argentina and other neighboring countries operate at 50 Hz.

The Garabi project resulted in the construction of two sets of parallel 500 kV AC transmission lines running a length of 490 km (355 km in Brazil) between the substations of Rincón de Santa Maria (RSM) in Argentina and Itá in Brazil. In addition, the project constructed two 1,100 MW high-voltage direct current (HVDC) back-to-back capacitor-commutated converter stations located at Garabi in Brazil, close to the Argentine border.

The construction contract for the project also included the expansion of the RSM and Itá substations.

The Garabi project is one of very few privately owned regional interconnector schemes in the world. It was developed by Endesa, which registered a special-purpose company in Brazil called Companhia de Interconexão Energética (CIEN) to execute the project and operate the resulting infrastructure. The project was designed and financed around a 20-year contract made between the Brazilian Ministry of Mines and Energy, the Argentine government, and CIEN for Brazil to import 1,000 MW of firm capacity from Argentina. Another 1,000 MW was available for private power purchase contracts with Brazilian distribution companies.

1.3 Current status and future plans

Imports from Argentina via Garabi in the first few years after it was commissioned helped to offset a drought-induced energy shortfall in Brazil. Thereafter, however, Argentina's decision to suppress market-driven energy prices and its reversion to direct control over many aspects of the economy (including the energy sector) quickly led to a situation where energy was in short supply. Far from fulfilling the earlier regional role which had been envisaged of being a major exporter of gas and of electricity produced from gas, Argentina became a country of energy deficits. As a result, the power flows through the Garabi have predominantly been from Brazil to Argentina, and not in the reverse direction as had originally been planned. Power has also been routed from Brazil (operating at 60 Hz) to Uruguay (operating at 50 Hz) via Garabi's high-capacity frequency conversion and Argentinean transmission system.

Future developments might include the proposed joint 2,800 MW hydropower project at Garabi. This would be a welcome addition to generation capacity in both Argentina and Brazil, but its development is constrained by environmental and social considerations and by the effects of the undermined confidence in regional schemes resulting from Argentina's defaulting on electricity and gas export commitments.

Within the Southern Cone region, the approach being taken at present in the electricity sector does not have a regional integration orientation consisting of multiple countries but instead is characterized by a series of bilateral generation and transmission projects. For the longer term, hopes have been expressed that the bilateral projects existing between Argentina, Brazil, Uruguay and Paraguay will eventually evolve to a stage where there will be the political will for a MERCOSUR regional energy market to be established.

2 Context for trade

2.1 Economic and political context

Economic and political context – general

Both Argentina and Brazil are classified as upper middle income economies. In the early 1990s, the two countries were major trading partners and founding members with Uruguay and Paraguay of the regional trade agreement Mercado Común do Sul (MERCOSUR). As is briefly outlined in the discussion that follows, major changes took place between the 1990s and the first decade of the new millennium in Argentina, while the other countries were more consistent in their economic and electricity sector policies.

Argentina initiated several market reforms during the 1980s and 1990s, including the deregulation of its labor and import/export markets. Argentina was badly but briefly affected by the Mexican Crisis of 1993/1994, which resulted in capital flight from the region. By 2001, Argentina had acquired a large public debt and, despite guarantees from the International Monetary Fund (IMF), capital flight increased. The government was unable to make debt payments. A decision to freeze bank accounts in order to avoid a further drain and a devaluation of the currency provoked public protests in the country. In 2002 the peso, which had been kept at a constant rate of 1 per US dollar since 1992 as set in the Convertibility Law, suffered an abrupt 70% devaluation when that law was repealed on January 1.

The government which took power in Argentina in 2003 had to reverse the decline in GDP and reduce the level of unemployment, which was reaching 25%. To avoid the problems which had occurred a decade earlier when foreign debt repayments had constrained domestic development, the government restructured Argentina's defaulted debt with a significant (66%) discount. The economic liberalization which had taken place in the 1990s was reversed, with some previously privatized industries being re-nationalized and contracts with private utilities being unilaterally changed by the Government. Trade restrictions were imposed, including on the energy sector (this is discussed further in the next subsection).

In **Brazil,** a long period of military rule ended when the military lost power in 1986 and democracy was reestablished with the passing of the new Federal Constitution in 1988. The pressing economic concern at that time was the very high levels of inflation the country was experiencing. A number of different programs were introduced to combat inflation (including the Cruzado Plan in 1986 and the Collor Plan in 1990), but these proved to be short-lived in their effects, and inflation continued at levels in excess of 1,000% per annum. Finally in 1994 the Plano Real had the credibility that was needed. It was implemented with complete consistency and succeeded in rapidly reducing the inflation rate and stabilizing the exchange rate. Plano Real's macroeconomic measures were supplemented by market reforms which encouraged competition and the privatization of public assets. The second half of the 1990s was characterized by sustained economic growth and political stability in Brazil. A large devaluation of the national currency (the "real") on January 13, 1999, interrupted the favorable economic cycle, but without creating significant political instability.

The economy of **Uruguay**, Brazil and Argentina's common neighbor, is closely connected to that of Brazil and Argentina. Uruguay is the second-smallest country in South America and relies heavily on trade, especially with Argentina and Brazil, which together account for almost 50% of Uruguay's exports. Embracing a free market economy throughout the 1990s, Uruguay was adversely affected by the economic slowdown of its neighbors during the years 2001 – 2002. Uruguay is one of the most politically and institutionally stable countries in South America, with a relatively high degree of economic freedom. Although Uruguay is not directly involved in the Garabi scheme, in recent years it has been importing power from Brazil via Argentina. This is discussed further in Section 3.1.

Table 1 summarizes some important economic and electricity indicators of Argentina, Brazil, and Uruguay as of 2007.

Table 1 Indicators for Argentina, Brazil and Uruguay (2007)

	Argentina	Brazil	Uruguay
Population (millions)	40	192	3
Surface area (km^2)	2,780,400	8,514,880	176,220
GDP (US$ billions)	262	1,313	23
GNI per capita (PPP)	12,970	9,270	11,020
GDP growth %	9	5	7
Inflation (GDP deflator annual %)	14	4	9
Exports (% of GDP) [a]	25	14	29
Life expectancy at birth (years)	75	72	76
Electrification rate (%)	95	97	95
Electricity consumption per capita (KWh)	2,714	2,340	2,408
Mortality rate under 5 years (per 1,000)	16	22	14

Sources: World Development Indicators (World Bank) and Human Development Report (UNDP) 2007 data

Energy sector reforms

Over the period 1980 to 2000, South America pioneered developing country reform of the power sector and the creation of competitive electricity markets. The process started in Chile, which in 1982 introduced an electricity sector framework where competition in generation and open access to transmission were key elements. Argentina incorporated similar reforms in a new electricity law which came into force in 1992, followed shortly thereafter by similar moves in Peru, Colombia, and Bolivia. Brazil and Venezuela took longer to follow this model, only making initial regulatory changes in 1997.

Similar reforms were made in the natural gas market, this being important for the electricity sector because of the increasing role of gas-fired thermal generation in the regional

generation mix. The momentum for reforms grew because early privatizations of state-owned utilities appeared successful, and there was rapid growth in new private-sector electricity investment projects.

The energy reforms were driven more by a need to maintain the momentum of economic growth while easing the pressure on government resources, than by any strong ideological commitment to a private-sector approach. Private investment in electricity took place not just in generation and distribution, but also in transmission, including three private regional interconnector projects: Argentina-Chile, Bolivia-Brazil, and Argentina-Brazil (Garabi). There were also large regional gas pipeline projects undertaken by both private and state-owned companies.

