Creating Harmony

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in South America

SOUTH AMERICA IS LOOKING FOR WAYS TO HARMONIZE POWER SUPPLY expansion with growing environmental concerns as electricity demand increases at a fast pace. While South America contributed little to the world's total pollutant emissions, societies are increasingly becoming aware of the impact that new hydropower plants or fossil-burning thermal generators have. And the "not in my backyard" syndrome, typical of developed countries, is also gaining strength in the region. Private investors leading key investment decisions in the reformed South American power sectors are facing organized opposition to the building of new plants. Brazil and Chile provide two examples of how countries are trying to reconcile the need for abundant energy supply with environmental constraints.

Electricity Markets and Environmental Challenges

Electricity Markets in South America

South America's electricity consumption is growing at an important pace, with countries having growth rates over 6% that require doubling installing capacity every ten years (Figure 1). This is born from low per capita electricity consumption levels (around 2,000 kWh compared to 12,000 in the United States and 6,000 in Europe) combined with high economic and population growth. Nevertheless, electricity markets within the region are very heterogeneous, with consumptions of 3,525 kWh per capita for Venezuela and 470 kWh for Bolivia (2000 figures).

The Challenge of Conciliating Energy Development and Environmental Constraints in South America

The countries of South America have plentiful energy resources, including natural gas, oil, coal, biomass, wind, geothermal, and other renewable resources as well as a significant hydropower potential. However, the most important reserves are highly concentrated in a few countries and often away from major consumption centers. While Venezuela has the largest oil and natural gas reserves in the region, hydropower potential is more evenly distributed, with Brazil having the largest share (Figure 2). This has meant that the share of hydroelectric power in generation of electricity is well over 50% in most countries (Figure 3).

The electric energy industry in South America faced a profound transformation in the late 1980s and early 1990s, with no parallel worldwide. New electric sector regulations were set in Chile in 1982, Argentina in 1992, Peru in 1993, and Bolivia and Colombia in 1994, with Brazil joining the group later on. In 1997, the reform also extended to the Central American countries. Challenges that gave birth to the process were diverse in the region, but all countries required high investment to respond to very large growth of demand. With governments urged to focus on more basic problems—education and health—creating competitive energy markets to incorporate the private sector was seen as a necessity for further economic development. Thus, most countries in the region completed the institutional transition from a state-owned centrally planned power sector to competitive markets based on private investment.

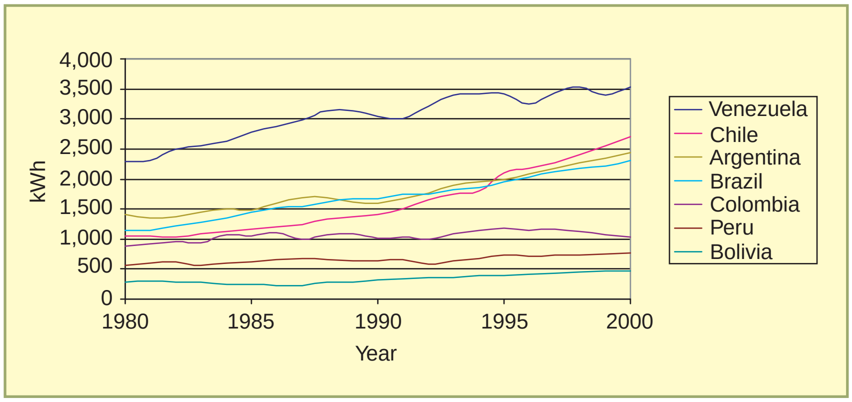


figure 1. Growth of per capita consumption of electric energy.

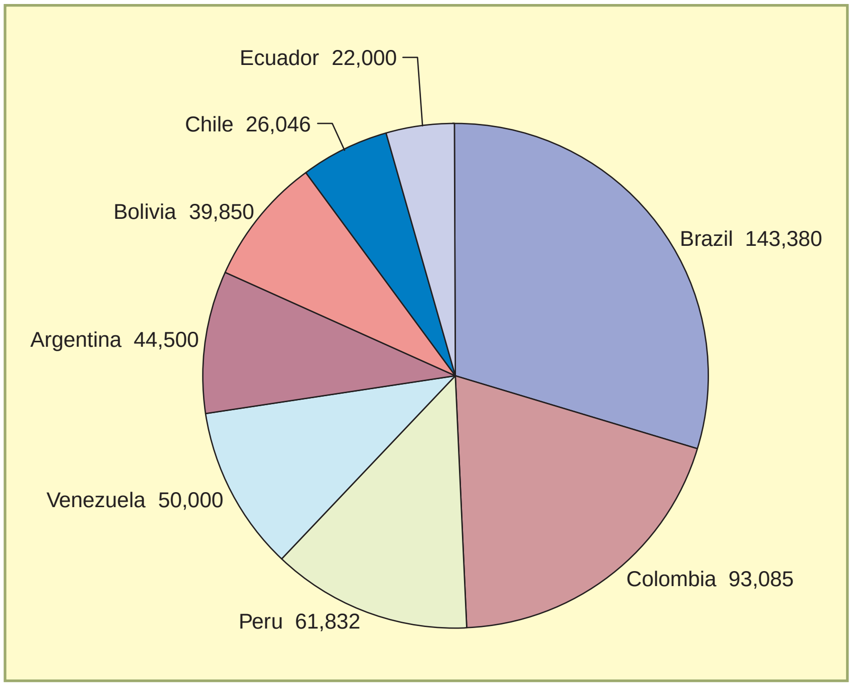


figure 2. Estimates of economically exploitable hydroelectric potential (MW), 2000.

Decisions on the sector reform model did not take into account explicitly any environmental restrictions and left investment and operational decisions to private players and market interactions. For example, decisions on the type, the opportunity, or the location of new generation investments are left to private players and their priorities. Countries such as Chile regularly elaborate an indicative generation investment plan, but the plan relies on orientation by private investors.

Power system operational policies are based exclusively on direct variable costs with more efficient technologies dispatched first, with no environmental variables involved. Security of operation is also a main obligation of the independent system dispatchers but that does not consider environmental impacts in the analysis either.

Most recently, the region went into a second generation of reforms, with the implementation of competitive auctions by private distribution companies for contracting capacity to ensure efficient system expansion. In Brazil, 23 average GW (energy, not peak) have been contracted since December 2004 (more than US$40 billion in contracts were awarded) with Chile starting auctions in 2006.

The reform processes, including these recent auctions, have aimed at creating conditions to respond to growing demand with economic investment and operation but with key decisions made by private actors and a limited role being played by central governments. The priorities of the private actors are essentially business oriented, responding to their strategies and their risk assumptions. The way their decisions affect the environment is also left to their assessment, restricted only by existing environmental laws, not necessarily made coherent with the electric market laws and regulations. While Chile has kept a market laissez-faire approach, leaving environmental licensing separate from energy supply processes, the Brazilian government, facing difficulties with hydro approval deadlocks, decided to interfere to facilitate private actions.

Environmental Challenges

Assessments made worldwide suggest that the Earth's climate has warmed over the past century, in what is named the *greenhouse effect*. Energy consumption and electricity production, among other human activities, are important driving factors in the production of greenhouse gases. CO_2, originating from burning fossil fuels, is the greenhouse gas that contributes most to the warming effects. Latin America with 8% of the world population contributed only 5.5% of the world's total 2002 CO_2 emissions (excluding that which originated from deforestation and forest burning) while the United States contributed almost 34% with 4.5% of the world population. Emissions of CO_2 from power generation in the region are very low if compared worldwide, mainly due to the high hydropower component in electricity generation (Figure 4).

Only one country in South America, Brazil, is in the top 20 highest fossil fuel CO_2-emitting countries. While Brazil emitted more than 85.5 million metric tons (t) of carbon in 2002, Argentina emitted 36.3, Venezuela 29.5, Colombia 15.6, and Chile 15.6. Liquid fuels account for over 60% of the regional emissions, with coal burning accounting for only 7.3% of CO_2 emissions. Per capita emissions of CO_2 are small, Argentina with 0.96 t of carbon per person per year, Chile with 1 t, and Brazil with 0.49 t, well below the global average per capita rate of 1.12 t of carbon. Nevertheless, even with those low figures, the concern is that the emissions in Latin America increased more than the world average between 1990 and 2000. Energy consumption, economic developments, and CO_2 emissions are closely tied to each other in the region (Figure 5), and efforts to decouple them through a more efficient use of energy have been weak. Nonetheless, it is in forest management, more that in energy efficiency improvements, that there are opportunities for reducing CO_2 emissions in the region. The destruction of the rain forest in the region was responsible for 30% of the world's total CO_2 emissions from the change of land use.

