The Future Of Large Dams In Latin America and the Caribbean: IDB's Energy Strategy for the Region

By
Jaime Millan
Principal Energy Economist IDB

1. Introduction

Latin America and the Caribbean (LAC) has been unique among regions because of its high reliance on hydropower in meeting electricity generation needs. Although this has resulted in cheap electricity and significant lower emissions of greenhouse gasses (GHG) it has also impacted the local environment, in ways not always for the good. The region has learned a lot since the sixties and seventies when it entered into a dash for hydro as a solution to rising oil prices. At the dawn of the new century the region has found in natural gas a cheaper alternative to hydropower for electricity generation. However, rising concerns for GHG emissions, associated with thermal generation, may put a premium on hydropower as the only available source with the potential to make significant contributions to diminish emissions in the short term.

This paper addresses the question of what the future role for hydro might be in meeting the electricity needs of LAC, what issues are involved and what actions the IDB could take to support these developments. Section 2 of the paper summarizes energy resources production and use in the LAC region, including associated environmental impacts. Section 3 discusses the energy outlook for the medium term in the region, highlighting the critical role of natural gas as a bridge to the new energies of the future, the roles of energy efficiency, renewables and hydropower. Section 4 provides a brief description of IDB involvement in Large Dams and section 5 outline the Bank's intended strategy for the next ten years. Finally, section 6 provides a summary and conclusions.

2. Energy Resources, Production, and Use in LAC

The countries of Latin America and the Caribbean have abundant and varied energy resources, including oil (13% of world reserves), natural gas (5.4%), coal (1.6%), biomass and other renewable resources, as well as great hydropower potential (22%). This apparent abundance of reserves in the region can be misleading, however, because they are highly concentrated in a few countries and there are other factors that limit the extent to which they can be developed at competitive prices. Venezuela and Mexico have the largest oil (88%) and gas (77%) reserves in the region. The economically feasible hydropower potential is more evenly distributed, but relative costs and/or local environmental problems mean that hydropower generation will only play a significant role in a handful of countries over the next few years. Other countries have considerable potential for unconventional renewable energy sources (solar, wind-powered, and geothermal energy), but their development is limited for geographical reasons and the high cost of technologies involved.

Despite the limitations, there is an enormous potential for trade in energy in the region. Currently, intraregional trade is dominated by exports of crude oil and its byproducts, but there are promising, albeit still incipient, prospects for integrated energy markets using integrated grid, for natural gas and electricity, for instance. For the time being the integration of gas and electricity markets has made the most progress in South America, where major international gas pipelines and electricity interconnecting grids already exist or are being built. However, eventually the SIEPAC power interconnection project and a possible gas pipeline from Mexico and/or Colombia will make it possible to integrate the electricity and natural gas markets of Central America with those countries.

Spurred by economic development and the population growth, the demand for energy in the region has been increasing at rates substantially above those in OECD countries. [1] Nevertheless, per capita energy consumption in the region, and electricity consumption in particular, will continue to be far below that of developed countries (2,300 kilowatt-hours in LAC compared with 12,000 kilowatt-hours in the United States and 6,000 kilowatt-hours in Europe). Within the region, markets are far from homogeneous. Four countries, Mexico, Venezuela, Brazil and Argentina, consume 73% of energy and 79% of electricity.

As for consumption by sector, industry (34%) and transportation (31%) are the biggest energy users, as they serve the most highly urbanized region in the developing world. The transportation sector accounts for 55% of all petroleum products consumed in the region, and the amount it consumes is growing at 3.5% a year. Energy consumption in rural areas is dominated by the use of biomass for cooking.

Demand for electricity, which accounts for close to 20% of the total demand for energy, grew at an annual rate of 5% between 1990 and 1995, [2] and it is expected to continue growing at that pace in the years to come. Primary energy used to generate electricity mainly comes from renewable sources (69% hydro and 1% geothermal), followed by thermal generation (14% oil products, 11% natural gas, and 3% coal, 2% nuclear). The industrial and household sectors consume most of the electricity (46% and 31%, respectively), although the distribution varies significantly from one country to another.