In the late 1990s and into 2001, Brazil was facing a serious electricity supply crisis due to low rainfall that was reducing water availability in reservoirs and thus hydro potential. In 2001 rainfall was less than 75% of expected levels. An energy rationing system had to be imposed. The situation in Brazil highlighted the internal shortcomings of the energy market in which the government at that stage still owned about 75% of generating assets, but had not adequately invested in the sector. In particular, the construction of thermal plants, necessary for diversifying away from heavy dependence on hydro generation, had been delayed. An inadequate regulatory framework to promote investments in firm thermal capacity in a system dominated by depreciated hydropower failed to raise investor interest. The result was a scenario in which there was insufficient firm energy to ensure national supply at times of unfavorable hydrological conditions.

Imports from Argentina via Garabi in the first few years after it was commissioned helped to offset the energy shortfall in Brazil. Thereafter, however, Argentina's decision to suppress energy prices and its reversion to direct control over many aspects of the economy quickly led to a situation where energy was in short supply. Far from fulfilling the regional role which had been envisaged earlier of being a major exporter of gas and of electricity produced from gas, Argentina became an energy deficit country.[1] The government first restricted gas exports to both Chile and Brazil and later (in 2004) introduced a regulation that forbade the export of electricity generated in Argentina with Argentine gas.

2.2 Supply options

Both Argentina and Brazil have large hydropower and gas resources to draw on for electricity generation. Hydropower potential is 44 GW in Argentina and 144 GW in Brazil, with approximately one quarter and one half, respectively, being already developed. Natural gas reserves are 25.8 TCF in Argentina and 22.8 TCF (52 TCF including new fields) in Brazil. Other energy resources include petroleum and uranium.

The present total installed capacity is around 28 GW in Argentina and 97 GW in Brazil (see Table 2). Argentina is heavily dependent on thermal power plants (61% of capacity), while in Brazil hydropower is dominant (76%) in the generation mix (see Table 3). Differences in

[1] From being an exporter of gas at around US$ 2 per m BTU, in six years Argentina became an importer, paying US$18 per m BTU.

generation mix, combined with the shapes of their seasonal load profiles, constitute the basis for bilateral electricity trade.

Table 2 Installed Capacity (GW)

Year	Argentina	Brazil	Uruguay
2000	23.5	68.2	2.1
2001	26.0	73.7	2.1
2002	27.5	76.2	2.2
2003	27.8	82.5	2.2
2004	28.5	86.5	2.2
2005	28.3	90.7	2.2
2006	28.3	93.1	2.0
2007	28.3	96.6	2.3

Table 3 Capacity by Fuel Source

Fuel	Argentina	Brazil	Uruguay
Nuclear	4%	2%	-
Hydro	35%	76%	69%
Non-hydro renewables	-	7%	-
Thermal	61%	15%	31%
Total	100%	100%	100%

With peak load of 62 MW in 2006, Brazil has a comfortable reserve margin in terms of installed capacity and significant storage capacity in several multi-year reservoirs. However, particularly in a system dominated by hydropower, security of supply has to be assessed in relation to ***firm energy***. For hydro generation, firm energy is calculated as the continuous production which would be possible under the worst hydrological conditions so far recorded. Similarly, firm energy for a gas generator is assessed in relation to continuity of supply of gas. In Brazil, electricity generators irrespective of fuel type are issued with a firm energy certificate by the Ministry of Energy. On the basis of firm energy, in 2008 and 2009 Brazil has a capacity deficit, in no small measure because a reassessment of capacity after natural gas supply difficulties from Brazil and Bolivia resulted in a downgrading of firm power capacity by 6 GW (a 12% reduction). To address the capacity deficit while also

diversifying away from hydro, since 2000 the Brazilian government has strongly encouraged private investment in gas-fired plants. However, success has been limited, with little additional capacity being installed, and most of this has been by the national oil company Petrobras.

In both Argentina and Brazil, shared regional hydropower projects are an important component of existing supplies:

- **Argentina** has two regional hydro schemes. One of them is co-owned with Uruguay (Salto Grande, 1,890 MW installed capacity), and the other is with Paraguay (Yacyreta, 3,500 MW of installed capacity). Both plants are jointly owned, and rights to installed capacity and energy generated are equally shared between Argentina and the other involved country. In the case of Yacyreta, almost all of Paraguay's share is sold to Argentina.

- **Brazil** and Paraguay are the joint owners of the Itaipu hydropower plant, the largest in the world until the Three Gorges plant in China is fully commissioned. This 14 GW project provides almost 20% of electricity consumed in Brazil.

Table 4 gives data for net imports. This shows that Argentina and Brazil have significant net imports, much of this being supplied by Paraguay, which has significant net exports (of the order of 45,000 GWh per annum). Uruguay moves between being a net importer and net exporter.

Table 4 Net Imports

Year	Argentina	Brazil	Paraguay	Uruguay
2000				
Imports (GWh)	7,245	43,000	_	1,328
Exports (GWh)	6,022	4	47,358	942
Net imports (GWh)	1,223	42,996	-47,358	386
Net imports % electricity consumption	1.7%	13.4%		6.0%
2001				
Imports (GWh)	7,420	37,860	_	335
Exports (GWh)	5,661	6	39,137	1,377
Net imports (GWh)	1,759	37,854	-39,137	-1,042
Net imports % electricity consumption	2.3%	12.5%		-15.7%
2002				

Year		Argentina	Brazil	Paraguay	Uruguay
	Imports (GWh)	8,700	36,570	_	529
	Exports (GWh)	2,856	10	41,777	2,288
	Net imports (GWh)	5,844	36,560	-41,777	-1,759
	Net imports % electricity consumption	8.1%	11.5%		-28.6%
		2003			
	Imports (GWh)	7,578	38,200	_	434
	Exports (GWh)	2,543	6	45,180	1,139
	Net imports (GWh)	5,035	38,194	-45,180	-705
	Net imports % electricity consumption	6.4%	11.4%		-11.7%
		2004			
	Imports (GWh)	7,612	37,392	-	2,348
	Exports (GWh)	4,143	7	45,005	100
	Net imports (GWh)	3,469	37,385	-45,005	2,248
	Net imports % electricity consumption	4.1%	10.6%		36.1%
		2005			
	Imports (GWh)	8,017	39,202	2	1,585
	Exports (GWh)	4,140	160	43,784	841
	Net imports (GWh)	3,877	39,042	-43,782	744
	Net imports % electricity consumption	4.4%	10.6%		11.4%
		2006			
	Imports (GWh)	7,417	41,447	1	2,835
	Exports (GWh)	4,059	283	45,654	16
	Net imports (GWh)	3,358	41,164	-45,653	2,819
	Net imports % electricity consumption	3.4%	10.8%		43.9%

Year	Argentina	Brazil	Paraguay	Uruguay
	2007			
Imports (GWh)	10,275	40,466	-	788
Exports (GWh)	2,628	2,034	45,133	995
Net imports (GWh)	7,646	38,432	-45,113	-207

Source: Environmental Impact Assessment,

2.3 Demand

Electricity demand in **Argentina** has increased since the 1990s at a rate of about 6% to 8% yearly with the exception of the crisis years 2001 and 2002, when growth rates were lower and demand actually fell between 2001 and 2002. In 2005, residential consumption accounted for 29% of the total, while industrial and commercial and public represented 43% and 26%, respectively.