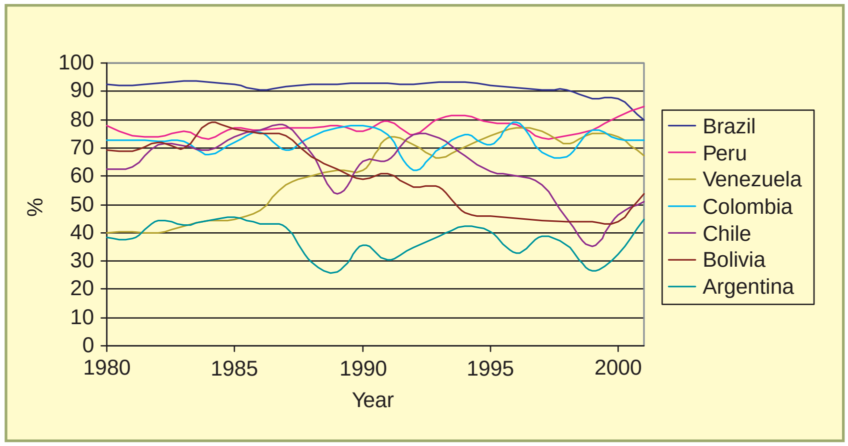


figure 3. Share of hydroelectric power in generation of electricity.

With those conditions, the actions in pollution control in electricity production in South America, with emissions much lower than those from transport and industry, are essentially driven by a population that is concerned more with their health impact than with the greenhouse effects. General environmental laws being implemented throughout the region are creating conditions for local communities in each country to limit CO_2 emissions and other pollutants. Often, farmers and environmentalists join efforts to challenge new coal- or gas-fired thermal power plants that they argue would be harmful for people and for the agricultural sector. In a region where agricultural export products significantly contribute to economic development, this can be a relevant barrier for new fuel-fired plants.

However, with the significant hydro potential of the region, a more important area of conflict for electricity supply expansion over recent years has arisen with the development of hydro resources. Risks of flooding tropical rainforest, flooding of scarcely populated areas (but having an indigenous population), and water use conflicts are making life harder for hydro developers. International environmental action groups are joining opposition to these projects in the region; Robert Kennedy Jr. is leading public actions against them.

An avenue to achieve clean and cheap energies for the future was seen in the use of abundant regional natural gas resources, both for industrial applications and electricity

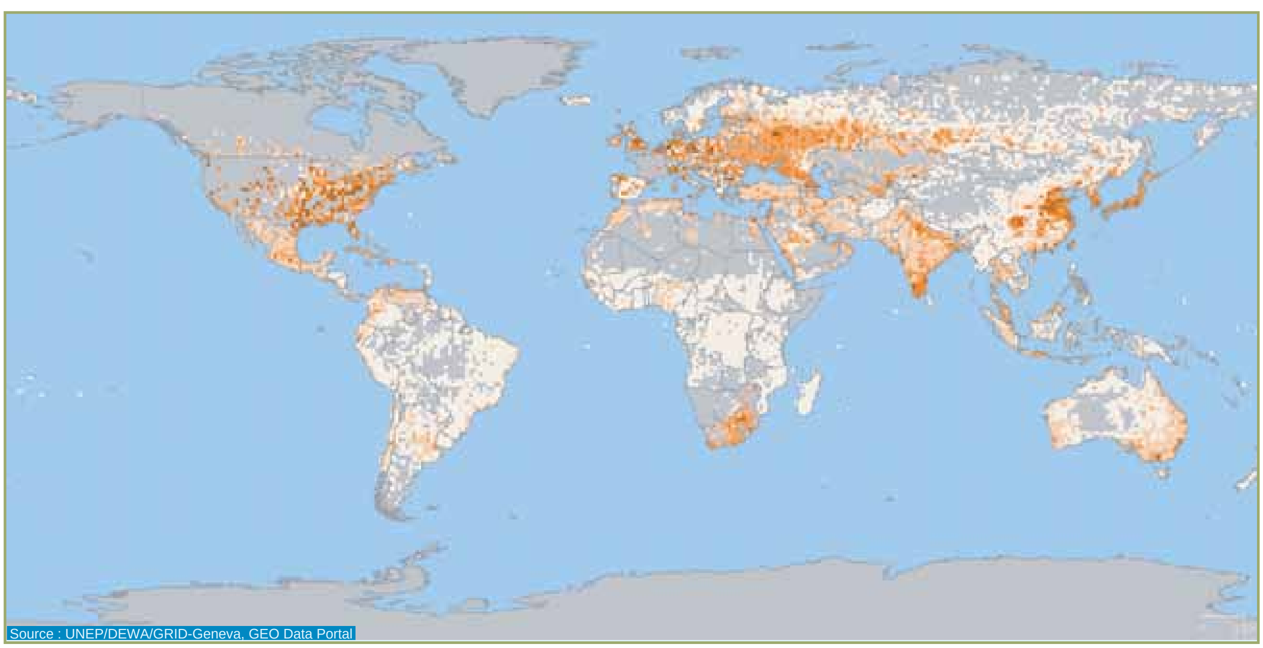
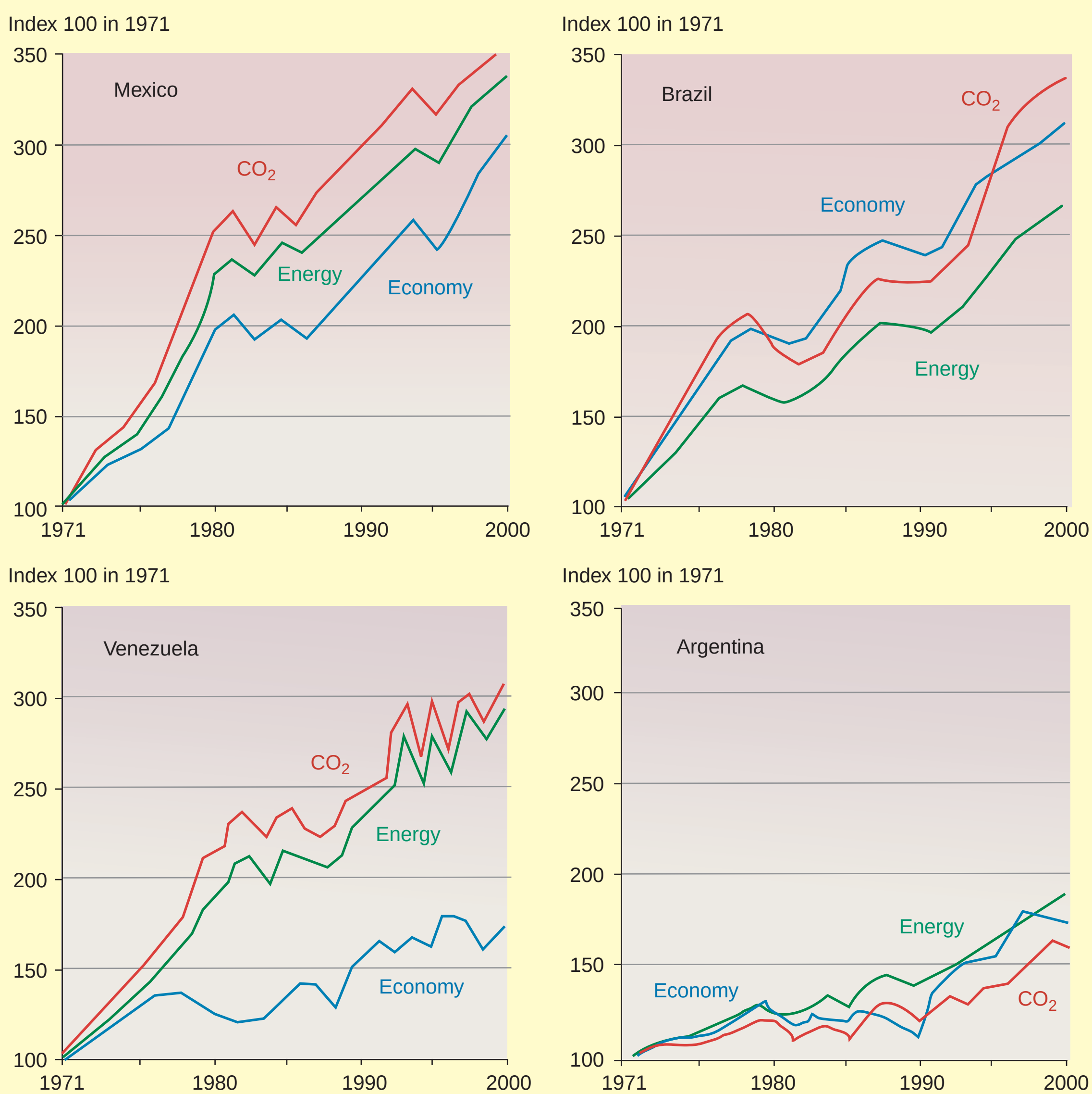


figure 4. 1995 emissions of CO_2 from power generation, United Nations Environment Program (2005). (Source: The GEO Data Portal: http://geodata.grid.unep.ch.)