The demand in **Brazil** has been increasing at the rate of about 5% per annum since 1980. The World Energy Outlook 2008 estimates the electricity demand growth rate in Brazil will be lower than this in the future, estimating average growth rates of 2.8% per annum for the years 2006–2015 and 2.3% for 2006–2030. The state-owned planning agency EPE estimates an average electricity growth of 4% per annum for the period 2009–2017. As of 2006, consumption was divided between residential (34%), industrial (25%), commercial (22%), public sector (13%), and rural (6%).

Table 5 shows energy consumption for Argentina, Brazil, and Uruguay since the year 2000.

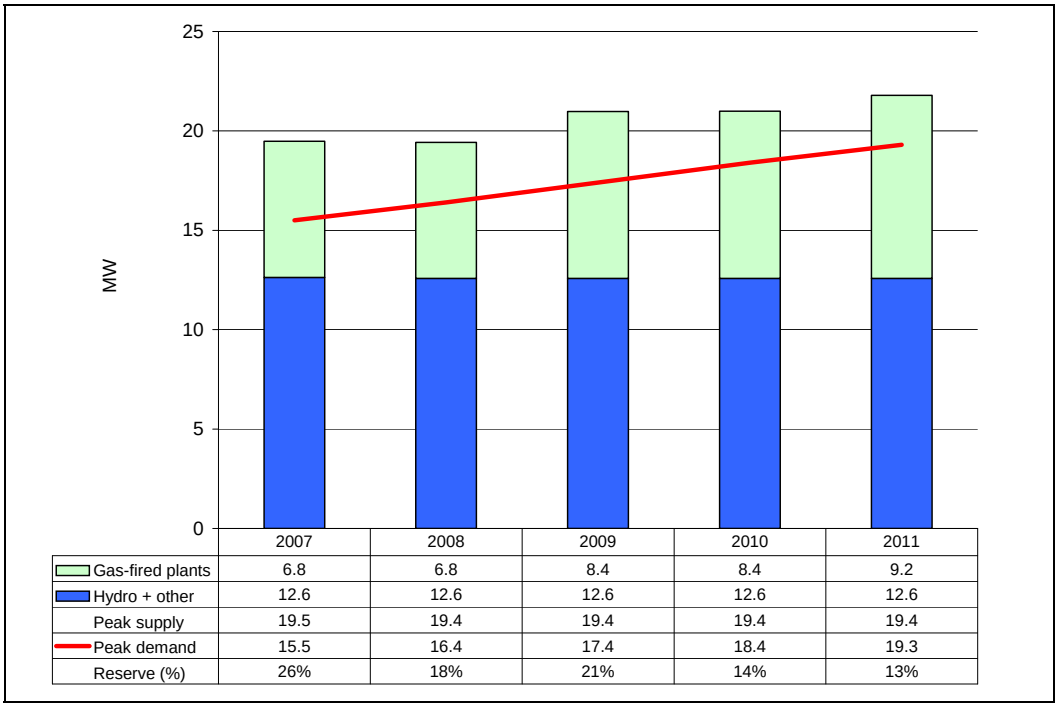
Table 5 Electricity Consumption (GWh)

Year	Argentina	Brazil	Uruguay
2000	73,302	321,467	6,468
2001	75,408	303,892	6,637
2002	72,488	318,235	6,142
2003	79,157	335,997	6,028
2004	83,724	352,433	6,224
2005	88,244	367,928	6,542
2006	97,719	382,358	6,424

Figures 1 and 2 illustrate the demand-supply balance in Argentina and Brazil, respectively:

- in **Argentina**, reserve margins are declining, particularly during the winter months;
- **Brazil** is in deficit in terms of firm energy, due to its reliance on hydropower generation and inadequate investment in thermal capacity.

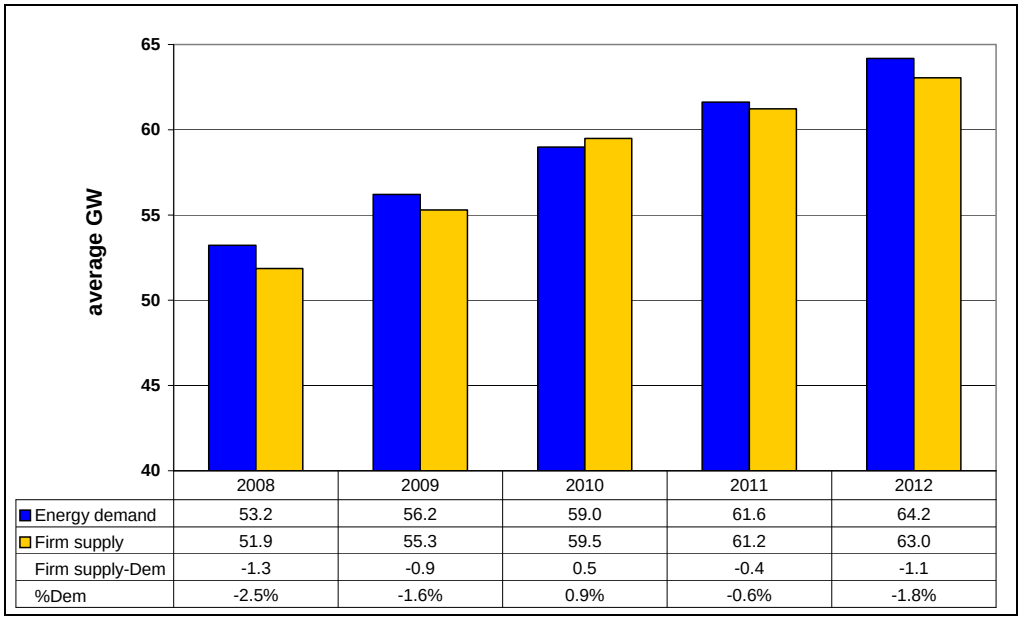
Figure 1 Electricity Supply and Demand Balance in Argentina



	2007	2008	2009	2010	2011
Gas-fired plants	6.8	6.8	8.4	8.4	9.2
Hydro + other	12.6	12.6	12.6	12.6	12.6
Peak supply	19.5	19.4	19.4	19.4	19.4
Peak demand	15.5	16.4	17.4	18.4	19.3
Reserve (%)	26%	18%	21%	14%	13%

Source: Pereira(2008)

Figure 2 Firm Energy and Average Load in Brazil (2008-2011)



	2008	2009	2010	2011	2012
Energy demand	53.2	56.2	59.0	61.6	64.2
Firm supply	51.9	55.3	59.5	61.2	63.0
Firm supply-Dem	-1.3	-0.9	0.5	-0.4	-1.1
%Dem	-2.5%	-1.6%	0.9%	-0.6%	-1.8%

Source: Pereira (2008)

2.4 Energy tariffs

In **Argentina**, in response to the 2001 economic crisis, electricity tariffs were frozen in domestic currency in January 2002 under the Public Emergency and Exchange Regime Law. At the same time, the local currency was devalued 70%. This represented a unilateral change in the concession contracts of transmission and distribution companies, which had to contend with rapidly rising costs and large foreign debt repayments while their revenues remained static. This situation resulted in suppression of investments financed by sector agents, sales of foreign-owned electricity companies to local investors, and growing supply-demand imbalances due to gross underinvestment in the sector while electricity demand was rising rapidly (9–10% per annum) as the economy recovered and tariffs remained low. This contributed to the 2003–2004 energy crisis and the persistent energy deficits to which the economy has been subjected ever since.