generation, in this last case making use of the major technological breakthroughs achieved with the development of combined-cycle gas turbines. This technology not only provided a low-emission fossil fuel but also raised average thermal energy efficiency to almost 60%. Another important fact for the countries of the region, some with small power systems, is that these efficiency gains occur even for plants as small as 150 MW, eliminating economy-of-scale conditions. The process was facilitated with the development of an international network of gas pipelines throughout South America, transporting resources available in Venezuela, Bolivia, Argentina, and Peru. Proved significant gas reserves in those countries, plus extensive drilling for natural gas rather than oil, was to be the main objective in this avenue, reducing the relative share of oil byproducts and hydropower. This clean, cheap fuel process, plus the energy integration development,



United Nations Environment Programme/GRO Arocdel

figure 5. Energy consumption, economic development, and CO_2 emissions in selected Latin American countries. (Source: World Resource Institute.)

came to a halt with the economic and political crisis of Argentina and Bolivia, which limited gas exports to neighboring countries. With the high prices of liquefied natural gas, countries like Chile were back to considering coal and hydro as the avenues for electricity generation, with the environmental barriers already mentioned.

Renewable generation is argued as an alternative to keep a clean environment in the region. However, apart from hydropower, in the region there are no renewable sources that could be competitive on a significant scale. Abundant geothermal energy is a risky business for private investors, given the high exploration costs involved. Renewable small-scale sources of energy are competitive only in isolated remote rural areas; only wind surfacing is a competitive alternative in interconnected systems with high marginal costs. Nevertheless, countries are looking for alternatives, such as the sugarcane cogeneration plants in Brazil and the incentive to build small renewable plants in Chile.

An interesting development in South America that links electricity generation and environmental control is the opportunity provided by the World Bank—on behalf of a number of countries and private companies (mainly in the northern hemisphere)—to local private investors to generate greenhouse gas emission reductions through the Kyoto Protocol. The first Clean Development Mechanism project in Chile is being followed by others in Brazil, Ecuador, Colombia, Peru, and Argentina. These emission reductions are paid to the investors and can make marginal projects in energy more attractive for them.

Environmental Regulations

The Case of Brazil

Environmental regulation in Brazil dates from the early 1980s, where a National Policy for Environmental Issues was launched and established that construction, installation, and functioning of activities that use environmental resources depend on the approval of licenses from environmental bodies. A National Council for Environment (CONAMA), a high-level cabinet with an advisory role on the country's environmental actions and standards, was created as well as the first federal and state environmental licensing agencies. Later on, the 1998 Brazilian Constitution devoted a chapter towards the formulation of an environmental policy for the country, and the creation of the Brazilian Institute of Environment (IBAMA) in 1989 consolidated the Brazilian environmental guidelines. IBAMA is the main governmental body for environmental issues, responsible for coordinating, formulating, inspecting, and enforcing the National Policy of Environmental Issues for a rational use of the natural resources. Finally, in 1992 the Ministry of Environment was created and became the main government body responsible (jointly with IBAMA) to plan the country's environmental guidelines.

The environmental licensing process is the instrument for the development of environmentally sustainable projects; it involves a systematic evaluation of the environmental consequences of a planned (or under development) activity. The licensing process of any project comprises three phases (and licenses): 1) prior license (PL) is granted in the planning phase of the project and approves its siting, conception, and environmental feasibility (the implementation of additional environmental compensation programs may be demanded during this phase); 2) an installation license (IL) authorizes the installation of the project, in accordance with the specifications of the approved environmental programs, including the additional implementations established with the issuance of the PL; 3) an operating license (OL), after verifying the execution of all requirements of previous licenses, effectively authorizes the operation of a project. PL, IL, and OL, are valid for at most five, six, and ten years, respectively. Studies of environmental impact assessment (EIA) are required to launch the licensing process. Depending on the localization of the project, this process may involve a complex relationship among several environmental agencies, including IBAMA, state agencies, and municipalities' bodies, all of them with the power to demand the implementation of additional compensation programs or socioenvironmental management systems to comply with the national environment standards. Public hearings are also mandatory and carried out during the licensing process. The licenses are finally issued by IBAMA or by a state agency, depending on the location of the project.

In the context of the energy sector, under the old regime the vertically integrated utility established technical guidelines for handling the environmental impact of new power projects. In cooperation with companies, it conducted technical reviews and studies before submissions were made to the licensing agencies. The privatization and restructuring of the electricity industry in 1996 forced a major change in this process. Concessions of hydro resources started to be granted by bidding in public auctions, and projects to be auctioned were chosen from inventory studies prepared from the old regime. Winning investors then would become responsible for the licensing of their hydro projects, conducting the needed engineering and environmental studies. The licensing process (phase 1–3) started to be applied on a project-by-project basis, following interactions between licensing agencies and investors. The same licensing procedure (phase 1–3) applies to thermal power plants (which are directly authorized to investors) and transmission lines (with concession contracts also granted through auctions). On one hand, the licensing of thermal and transmission projects became very concentrated in specific issues, such as conflict for water use or decisions on the best environmental routes. There is no need of a population's reallocation, and, overall, atmospheric pollution is still not saturated in Brazil. On the other hand, the complexity of evaluations of the impacts on the physical, biotic, socioeconomic, and cultural systems of regions where projects are built have made the licensing of hydropower plants a strict and time-consuming process. As will be discussed next, this strict process has resulted in environmental cost overruns and delays in the construction of several hydro projects in the country. In turn, licensing thermals proved to be easier, faster, and more effective.

The implementation of the second stage of the country's power sector reform in 2004 aimed to ease the environmental licensing process to investors through three actions: 1) force all projects to have PL as a requisite to become candidate expansion options in the auctions for new generation (this task aims at reducing the environmental risk on the later development of these projects); 2) in the case of hydropower plants, make the government responsible for obtaining the PL; and 3) use the recently created body for planning studies (EPE) to carry out an integrated environmental assessment of hydro projects, inventory studies, and feasibility studies, which form the basis of EIA analyses.

These actions indicate that the government is taking on the responsibility of approving the first licensing for hydro plants and, therefore, is significantly reducing the investor's risk of obtaining a concession that is environmentally infeasible. However, as shown next, deadlocks are still frequent and this process still has not fully succeeded.

The Case of Chile

The Chilean electricity law does not treat two relevant issues from an environmental perspective: investment in new power plants, including plant location and technology, and power plant dispatch. There is full freedom for investment in the electricity sector, with minimal requirements for the installation of hydro plants and transmission lines. Private investors develop projects that, with the tariffs and costs identified, produce a desired rate of return, while responding to their strategic interests. These interests do not always coincide with the social appraisal of fuel costs, investments, return rates, and, of course, environmental considerations.

The 1980 Chilean Constitution grants all citizens the right to live in an environment free of pollution. It further provides that other constitutional rights may be limited in order to protect the environment. The electricity companies that operate in Chile are subject to the Law 19300 (the Chilean Environmental Law), which was enacted in 1994. Law 19300 recognizes the existing legal and technical competitions in the different services of the state and the necessity to coordinate the joint environmental management with each one of them. The law requires companies to conduct environmental impact studies of any future projects or activities that may affect the environment and the review of such studies by a state agency, CONAMA. It also requires an evaluation of environmental impact by the Chilean government and authorizes the relevant ministries to establish emission standards.