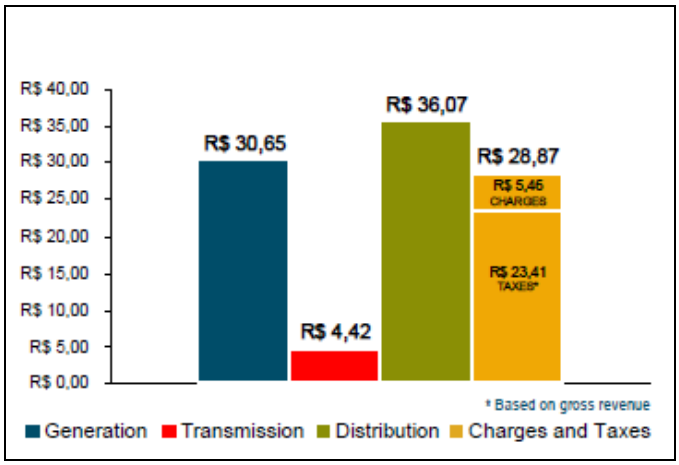
Over time, industrial and commercial electricity tariffs were allowed to rise, but residential tariffs remained frozen for seven years. During 2008, larger increases in tariffs were allowed, and in the areas outside of Buenos Aires and La Plata, where provincial authorities have some jurisdiction over electricity tariffs, even residential customers began to face increases in electricity prices. In August 2008, electricity tariffs in the Buenos Aires metropolitan area were also increased significantly. But at the end of the year, electricity tariffs in Argentina were still below the long-run marginal cost levels, said to be around 11 US c/kWh. Further tariff revisions were implemented in 2009 but had to be reversed due to the threat of social unrest.

In **Brazil,** tariffs were uniform throughout the country until 1993, but in recent years (2003–2005), company-specific tariffs derived from performance-based regulation have been

instituted. Wholesale energy is sold by public auction and is purchased by distributors, which sign bilateral power purchase agreements (PPAs) with existing and new generators. Official results of mid-2009 auctions for new energy were 99 R$/MWh (hydro) and 140 to 146 R$/MWh (thermal), while an auction for a special hydro project (exceptionally low cost) came out at around 70 R$/MWh. As of mid 2009, the composite overall wholesale price for new energy was around 130 R$/MWh, equivalent to about 6.5 USc/kWh.

For final consumers, market size, cost of energy purchased, and state taxes play roles in the price paid. Figure 3 gives an example of the components of the residential tariff for one concession area, COSERN, in Brazil assuming the customer has an electricity bill of R$100 (US$52) per month. Residential tariffs in different regions of Brazil varied in 2007 from 0.21 R$/kWh (10.9 US c/kWh) to 0.433 R$/kWh (22.5 US c/kWh), with a national average of 0.294 R$/kWh (15.3 USc/kWh). The average tariff for all customers in 2007 was 0.253 R$/kWh (13.2 USc/kWh). [2]

Figure 3 COSERN Residential Tariff Calculation



Source: COSERN

[2] http://www.aneel.gov.br/area.cfm?idArea=507

3 History of scheme

3.1 Overview including timeline/chronology

With the support of the two governments, the Garabi project was planned, promoted. and implemented by private-sector interests led by the Spanish-based electricity company Endesa. In April 1997, the governments of Argentina and Brazil signed an agreement to facilitate cross-border energy trading between the two countries. Brazil called for bids for the delivery of 1,000 MW of firm capacity from Argentina. The tender was won by the Spanish-based international electricity company Endesa and in early 1998, Endesa registered a special-purpose company called Companhia de Interconexão Energética (CIEN) in Brazil. In May 1998, the Brazilian Ministry of Mines and Energy and the Argentine government signed a 20-year contract with CIEN, for Brazil to import 1,000 MW from the wholesale energy market in Argentina. At the time it was estimated that Argentina had nearly 7,000 MW of surplus capacity that could be exported to Brazil if there were appropriate transmission systems in place.

Having completed the feasibility studies and an environmental impact assessment, CIEN contracted ABB to provide a turnkey package for the 500 kV power transmission system and 50 Hz–to-60 Hz converter stations. The time schedule for the first phase allowed for 22 months from the date of signing until commercial operations were to start. The first phase (1,100 MW) was tested on time and completed by June 2000, which was within 25 months of the construction contract signing. The second phase, which added a parallel transmission line and converter station for an additional 1,100 MW of capacity, was completed in 2002.

The project operated as intended in the first few years after commissioning. However, when Argentina, faced with a domestic energy crisis, banned exports of power, CIEN declared a contractual breach and sought other customers to make use of the transmission infrastructure. Recently Uruguay has been importing power from Brazil using Garabi, as the direct link between Uruguay and Brazil does not have sufficient capacity for the level of imports presently required. Garabi is useful for relatively high volume trades which require 50 Hz-to-60 Hz frequency transfers.

Table 6 outlines the progress of the Garabi interconnector project.

Table 6 Chronology of Regional Power Integration for Argentina and Brazil

Year	Event
1997	Argentina and Brazil sign agreement on cross-border trade.
1998	Endesa-CIEN is formed. Argentina and Brazil sign 20-year contract with CIEN to import electricity from Argentina to Brazil.
October 1998	EIA completed.

Year	Event
November 1999	Commissioning begins.
June 2000	Phase I completed, converter station handed over for commercial operation.
2000	Formation of the Initiative for the Integration of Regional Infrastructure in South America (IIRSA)
March 2001	Construction begins on phase II.
2002	Completion of phase II
2004	Argentina passes regulations which have the effect of abrogating Argentina's Garabi agreement commitments.
2006	CIEN declares a contractual breach.

3.2 Project concept, objectives, and development

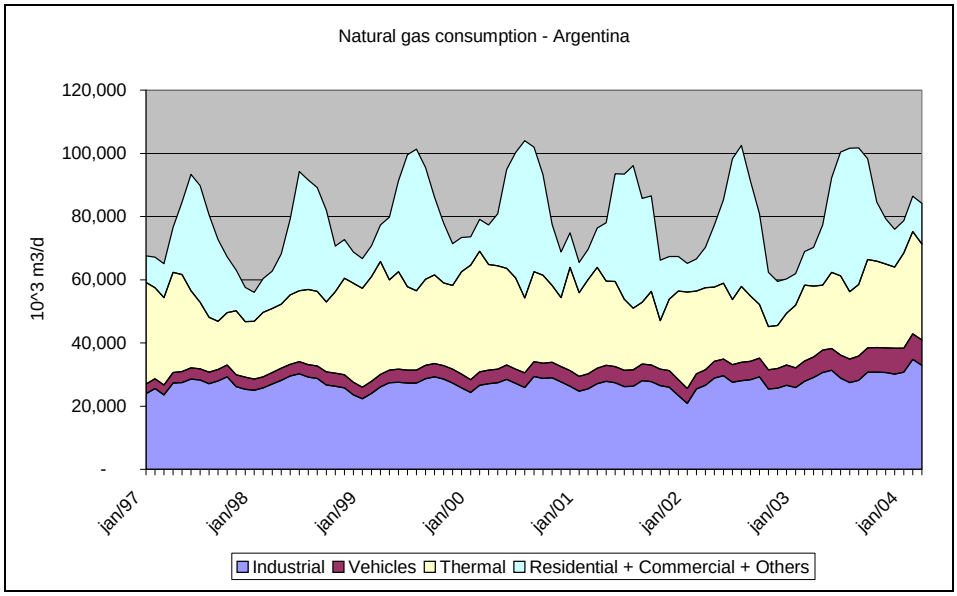
As already mentioned, the energy shortage and vulnerability to drought of Brazil's hydropower-dominated system provided the underlying rationale for the Garabi interconnection to be built. The scheme was designed around the contract for 1,000 MW of firm capacity being supplied from Argentina to Brazil, but the seasonal variation and opposing load profiles of Argentina and Brazil together with different fuel mixes, provides a clear opportunity for seasonal exchanges.

The demand for gas in Argentina shows a high seasonal variability with a peak in the winter months, as can be seen in Figure 4.

The timing of the high hydro season in Brazil coincides with these colder winter months in Argentina, making it possible for Brazil to export hydroelectricity at a time when Argentina would welcome a means to reduce gas demand. If the full capacity of Garabi were to be used, Brazil could export 2,000 MW during the four winter months, thereby displacing about 10 MMm^3/day of gas in Argentina. Brazil in turn would be able to import 1,000 MW during the remaining eight months.

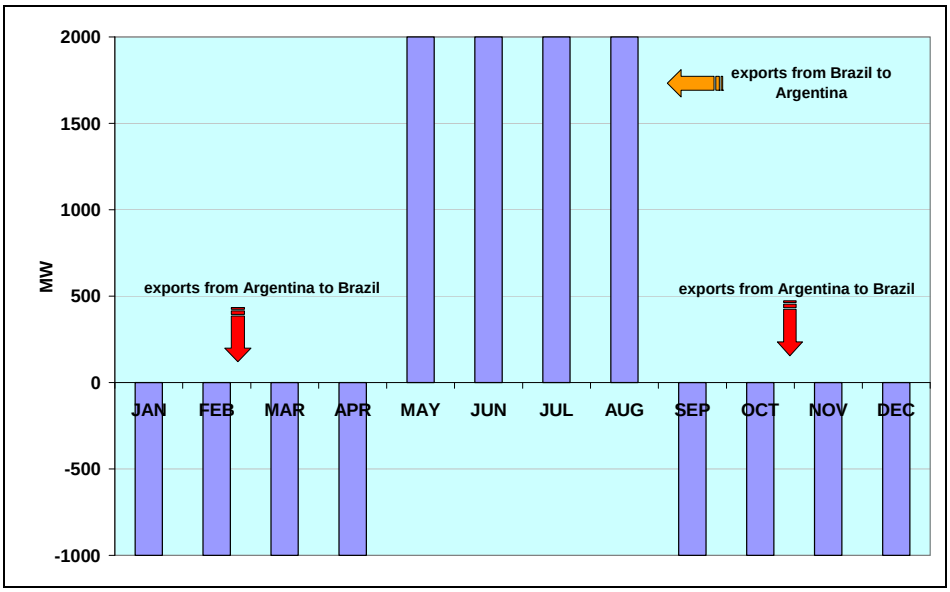
Figure 5 illustrates that possibility.

Figure 4 Natural Gas Consumption



Source: Tavares (2005)

Figure 5 Potential Energy Swap



Source: Tavares (2005)

When Garabi was planned, Argentina had surplus capacity in both gas and electricity and was well positioned to supply the 1,000 MW of firm capacity that Brazil sought to contract. While Brazil needed to secure its firm capacity position, in normal years it would have significant surpluses of non-firm energy which could be exported at a low price. Recognizing this, the Argentine government was reluctant to allow non-firm energy exports

from Brazil into the wholesale Argentine market, and thus imposed a transmission limit for imports from Brazil via the Garabi system of 300 MW.

In the event, the surplus gas and electricity capacity in Argentina was quickly taken up after the crisis in the early years of the new millennium, so the underlying rationale for Garabi was eroded and then formally stopped when Argentina banned exports of domestically produced electricity to its neighbors. Instead, Argentina has sought to import power in order to supplement its inadequate domestic supplies. As a result, the power flows through the Garabi system have predominantly been from Brazil to Argentina, and not in the reverse direction as had originally been planned. Power has also been routed from Brazil via Garabi to Uruguay, taking advantage of the high-capacity 60 Hz-to-50 Hz converter station.

3.3 Feasibility studies done

In addition to the economic feasibility studies and the environment impact assessment, a number of technical studies were completed by ABB together with the Centro de Pesquisas de Energia Elétrica (CEPEL) of Brazil. These include:

- Steady state and fundamental frequency dynamic overvoltage studies
- Transient stability studies
- Transient performance studies
- Electrical performance
- Harmonic considerations

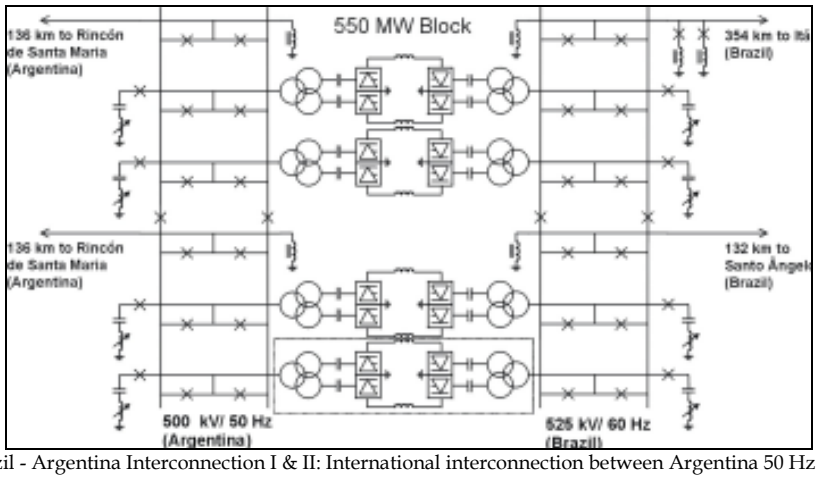
These studies showed compliance with the power purchase documents and national standards even under extreme load flow and voltage swing scenarios.

Similar studies were conducted on the Argentine side, these showing that the export of 1,000 MW from Argentina to Brazil should not impact negatively on the quality of service in Argentina.

3.4 Assets built and planned resulting (directly and indirectly) from scheme itself

The transmission assets from the project are two sets of parallel 500 kV AC transmission lines running a length of 490 km (355 km in Brazil) between the two substations of Rincón de Santa Maria in Argentina and Itá in Brazil. In addition there are two 1,100 MW high-voltage direct current (HVDC) back-to-back capacitor-commutated converter stations at Garabi in Brazil, close to the Argentine border. The construction contract also included the expansion of the RMS and Itá substations. Figure 6 shows a schematic outline of the first phase of the system.