The System for Environmental Impact Evaluation (SEIA) is the vehicle that allows the environmental dimension to be introduced into the design and execution of projects or activities realized in Chile. This system attempts to insure that initiatives in the public and private sector are environmentally sustainable and to certify that they comply with environmental regulations that may be applicable.

The Chilean Environmental Law and the regulations of the SEIA of CONAMA establish that investment projects in Chile must be evaluated before their execution. Various categories of projects are defined that must be evaluated. The projects concerning the electricity sector that must be submitted to the SEIA include generation plants larger than 3 MW and high-voltage transmission lines and their substations.

The Ministry of Economy, advised by the Superintendence of Electricity and Fuels, needs to grant definitive concessions for the construction of a hydro plant and the building of the associated transmission lines (the building of thermal plants does not require concessions under the electricity law). The hydro plant must own the required water rights for the project, water rights that are granted by the General Water Authority, a part of the Ministry of Public Works. CONAMA needs to grant the plant an authorization that it meets environmental restrictions, with an impact study to be submitted by the plant owners. In indigenous lands, other regulations intervene. An important restriction arises as articles of the Indigenous Law prohibit forcing inhabitants to sell their land.

Brazil: Environment, Hydropower, Generation Auctions, and Clean-Energy Programs

Brazil has an installed capacity of 95 GW (2005)—hydropower accounts for 85%—with a peak and energy demand near 54 GW and 44 GW, respectively. The hydro system is composed of several large reservoirs, capable of multiyear regulation, organized in a complex topology over several basins. Thermal generation includes nuclear, natural gas, coal, and diesel plants. In order to couple the development of hydro generation and to benefit from hydrological complementarities, the country became fully interconnected at the bulk power level by an 83,000-km meshed high-voltage transmission network. However, less than 30% of its hydropower potential is currently used. As shown in Figure 6, the country still has an undeveloped hydro potential of more than 150,000 MW, most of it located in the environmentally sensitive Amazon region, far from load centers and where mega hydro resources such as the Madeira river complex (7,000 MW) and Belo Monte project (5,500 MW) are being considered as expansion options (location and distance to main load centers highlighted in Figure 6). Although in the future the energy matrix composition should become more diversified (including cogeneration, local coal, and gas), hydropower is currently still the cheapest supply expansion option and will drive the system's expansion for next years. Predicted annual energy load growth rate runs at 5%, requiring about an average of 3,500 MW per year and around US$4 billion/year of investments in generation. Hence, the main challenge for the country is to promote a clean and economically efficient energy growth. In this sense, hydro generation has an important role.

Hydro Development and Environmental Constraints with the Sector Reform

From 1996–2002, about 20,000 MW of new concession rights for hydro development were granted to local and foreign

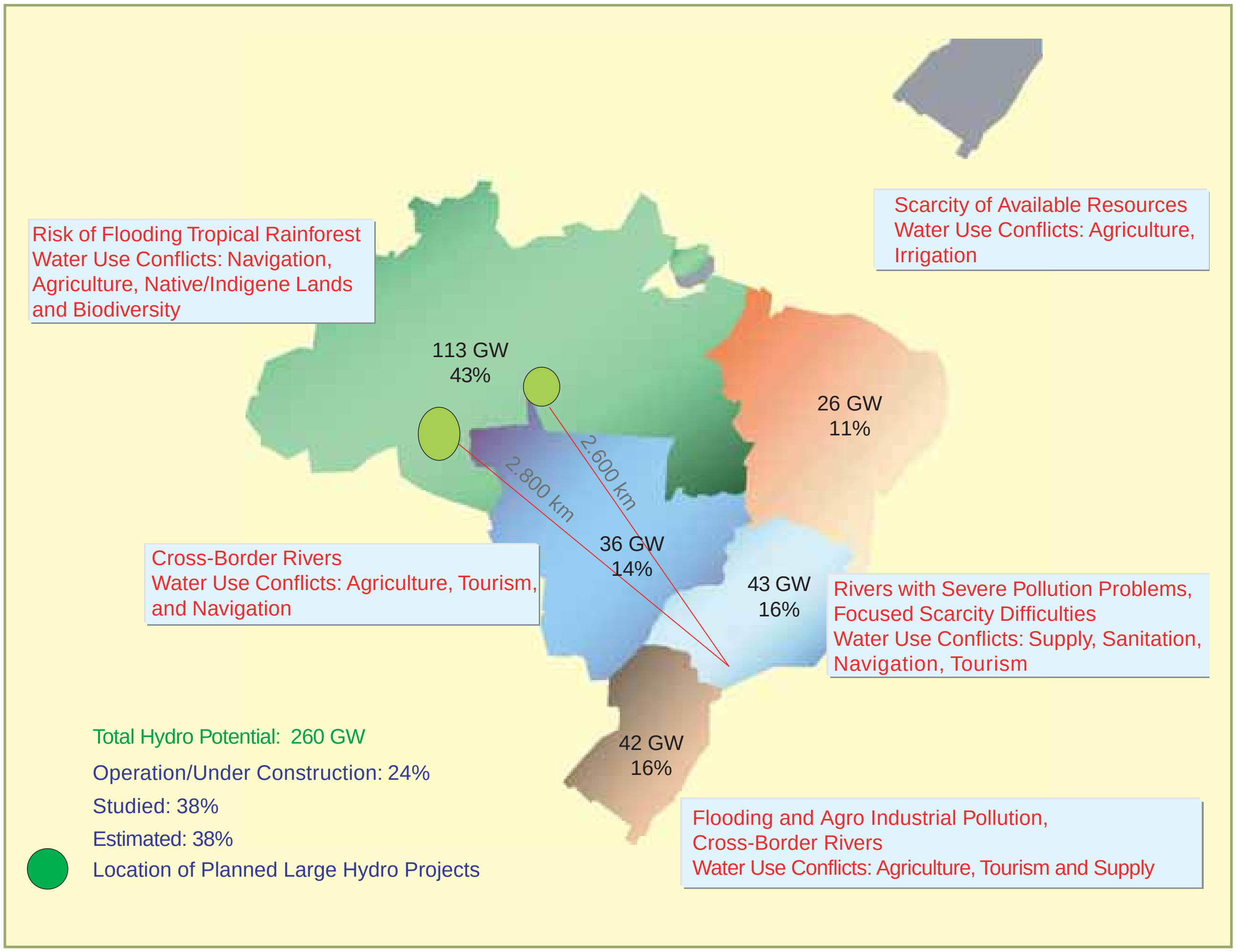
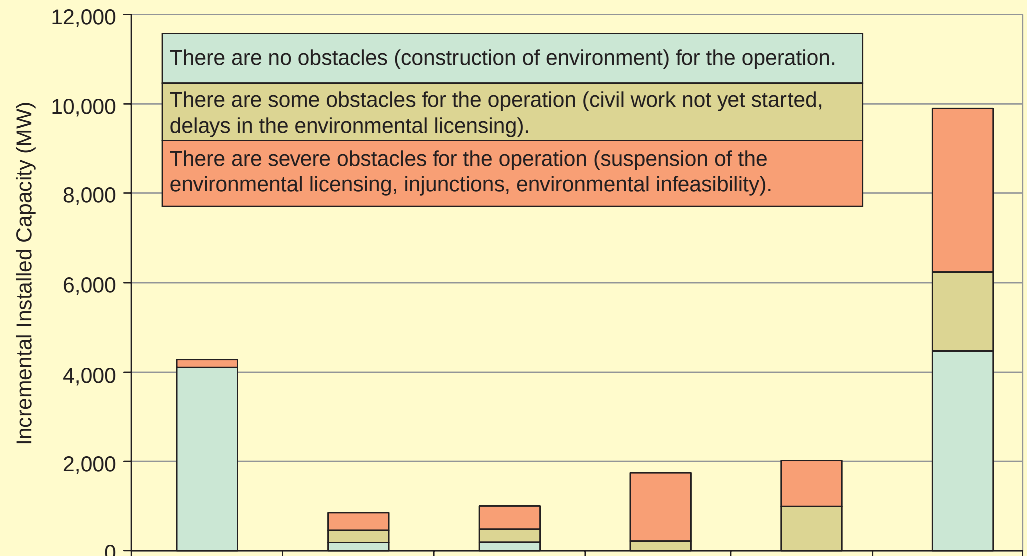


figure 6. Brazil: hydro potential and environmental issues in hydro development. [Source: Eletrobras, 2004, and S. Helena Pires (a Course on Environmental Issues in Brazil, FGV, 2005).]