Figure 6 The Garabi System

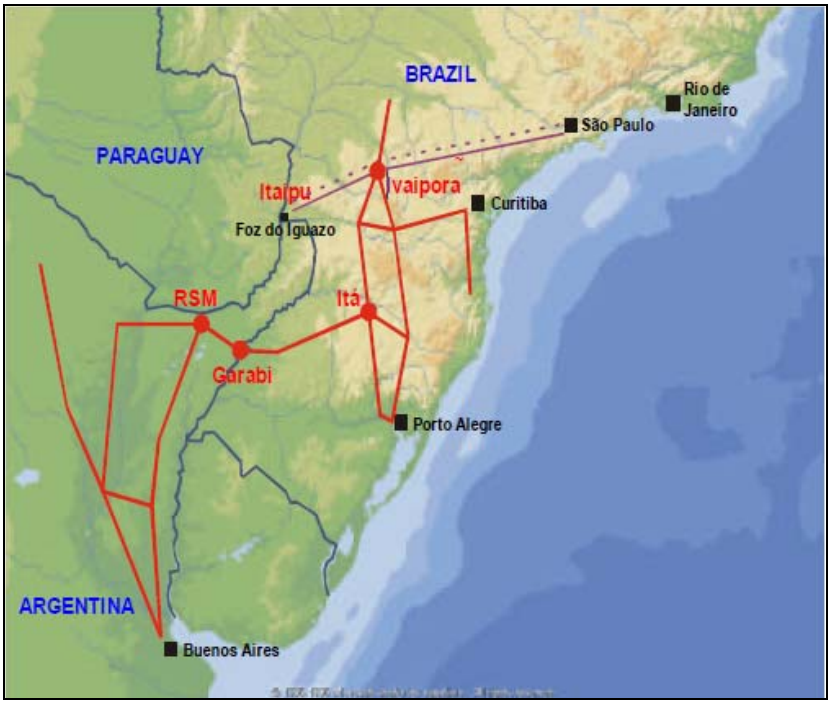


Source: ABB, Brazil - Argentina Interconnection I & II: International interconnection between Argentina 50 Hz and Brazil 60 Hz

3.5 Interconnections and electricity trade

The Garabi interconnection is one of a very small number of privately owned regional interconnector transmission projects in the world.

Figure 7 Transmission Network



Source: Graham et al. (2000)

Figure 7 shows the completed network operating between RSM and Itá substations in Argentina and Brazil, respectively.

3.6 Environmental and social issues

In **Argentina**, the main environmental entity is the Department of the Environment and Sustainable Development of the Environmental and Social Development Ministry. Its main purpose is to set out regulations, standards, and policies for environmental protection, environmental contamination, auditing, and human settlements. The department is also responsible for the development of environmental studies of the country and environmental certification of companies. The environmental licensing process was taken care of by the sector Departments of Mines and Energy, Mining, and Transportation.

In **Brazil**, the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) is the main institution involved in the environmental licensing process of energy projects. In the case of Garabi, it was also responsible for issuing environmental permits after the other state environmental agencies and other agencies involved had made their inputs.

IBAMA and its Argentine counterpart were the agencies which addressed the environmental and social issues that could arise by the construction and operation phases of the project. All the municipalities crossed by the transmission line and associated works were included in the area of indirect influence. A 10 km–wide corridor along the axis of the transmission line throughout its entire extension (490 km) was defined as the area of direct influence.

For Interconnection II, specifically, an immediately affected area was defined as comprising the right-of-way 65 meters wide in Brazil and 100 meters in Argentina and the areas of the Garabi Conversion Plant in Garruchos, the Itá substation, and the Rincón de Santa Maria substation. Detailed specific impact studies were performed for each of these sites.

In respect of flora and fauna:

- In **Argentina,** the project area had flora elements of Paranaense and chaco vegetation. In terms of fauna, the pampas deer prevalent in the region is under threat of extinction. However the deer had not been observed in the direct project area, and furthermore three other transmission lines had already been installed.

- In **Brazil**, the areas crossed by the interconnector were originally occupied by swathes of indigenous vegetation. At the time of the project, these formations were already highly degraded, with a predominance of annual monocultures of soy, corn, and beans. In Brazil no migratory bird routes were found in the project region and no endangered species lived there.

Environmental groups have been critical of Garabi. However, the main criticism is directed at the proposed 2,800 MW hydroelectric Garabi dam, rather than at the existing interconnector-converter station project. This is discussed further in Section 6.

4 Institutional arrangements

4.1 Governance structure

As noted in Section 3, the special-purpose company CIEN was set up in Brazil to execute the Garabi project. Engineering, procurement, and construction were contracted to ABB in a turnkey project. After handover, the infrastructure has been operated and managed by CIEN.

At the national level, the systems and market operators manage the technical environment in which Garabi operates. These institutions are:

- in **Argentina**, Compañía Administradora del Mercado Mayorista Eléctrico (CAMMESA), established in 1992.
- in **Brazil,** Operador Nacional do Sistema Elétrico (ONS), established in 1998.

An operations agreement between the two agencies exists, detailing procedures and responsibilities regarding trade, voltage control and repairs, and upkeep of the interconnection.

In **Argentina**, CAMMESA's main functions are real-time operation of the electricity system, which involves operation and dispatch of generation, price calculation in the spot market, and the administration of the commercial transactions in the electricity market. CAMMESA acts as agent for the various players in the wholesale electricity market and organizes and leads the use of transport facilities for spot transactions. The wholesale market allows exchanges with neighboring countries through power contracts between private companies that meet the requirements of the regulatory framework.

Brazil's independent system operator ONS is responsible for coordination of operations and control of electric power generation and transmission facilities in the Brazilian interconnected power system. ONS is governed and administered by electric power companies in generation, transmission, and distribution as well as retail utilities, electricity importers and exporters, certain high-energy-consumption consumers, and the Ministry of Mines and Energy.

CAMMESA and ONS are only incidentally involved in the Garabi project; it is to be noted that, unlike most other regional power integration schemes, there is ***no*** supranational regulatory or coordination body for the Argentina-Brazil electricity trade initiative. Any coordination that is needed is done through CIEN: there is no standing committee with public sector membership to serve as a forum or to assist with coordination.

4.2 Role of national governments and regional institutions

The governments of Argentina and Brazil were indirectly involved in the Garabi project by creating the framework for trade to take place. Specifically, the Argentine government, the Brazilian Ministry of Mines and Energy, and CIEN were the signatories of the initial 20-year

contract to utilize 1,000 MW of Garabi capacity. At the time, CIEN had contracts with IPPs in Argentina to supply the electricity and power purchase agreements with two companies in Brazil who were to be the importers. Additional power could be sold into the Brazilian spot market.

The somewhat procedural role of the national governments in the start-up phase stands in contrast to subsequent developments when the effects of the post-2002 economic and political crisis in Argentina spilled over into a failure to meet obligations to export gas and electricity to Chile and Brazil. The short-term consequences were largest for Chile, which was obliged to replace 25 million m^3 of Argentine natural gas with diesel and to absorb the significant increase in electricity tariffs which resulted. There were corresponding problems for electricity generators in Brazil, but on a lesser scale. Impacts of Argentina's default on Brazil as a country were fairly limited, but extremely significant for the affected private agents. For CIEN, the measures taken by the Argentine government were a disaster in the short run. Over time, with the growing shortage of power in Argentina, mainly the result of an anti-investment policy environment, the flow of electricity through Garabi has become the reverse of what was planned, with Brazil exporting its non-firm hydropower energy surpluses to Argentina.

In the planning of the project, deepening regional power integration was entirely consistent with the aims of the regional trade grouping, MERCOSUR. However, following the Argentine default, as is discussed further in Sections 5.1 and 6, the approach has become a more ad hoc one of bilateral electricity trades, rather than a purposeful move toward a regional electricity market. This is despite the existence of a body formed in the year 2000 by the presidents of twelve South American countries specifically to promote regional infrastructure integration (the Initiative for the Integration of Regional Infrastructure in South America—IIRSA). This body "seeks to promote the development of transport, energy and telecommunications infrastructure from a regional viewpoint, aimed at the physical integration of the twelve South American countries and the achievement of an equitable and sustainable territorial development pattern." The principal focus is on transport, with development corridors being identified for integrated infrastructural development, but regional gas and electricity investments are also part of IIRSA's implementation agenda.

4.3 Regulatory agencies

Both Argentina and Brazil have electricity sector regulators. In **Argentina**, El Ente Nacional Regulador de la Electricidad (ENRE), established in 1992, is responsible for regulatory functions and tariff matters relating to concessions granted by the national government. In **Brazil**, the regulatory agency is the Agencia Nacional de Energia Eletrica (ANEEL), which is autonomous but has links with the Ministry of Mines and Energy. ANEEL was created as a result of legislation passed in 1996 as the national electric system regulator, inspector, mediator, and licensing authority.

The core function performed by both agencies is the regulation of tariffs for end users. The methodologies officially used for this are as follows:

- In **Argentina,** under the existing legislation ENRE establishes tariffs for distribution companies according to an efficiency pricing model differing by zones. Retail tariffs are established by an indexed rate formula for a five-year

period. The prices are set in such a way as to recover the cost of purchased power, transmission charges, distribution system operating expenses, taxes, and amortization. Tariffs include a rate of return to encourage investment. Penalties have to be paid when quality criteria are not met. In the generation wholesale market, CAMMESA uses the declared costs and availabilities of the companies for load dispatch.

- In **Brazil** distribution charges are fixed to reflect the long-run average incremental costs at each voltage level. Transmission charges are based on long-run marginal costs, which are calculated as the cost of new investments needed to meet incremental use of the network. Generation is privatized, and a charge for available capacity is computed within an incentive-rate-making framework similar to the RPI-X incentive-based regulatory system developed in the United Kingdom. Energy acquisition costs are allowed as a pass-through to the user.

In Argentina, since the 2001/2002 crisis, electricity tariffs have in fact been highly politicized. In practice, they are set by the government and not by ENRE as is prescribed in the legal framework. As described in Section 2.4, except for residential tariffs which remain frozen, there is now a move to reapply the tariff regulation methodology and to restore market-related prices.

In relation to regional electricity trade, ENRE has precisely defined regulatory functions relating to import and export activities, including:

- Public service obligations
- Firm capacity ownership (a requirement for a firm export-import contract)
- Open access to surplus capacity
- Payment for surplus capacity through a regulated transmission service remuneration, which includes:
  - economic cost–based generation and dispatch markets
  - open access to surplus transmission capacity
- Nondiscriminatory conditions upon involved countries' demand and supply markets.

4.4 Role of outside agencies

The Garabi project, being privately owned and operated, has not involved outside agencies to a significant extent, other than at the financing stage. As will be spelled out in Section 5.2, the Inter-American Development Bank played an important role in the financing, while MIGA offered partial risk guarantees.

5 Contractual, financial and pricing arrangements

5.1 Contracts

The initial 1998 Garabi agreement was a 20-year contract for 1,000 MW of firm capacity from Argentina to Brazil, guaranteed by CIEN and its subsidiary, the Compañía de Transmisión del MERCOSUR. To back this, CIEN had signed supply and purchase contracts, respectively, with companies in Argentina and Brazil. As already mentioned, the Argentine government sought to protect the wholesale market from imports of cheap non-firm hydropower from Brazil by limiting the allowed transmission capacity to 300 MW for imports to Argentina.

The 2001/2002 natural gas crisis in Argentina and the persistent shortages of gas and electricity which followed led Argentina to mandate that gas had to be retained for domestic energy needs and could not be exported directly or in the form of gas-fired electricity. It is understandable for the shortage of electric energy in the domestic market to cause the Argentine government to change the rules, only exporting energy when the internal demand has been served, but this implied that Argentina would have to abrogate international export agreements.[3]

Due to the nondelivery of electricity, CIEN declared a contractual breach, resulting in the application of fines and reimbursements established in the contract. Electrobras (the main Brazilian electricity utility), CIEN, and the Brazilian Ministry of Mines and Energy are trying to resolve the conflict with the Argentine government.

From the perspective of the potential of expansion of regional power trade, the breakdown of the contractual framework is very significant.[4] The energy trade treaties and agreements which were made during the period when Argentina and most of its neighbors were reforming their energy sectors in some cases had juridical status superior to national laws. The principles of reciprocity and non-discrimination (in price and access) of commercial agents of both countries involved in energy exchanges were key elements of these agreements. This provided the framework within which substantial energy trading infrastructural investments were made by private investors as well as state-owned enterprises.

The institutional crisis in Argentina destroyed the framework on which many of the infrastructure projects had been conceived and built. Most of the infrastructural assets built in the expectation of a regional market developing are currently not being operated, or are being used for a different purpose from that which was intended. The longer-term

[3] When Argentina banned electricity exports, one of the difficulties that CIEN and Brazil faced was the complexity of the agreements, with multiple parties, on which Garabi was based. The original agreement, signed on May 5, 1998, was between CIEN, the Brazilian Ministry of Mines and Energy, through Electrobrás, Furnas and Gerasul, and the Argentinean government and was for the CIEN subsidiary, Companhia de Interconexão Energética, to import 1,000 MW firm capacity from the wholesale energy market in Argentina. The CIEN group was led by the two ENDESA companies from Spain and Chile, respectively.

[4] This section draws on Antmann (2009)

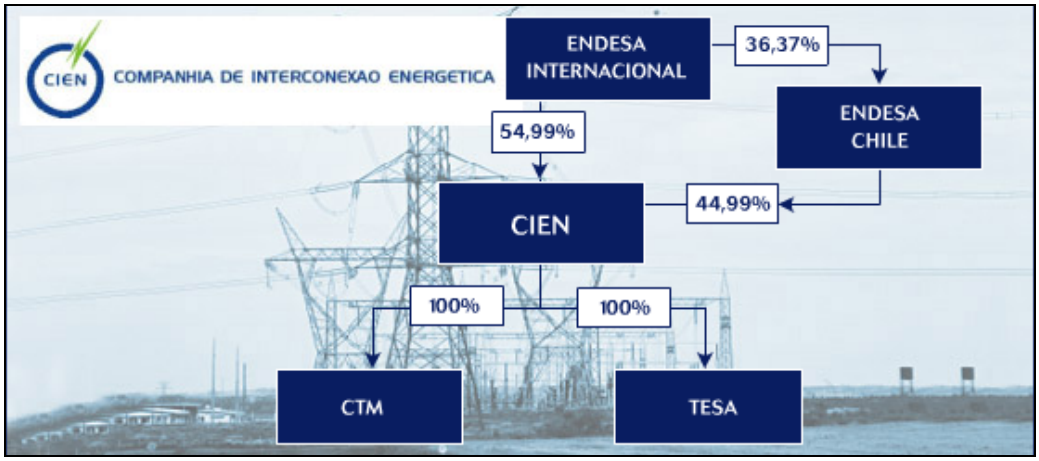
consequences could be even more severe, though, as abrogation of the legal and regulatory framework directly affects the fundamentals of capital-intensive infrastructure projects.