investors. The underlying projects were expected to come online from 2000 onwards. Investors were supposed to go through the standard licensing scheme previously described. However, the process proved to be strict and complex: the project-by-project environmental analysis was shown to be inadequate, since environmental impacts of a hydro project are synergic and cumulative with other plants in the basin and subbasins and, therefore, cannot be locally assessed. In this sense, studies of inventories that had not been made on an integrated basis with the environmental dimension (only the economic assessment was taken into account) demanded long and complex discussions by federal and state environmental offices, delaying the project's construction schedule. Although inventory studies are not in the scope of environmental licensing, they are fundamental to ensure that projects located in the same basin can meet the requirements of the environmental legislation. The inadequacy of some of these studies (gathered with other poor related specific analysis) also resulted in demands for additional environmental compensation programs for the projects, which is implied in environmental costs overruns.

These deadlocks have made hydropower plants increasingly more expensive. For example, the environmental costs of the Luis Eduardo Magalhães hydro plant (900 MW located at the Tocantins River, auctioned in 1996 and started operation in 2001) reached about 22% of the project's total budget, resulting in a cost overrun of about 500% of the project's planned environmental total budget. Another emblematic case is the licensing of Barra Grande project, a 690-MW hydro whose OL was once suspended due to inadequate studies on vegetation impact investigated just before the filling of the reservoir. This also resulted in high costs and negative impacts on the power sector.

Delays on the construction schedules of hydro plants have also become frequent due to difficulties in obtaining the licenses. Figure 7 presents the planned incremental capacity additions of hydro plants for the next five years according to the original operation schedules set on the concession contracts. The figure is stacked according to the existing obstacles to allow the projects to start operation. Environmental difficulties form the majority of these obstacles. Although this list is updated quarterly, it can be observed that there are obstacles (environmental difficulties) for the majority of



	2006	2007	2008	2009	2010	Total (2006-2010)
Severe Obstacles	179	405	523	1,531	1,027	3,664
There Are Some Obstacles	0	268	295	214	992	1,769
No Obstacles	4,098	183	187	0	0	4,468

figure 7. Incremental capacity additions of hydro plants and environmental status. [Source: ANEEL (Electricity Regulator); http://www.aneel.gov.br (March 2006).]

projects planned to come online in 2007, which will result in further delays and can affect the security of electricity supply. Examples include hydro plants Estreito (1,087 MW) and Serra do Facão (212 MW), which are facing severe difficulties with their environmental licensing process, the latter with construction already started. Thermal projects, on the contrary, started to come online without major deadlocks in the licensing process. In order to avoid this deadlock and to ease the licensing of hydro plants for investors, the government interfered to obtain the PL for hydro projects before the auctions for concession rights are carried out. The first experience under this new scheme was carried out in December 2005, which is described next.

Current Situation with the Second Market Reform: Deadlock Between Developers and Environmental Agencies

As part of the revisited set of power market rules, in December 2005 the Brazilian distribution companies carried out the first competitive auction for contracting new (greenfield) generation to ensure an efficient system expansion. Fifteen-year financial forward energy contracts and energy call options for delivery in 2008, 2009, and 2010 were offered for investors on the basis of the lowest bid. Candidate projects comprised hydro plants studied by the government (whose concessions were also granted in the auction) and thermal plants suggested by investors. Following the new rules, only projects with prior environmental license can be auctioned, and the responsibility of getting these licenses for hydro projects belongs to the government. Observe that the issuance of the licenses has a great impact on the total candidate supply in the auction and, thus, in the increase of competition and tariff adequacy.

However, after almost two years of direct effort by the Ministry of Energy and other officials, the result was disappointing. From an initial target of offering 17 new hydro projects in the auction, totaling about 2,800 MW, only five projects (totaling about 800 MW) were licensed in time for the energy auction. Besides facing a strict and time-consuming licensing process, some projects also faced legal injunctions from local courts, based on (sometimes poor and inadequate) information on the project impacts and on complaints from local inhabitants that would be directly affected by the filling of the reservoir. Two other competitive hydro projects (that could add 650 MW of additional capacity) were forbidden to participate in the auction due to injunctions issued on the day before. In parallel, several investors of thermal generation (gas, coal, oil, diesel, and biomass) were able to get their licenses in time.

The auction resulted in the contracting of a total of 3,300 average MW (energy, not peak), involving a transaction of US$27 billion. Contracted generation included a mix of technologies from all candidate suppliers. In particular, 35% of the new energy contracted came from hydro generation at an average price of US$45/MWh, while 56% came from thermal generation at an average price of US$50/MWh (9% of the new energy contracted came from sugarcane biomass plants, to be discussed next). A simplistic calculation shows that if, for example, 500 average MW (energy) of hydro generation replaced the same amount of thermals, the yearly net reduction on consumers' contract payment would be about US$22 million, which could be used, for example, to reduce the social inequality of the country. In summary, the concern with the social-environmental impacts is absolutely legitimate but makes the licensing process for hydro very complex and long, which has resulted in the construction of more expensive equipment for the country and, ironically, pollutants.

Solution Perspective: Integrated Environmental Assessment

The main approach that is being adopted to solve this deadlock is an integrated environmental assessment (IEA) of inventories and planning of hydro plants, looking at the cumulative and synergic environmental impacts in the whole basin instead of on a project-by-project basis. The methodology takes into account impacts on biodiversity, water quality, sustainable development, and social aspects (i.e., stronger participation of the society through workshops and seminars among institutions, investors, and the population). By identifying the proper or fragile areas through the environment point of view, a multicriteria approach of evaluating the system expansion alternatives both economically and environmentally can be carried out. The IEA will be the first step before the issuance of EIA and PL and will ease the whole licensing process. It will be carried out for either the greenfield hydro projects and redone for the projects whose concessions were already granted in the past but still have no license. In both cases, the objective is to ease the full licensing procedure with robust EIA studies and the active participation of several sectors of society. Inventory studies are also part of this framework, which will also review inventories of other basins studied in the past.

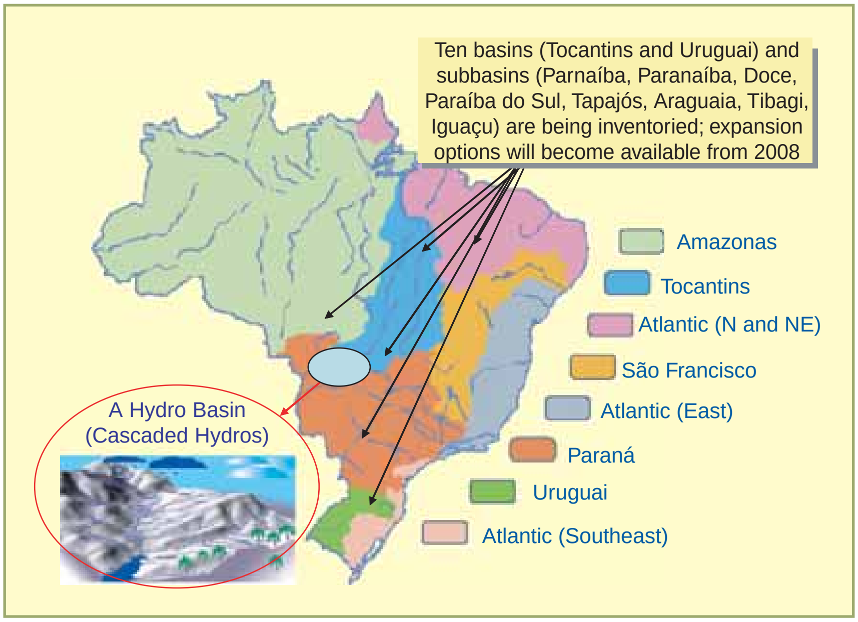


figure 8. Brazil: Hydro basins with cascaded hydros and selected basins for IEA.