A paper written in 1997 describes the political context then as one in which there is "a deep fear of energy dependence. These fears are being overcome through the signing of bilateral and multilateral agreements, supported by a return to democracy and political stability of the region."[5] The subsequent abrogation of regional power agreements vindicates those with the "deep fear" about energy interdependence. The Argentine crisis has shown that agreements which may require restrictions in supply of domestic demand to fulfil export commitments are simply unrealistic. Security of supply of energy will always remain a vital national responsibility. Ensuring that there is sufficient national generation capacity to meet peak demand, even if that capacity is unlikely ever to be used because of the availability of cheaper electricity from neighboring countries, may ironically be the guarantor that is needed to obtain political commitment to regional integration in the power sector.

5.2 Ownership and finance

At the time it was created in 1998, CIEN was an affiliate of Endesa. CIEN's capital is currently distributed between Endesa itself and an Endesa subsidiary in Chile, which is partly owned by Compania Electrica Conosur, the largest power generation and transmission company in Chile. The two Garabi transmission lines are registered as the principal assets of two subsidiary companies: Compañia de Transmissión del MERCOSUR (CTM) was responsible for Interconnection I and Transportadora de Energia (TESA) for Interconnection II. Both companies are 100% owned by CIEN. Figure 8 illustrates the relationship between Endesa, CIEN, CTM, and TESA.

Figure 8 CIEN Structure



Source: CIEN (http://www.endesageracaobrasil.com.br/)

[5] Rudnick (1997), pg 12.

The total capital cost of the Garabi project was around US$700 million. The IDB was involved with organizing an equity facility of around $150 million, together with A and B loans[6] of $74 million and $174 million, respectively. The total package that IDB provided is summarized in Table 7.

Table 7 IDB Loan Package

Equity/Debt	Amount (US$ million)
Equity	
EKN Facility	150.6
Debt	
A Loan	74.0
B Loan	169.9
Total	394.5

Source: IDB

MIGA issued guarantees for $28 million to Endesa and $37 million to Banco Santander Central Hispano for their investments and loans in CIEN to expand its power distribution capabilities in Brazil. The guarantees covered the investors against the risks of transfer restriction and expropriation.

5.3 Pricing arrangements

The original contract had a fixed monthly charge for the 1,000 MW of firm capacity, together with a tariff for energy that was payable only when the electricity was delivered.

In general, contract prices for energy trade and wheeling via the Garabi system are negotiated by the parties concerned. Historical prices have not been put into the public domain. It is understood that the principle, however, is that the benefits of trade should as far as possible be equally shared between the contracting parties. Where imports occur because of differential generation costs, the price is set at the midpoint between the lower marginal cost of imports plus transmission costs and the higher marginal cost of domestic generation. In cases where the importer has no domestic generation alternative, the price reflects the full cost of supply, including depreciation and fixed costs.

[6] A loans are from paid-in capital from IDB member countries, as well as reserves and funds borrowed in international markets. B loans are provided through other banks and institutional investors on a co-financing basis.

6 Future plans

During the 1970s a proposal was made to build a hydropower project at Garabi. This would be a shared project between Argentina and Brazil and is now being considered as a potential complement to the converter stations and transmission lines, as these would be available to evacuate the power to Brazil at 60 Hz or to Argentina or other countries in the region at 50 Hz. The hydropower site is on the Uruguay River, about 47 km from Apostoles (in Argentina). Installed capacity would be about 2,800 MW, with an associated cost of US$1.3 billion.

The Garabi hydropower project is one of a series of potential projects that Brazil's Electrobras is studying in order to increase generation capacity. Two problems are likely to keep the Garabi project relatively low in the priority order. The first relates to the strenuously articulated objections of environmental groups, which are concerned that up to 33,000 hectares of inhabited land may be inundated and that water supply downstream of the dam may be severely compromised. The second relates to the undermining of confidence in regional schemes resulting from the Argentine institutional default. Garabi is not a Brazilian project but a binational initiative that needs to be jointly developed by both countries.

The dirigiste policies adopted by Argentina in its response to its economic crisis will have adverse consequences for financial flows and investment for many years. This applies to projects in all sectors of the economy, but the effects of the institutional crisis on infrastructure sectors is likely to be more persistent than in other sectors because the value of an infrastructure asset is completely dependent on legal and institutional certainty and enforcement. Similar situations have been encountered elsewhere in the region—for example, Bolivia not adhering to commitments to export gas to Brazil. The result is that the concept of energy market integration that seemed to be gathering momentum in Southern Cone countries in the 1990s has been severely compromised.

Within the region as a whole, therefore, the approach being taken at present in the electricity sector does not have a regional integration orientation but instead is characterized by a series of bilateral generation and transmission projects. For the longer term, hopes have been expressed that the bilateral projects existing between Argentina, Brazil, Bolivia, Uruguay, Paraguay, and Chile will eventually evolve to a stage where there will be the political will for a MERCOSUR regional energy market to be established.

Bibliography

ABB Group: *Brazil - Argentina Interconnection I & II: International Interconnection between Argentina 50 Hz and Brazil 60 Hz*. http://tiny.cc/49Nhl

Antmann, Pedro (2009): *Power Exchanges in South America Southern Cone: History and Emerging Lessons*. Washington DC: World Bank.

Cabrera, R., Vellutini, R., Montgomery, R., Brito, E. (2001): *Environmental and Social Impact Report.* Washington, DC: Inter-American Development Bank.

CAMMESA, Cubrimiento del Pico Real del SADI.
http://www.cammesa.com/inicio.nsf/marcomemnet

CIEN : http://www.endesageracaobrasil.com.br/.

COCERN: *Inside the Electricity Bill*. www.aneel.gov.br.

Environmental Impact Assessment, Country Energy Profiles.
http://tonto.eia.doe.gov/country/index.cfm.

Environmental Impact Assessment, International Energy Statistics.
http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm.

Furnas Centrais Electricas, Note 11 – Sundry Receivables. http://tiny.cc/vyvV7

Graham, J., et al. (2000): "Electrical System Considerations for the Argentina-Brazil 1000 MW Interconnection." Presented at the Cigre 2000 Conference, Paris, France, August 27-September 2, 2000.

Graham, J., et al. *The Garabi 2000 MW Interconnection Back-to-Back HVDC to Connect Weak AC Systems*. ABB paper.

Inter-American Development Bank (2004): *Private Infrastructure: Support from the Inter-American Development Bank Group, 1990-2003*. Washington, DC: Inter-American Development Bank

Inter-American Development Bank, Project No. RG 0054.
http://www.iadb.org/projects/project.cfm?id=RG0054&lang=en

Menzies, D. et al. (2001). "'Garabi' the Argentina–Brazil 1000 MW Interconnection Commissioning and Early Operating Experience." Presented at ERLAC Conference, Foz do Iguaçu, Brazil, May/June, 2001.

OECD (2005): *Economic Survey of Brazil 2005: Regulation of the Electricity Sector*, ISBN 92-64-00747-4.

Pereira, M.V. (2008): "Energy Supply in South America: Opportunities and Challenges." Presented at Cargill September 28, 2008.

Rudnick, Hugh (1997): "Interactions Between Gas and Electricity Markets." *IEEE Power Engineering Review*. Part of report on a panel discussion on "Power and Natural Gas in Latin America: Towards an Integrated Market"

Tavares, M. (2005): IEEE General Meeting in San Francisco, June 15, 2005

The World Bank, *World Development Indicators*, 2007 data.