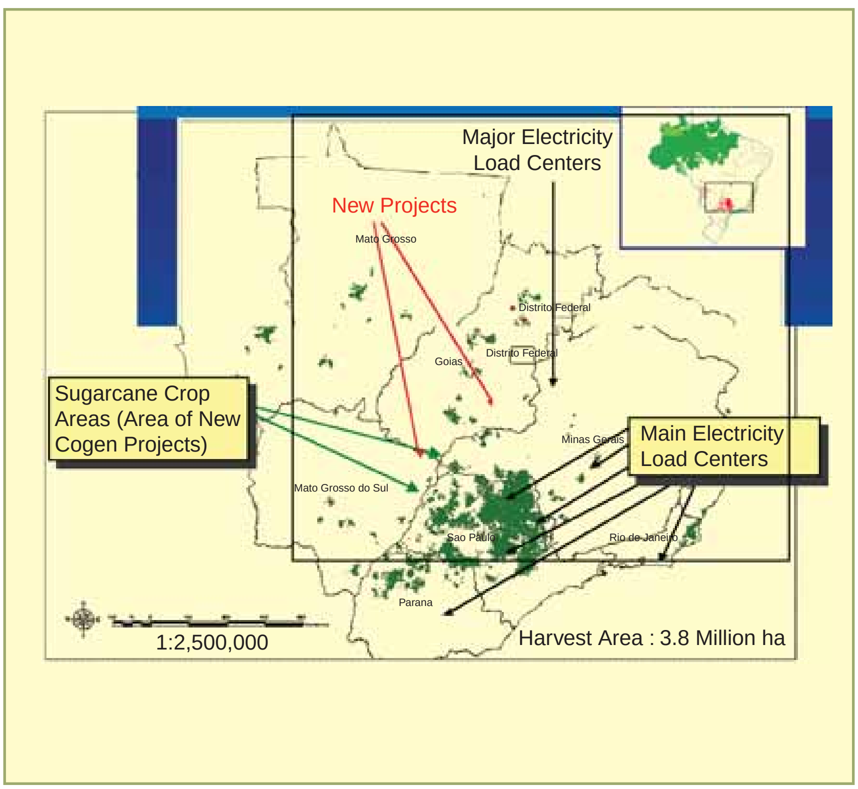


figure 9. Brazil: Location of sugarcane biomass cogen plants.

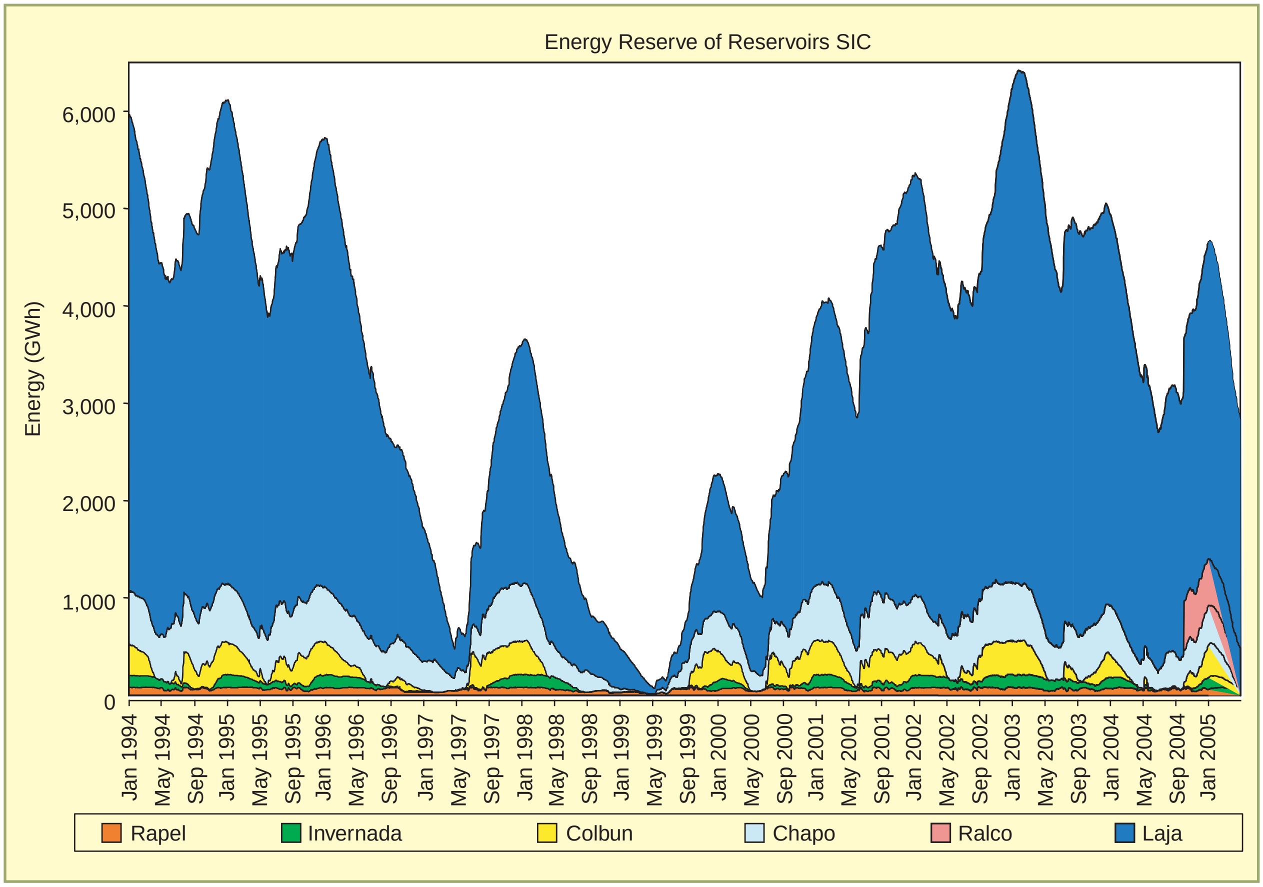


figure 10. Energy reserve of hydro reservoirs in the Chilean main system.

The IEA is being carried out by EPE (Figure 8). Ten basins, totaling more than 10,000 MW are being inventoried, and the IEA and hydropower options resulting from those studies should become available again by 2008 (starting operation in 2013).

Other Actions and Clean Electricity Programs: The Bioelectricity Initiative

Brazil has also been searching for alternative clean energy developments besides medium-large hydro plants. A program based on classic subsidies was created to contract 3,300 MW of renewable energy (equally shared among small hydro, wind, and biomass) for delivery in 2008, but it has been criticized on the grounds of its economic rationale and lack of economic signals for efficiency and technological improvement.

On the other hand, Brazil is an important sugar and ethanol producer, and cogeneration (cogen) plants using sugarcane waste (biomass) started to be a remarkable generation option. Currently, there are 2,800 MW of sugarcane biomass cogen in the country, where 600 MW are commercialized with distribution companies (DISCOs), and the rest is used for self-consumption. Motivated by opportunities in the international (export prices for sugarcane and ethanol) and domestic (development of bi-fuel vehicles, the rise of ethanol mix in gasoline) markets for sugar and ethanol, Brazil will expand its sugarcane production area by 50% in the next five years. Once cogen cost is the incremental investment in larger/more efficient boilers, this results in a window of opportunity for developing a competitive and clean energy source, with no environmental impact and the ability to mitigate greenhouse gases, thus easing significantly the environmental licensing. In addition, gains in transmission investments and losses are observed, since these plants are located closer to the main load centers (see Figure 9).

Hence, a joint initiative of sugarcane producers, cogen associations, and equipment manufacturers was launched, with the objectives of increasing the participation of biomass cogen in the energy sector. Instead of subsidized mandatory programs, this so-called bioelectricity initiative relies 100% on private investment and aims at competing with other sources on the same footing. Electricity regulation has been adjusted to account for the specificity of such plants, and about 200 MW of biomass cogen were already offered and contracted in the "new energy" auction of December 2005 through competitive prices and in a straight economic competition against all other generation options, such as hydro, coal, and natural gas. The bioelectricity initiative is planning to organize a more aggressive bid in the next auctions for new generation (the first and second semester of 2006, for energy delivery in 2009 and 2011, respectively) by offering from

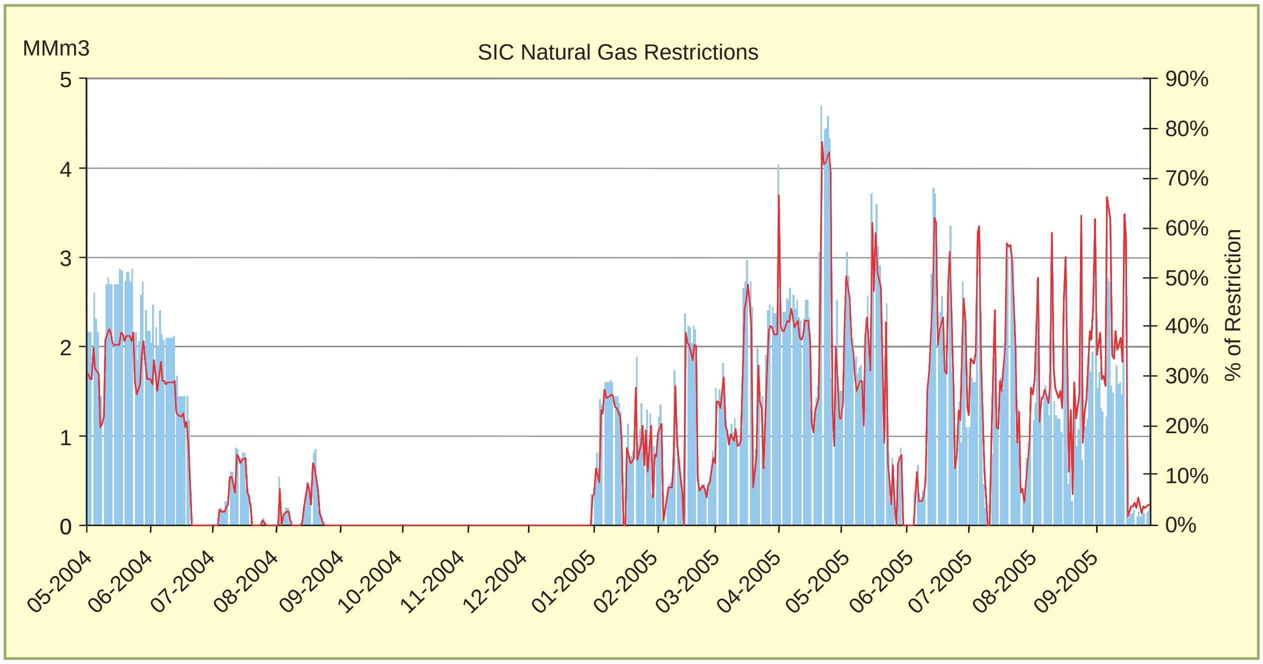


figure 11. Natural gas restrictions from Argentina to the main Chilean system.

1,000–3,000 MW in additional biomass cogen projects. In addition, the revenue stream from long-term electricity contracts can be used as collateral for private financing of additional ethanol/sugar production capacity (leverage of investment), which in turn will produce more electricity and can allow a higher participation of these plants in the system's expansion. Finally, bioelectricity plants can qualify for carbon credits (cuts in greenhouse gas emissions generated by these projects would count against the investor's own emissions reduction commitments), which can provide additional revenue streams to leverage investment in clean energy. The bioelectricity alternative has become a win-win situation for consumers and environment, relying on private investment and competition. In schemes such as this, the government has an essential role as regulator and promoter of efficiency and technological advances.

Energy and Environment in Chile: Lack of Energy Resources, Hydroelectricity, and Imported Coal

Chile has abundant hydraulic energy resources but is devoid of fossil resources, such as coal, petroleum, or natural gas, which are necessary for the complementariness of the Chilean energy matrix. This implies the necessity to import important volumes of petroleum for effects of industrial consumption and transport and coal for electrical generation. In the context described, it was very attractive to begin the import of natural gas from Argentina for the Chilean central zone in 1997 and for the north of the country in 1999. Chile took advantage of a very low price resource that was thought to be abundant and reliable. The Argentine natural gas import derived from investments of approximately US$4,000 million dollars, including the construction of four new gas pipelines along with several combined-cycle generators. The arrival of Argentinean natural gas implied a turn in the Chilean energy matrix, reducing the power generation with coal, allowing a complementariness with the dammed hydraulic resources and an important diminution of the costs of the electrical energy in Chile as well as of emissions.

Nevertheless, in the last ten years, Chile has undergone two major crises of its two main supplies for electricity generation. First, crises occurred in 1997–1999 in the main electricity system, the SIC (Figure 10), the product of an extreme and prolonged drought, which implied a drastic diminution in the capacity of hydroelectric generation. The second episode, which has been in effect since April 2004, corresponds to the imposition of restrictions by the Argentinean government to the exports of natural gas to Chile. These restrictions affect seriously the provision required in Chile, which presently imports from Argentina all of the natural gas used for generation by means of combined-cycle plants (Figure 11).

This last event has implied a greater use of hydraulic energy along with thermal generation on the basis of coal and diesel petroleum, fuels that coincidently show a sustained rise of prices worldwide, which translates into high generation costs and the obvious higher impact on the environment, hence causing a heated discussion on the subject in Chile.

Hydro Development and Environmental Constraints

The true challenge for Chile is that it must obtain its power diversification and sustainability in the scheme of a competitive

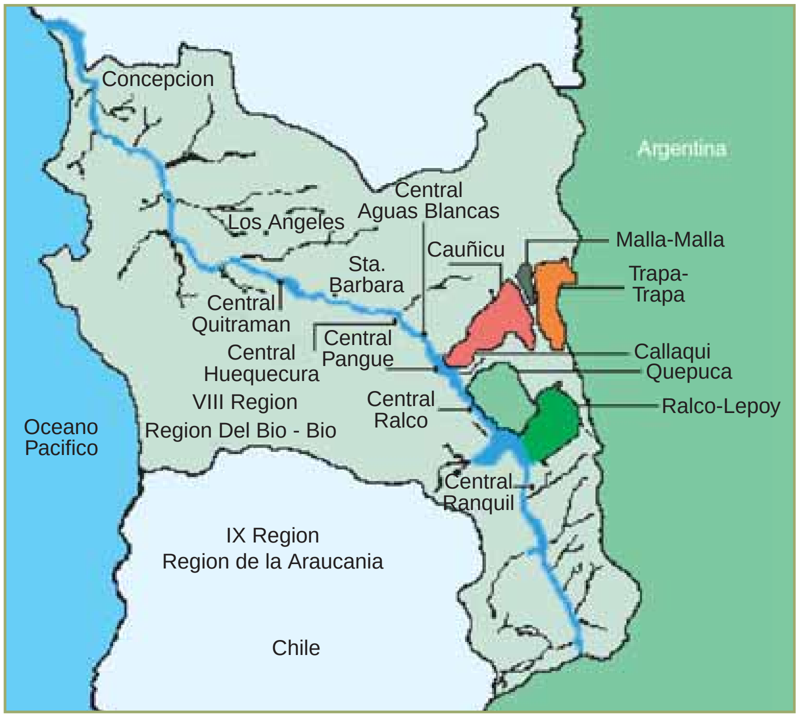


figure 12. The Bio Bio basin, indicating existing and projected plants and indigenous communities.

market and with limited state intervention. Chile was a pioneer in liberalizing the electrical generation segment in 1982, introducing a competitive and private market, where the entrance of new agents depends on the economic signals that the investors gather from the market. Therefore, in Chile, the decision regarding what technologies to develop essentially relies in the private capital investment evaluation. The government is solely limited to generate the conditions so that it is possible to reach economic efficiency.

The process of liberalization and deregulation of the electricity market was accompanied by the privatization of the existing state-owned electrical companies. Currently, the government's influence in the sector is limited mainly to regulatory function, elaboration of indicative expansion plans, and fixing of electrical tariffs for regulated clients. Objectives such as the diversification of the power matrix and environmental sustainability conform to a secondary level, where the government has limited tools to intervene. The development of the generation segment has occurred within the framework of technological neutrality, as far as the technologies and fuels used, having all types of energies to compete in similar conditions of quality and price.

Over the years, hydro plants seemed to lose advantage over fossil-fueled plants, particularly when abundant Argentine gas was available at a low price, such as combined cycles, but now they have been revisited under the current crisis situation. There are still important unexploited resources in the country; however, these resources are located either in indigenous populated areas, in regions with a high tourist potential, or in unexploited natural forest reserves. Some recent examples are the Ralco plant commissioned in 2004 and the Aysen project, which is currently under study.

Ralco was built in the high Bio Bio basin (Figure 12), the basin with the highest energy potential in the country (only Pangue and Ralco, 467 MW and 690 MW plants, respectively, are in operation, with the potential in the basin being 2,900 MW). Ralco, the plant commissioned in 2004, faced important opposition, led by environmentalists that questioned its environmental impact and its social impact on Pehuenche communities living in the area because it would flood an area of 35 km^2. The Ralco project was complicated by many factors. Strong opposition by environmental groups developed and were even supported by international groups (such as International Rivers Network). CONAMA initially did not accept the Environmental Impact Study submitted by the project owner, but a new study was presented and accepted. Although not directly involved in the concession process, the National Corporation of Indigenous Development (CONADI) rejected the building of the plant. This occurred because, although most Pehuenche families living in the Ralco area agreed to sell their lands to the owners and accepted relocation elsewhere, a few families refused to sell. Even the judicial courts intervened. Furthermore, the World Bank also intervened; its IFC branch complained to the Chilean government that there were environmental requirements agreed to under a financing package that were not being fulfilled by the Pangue and Ralco plants. The discussions were not limited to legalistic or social terms; the parties involved developed technical and economic studies to demonstrate that the Ralco plant was or was not the best solution for electric energy supply in the country. However, differences arose on how to quantitatively measure the environmental impact, as regulations in place do not provide for a method to quantify it. It is important to highlight that the energy regulatory agency, the National Energy Commission, had no tools to intervene.

Nobody in Chile has remained indifferent to the discussion on the construction of hydroelectric power stations in the Baker and Pascua rivers, located in the extreme south of Chile in the Aysen region (Figure 13). The project owner has announced that the project consists of the construction from 2009–2018 of four hydroelectric power stations with a joint installed capacity of 2,430 MW. In addition, the project involves the construction of a transmission line in direct current of 2,000 km to unite the power stations directly to Chile's capital, Santiago, the largest demand center. The project involves an investment superior to US$4,000 million dollars. These power plants will allow the access to energy of clean production in great volumes, energy of a domestic origin that will contribute to reduce the foreign fuel dependency. These projects will also allow, during their construction, an important economic contribution to the zones where they will be located. It is important also to recognize that these power stations will be inserted in zones of great natural beauty, not spoiled by man. Its construction, without a doubt, will cause alterations to the ecosystems of the zone, with a total flooded surface of 93 km^2.

The development that finally achieves the Aysen project will be a test of maturity for the Chilean model and the ability of the deregulated electricity markets to satisfy the interests of the country. As never before, Chile will need a long-term vision that sees far beyond short-term interests or necessities. The benefits or costs that the construction of these hydraulic power plants will bring to Chile will remain for generations of Chileans to come.

Natural Gas Being Replaced by Coal and LNG

Given the natural gas import restrictions, the National Petroleum Company (ENAP) was given the task of leading a pool of large natural gas consumers who have grouped an attractive demand, which through an international bid hired British Gas to invest in a regasification terminal located in central Chile, along with the supply of LNG. Nevertheless, the high world prices exhibited by LNG anticipate that this one single alternative will have a backup function, more than a source for generation expansion. This project has already been given environmental licensing, which was pursued by ENAP prior to the international bidding.

With those restrictions, coal-fired plants are again being considered in the country as a tool for development. They are being planned equipped with pollution controls like circulated fluidized bed or pulverized coal with additional pollution filters, with the added costs of emissions mitigation equipment negatively impacting their economical assessment. Environmental opposition to thermal plants in the central part of the country is growing strong in the country, and current projects under study have faced long environmental licensing.

Other Paths: Renewables, Clean Technologies, Energy Efficiency, and Demand Management

Although the environmental preoccupation is to remain a central issue in the economic development of Chile, there is consensus that the energy supply of the country as a whole must not be neglected, differences arising on what path to follow. Principles for the establishment of a power policy must consider economic efficiency, energy supply security, and social and environmental sustainability. It must be remembered that substitute projects for hydroelectricity, in the volumes required for the development of Chile, are generation plants burning fossil fuels (coal, natural gas, or diesel) and even nuclear energy. Nonconventional energy, such as renewables, will contribute to the power supply but not in the volumes that Chile requires for its economic growth. Similarly, power efficiency is a path that must be pursued but will not be a complement to the necessary power generation investments. Nonetheless, other initiatives have been undertaken in order to deliver environmentally friendly development for Chile, some of which are discussed in the following.

Renewable energy is being incentived in Chile in the form of so-called nonconventional renewable energies, such as mini hydraulic generation, wind, geothermal generation, biomass, and biogas, among others. Law 19940, enacted in March 2004, modified the electricity regulatory framework, incorporating access to the generation markets for small generators connected to the grid; in this scope, preferably nonconventional energies and cogeneration projects will develop. The dispositions are mainly focused on ensuring the right of any generator proprietor to sell its energy in the spot market at the instantaneous marginal cost and its capacity excesses at the regulated price. Also, conditions are created to give greater stability and security in the remuneration of the energy produced by small generators in addition to the exception of the total or partial payment of tolls for the use of the main transmission system. In 2005, with the enactment of Law 20018, the access for nonconventional renewable energies to the 5% of the annual volume of energy bid on by distributors was guaranteed. It is clear that more can been done in this matter, especially considering the enormous potentials available in Chile.

figure 13. The Aysen basin.

Clean Development Mechanism projects are growing in Chile, where they are expected to be an important driver for clean energy development. The Chacabuquito Project is the first Clean Development Mechanism project in Latin America and consists of a run-of-the-river power plant of 25-MW capacity that utilizes the waters of the Aconcagua River. It is located in the 5th Region, about 100 km northeast of Santiago. The total cost of the project is expected to be US$37 million. The Prototype Carbon Fund (PCF), a private-public partnership operated by the World Bank, has contracted to purchase at least US$3.5 million of emissions reductions from the project.

Another key aspect in the energy policy of any given country is the incentive in energy efficiency, a concept that must be integrated into the development of the country as a whole. It is a necessary objective to uncouple the economic growth of the country from the growth of energy demand. Chile is working, through a national program called Programa Pais Eficiencia Energetica, in a joint venture of the public and private sector to generate lines of intervention that will allow the introduction of energy efficiency in the national economic activity.

With the enactment of Law 20018 in 2005, demand-side management is given as another solution for making the Chilean energy growth compatible with limited domestic energy resources, giving the opportunity for an effective solution that has a smaller social and economic impact, than, for example, rationing. The reform implemented allows flexible handling of the demand, where possible, with price incentives to negotiate reductions of consumption between generators and regulated clients. Until the enactment of the aforementioned law, only large consumers were able to receive such incentives.

Challenges

The primary challenge for South American countries is to ensure sufficient capacity and investment to serve their growing economies reliably. Social and environmental impacts are an inherent part of electric markets and cannot be swept under the rug. The concern with the environment is absolutely legitimate but, in some cases, has resulted in the construction of more expensive equipment. Obviously, the interest of a local population should be considered and respected, but the legitimate interest of the society to have energy at the lowest possible cost also should not be ignored.

The most fundamental challenge is to allow the society to know, through lively participation in the studies and licensing process of hydro and thermal plants, that there is no competitive energy with no environmental impact. A policy of zero environmental impact has obviously a very high economic cost, and the society must be aware of this tradeoff so that the best option to reconcile environmental concerns, economic growth, and social justice can be chosen.

The challenge for the countries of South America is to balance requesting extra environmental requirements with the ensuing increase in marginal costs and, finally, energy prices. This is not an easy equation. The authority must determine how much the reduction of an additional kilogram of a polluting gas is worth to society. Additionally, it must find the mechanisms that would allow incorporating this cost into each agent's decision-making process. The rapid and hardly predictable changes in the sector, including national and international interconnections of the power and gas networks, strategic considerations by firms, availability of fuels, and increasing public participation, make this a complex task.

Acknowledgments

The authors gratefully acknowledge the valuable contributions by Fondecyt and Universidad Catolica de Chile and the valuable discussions with Mario Pereira from PSR.

For Further Reading

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