LAC has the highest electricity coverage (84%) of any region in the developing world. This high electricity service coverage disguises the fact that approximately 75 million people still lack it, mostly in the countryside. Indeed, about 60% of the rural population has no access to electricity. Much of the energy consumed in the countryside is still "traditional" (mainly burning of biomass materials in cooking). These traditional practices, which involve unsustainable consumption of resources, not only do cause major damage to the environment by reducing vegetation and forest cover; but also cause severe respiratory health problems, particularly in women and children. Despite the fact that the rural

---

1 See IEA's World Energy Outlook 1998 Edition.

2 Financial Times, *Electricity in Latin America*, London, 1995.

population without access to electricity has been dropping in absolute terms over the past 20 years in Latin America, the shift to modern forms of energy is not occurring as rapidly as it should. There is also a strong correlation between levels of development and electric power coverage. The countries in the region with the lowest levels of access to electricity are the least urbanized countries: Honduras, Haiti, Bolivia, El Salvador, Guatemala, Nicaragua, and Peru, for instance, where less than 20% of rural households have electricity.

Although there is no thorough and exact assessment of energy efficiency, most studies indicate that there is great potential for investment to improve it in the region, especially in the transportation sector. The use of renewable forms of energy from new sources (other than hydropower and geothermal sources) is still incipient in the region, as in the rest of the world.

The local environmental impact of energy use is dominated by atmospheric emissins from the transportation sector. Small particle emissions, known as PL_{10} (particles of less than 10 microns in diameter) and sulfur dioxide emissions are responsible for thousands of premature deaths every year. As regards global climate change problems, greenhouse gas emissions in the region are significantly below those of the OECD countries and of the rest of the developing world, mainly due to the high hydropower component in the energy basket for electricity generation. The Intergovernmental Panel on Climate Change estimated that in 1990 emissions from Latin America and the Caribbean accounted for 4.8% of global gas emissions. The transportation sector is also the main source of CO_2 emissions (35%), followed by industry (22%).

3. Energy Outlook 1999-2006

A. The trends

Driven by economic development and demographic growth, demand for energy in the region will continue to increase over the next decade. The demand for oil, which grew at an average annual rate of 3.5% over the past decade as a result of the use of cars, will increase at an even faster pace due to urbanization and improved living standards. Demand for power is also growing (at an average annual rate of around 5%), although the pace of growth is beginning to slow as a result of eventual market saturation and greater efficiency in end-usage[3]. In 1997 we estimated around 80 GW of new installed capacity will be needed in the decade ending in year 2006. However, owing to the abundance of natural gas and the marked decline in costs following the introduction of new combined cycle gas turbines (CCGT), environmental considerations, and other reasons, the relative share of primary sources in meeting this demand may change considerably. Thus, the share of generation capacity based on natural gas will double by 2006 while the oil-fired capacity share will fall to half its current level. Coal's share will stay the same and renewable energy will decrease some four percentage points.

[3] At this moment, recesion experienced by most countries in the region has considerably slowed this rate.

Natural gas will become the bridge fuel toward the clean and cheap energies of the future, and will call for major investments, especially in gas pipelines. The share of natural gas in the basket of primary sources for power generation will increase, reducing the relative share of oil byproducts and hydropower Trade in natural gas will grow at a substantially faster pace to cover demand, with Mexico importing in the short term, and Brazil and Chile in the long term. For the first time there will be extensive drilling for natural gas, rather than oil, as the main objective.

The new investments in electricity will be less capital-intensive than in the past and so will be total investment (US$15 billion per year compared to an estimated US$24.5 billion in 1991). Nonetheless, investment needs in the region will continue to be dominated by the drilling and production of oil and gas and power generation.

The percentage of greenhouse gas emissions from power generation will continue to be very low, compared to other regions of the world. Nevertheless, urbanization will accelerate the increase in the number of cars, which in turn will lead to an increase in fuel consumption, traffic congestion, and environmental degradation.

B. Natural gas as a bridge to the clean, low-cost energies of the future

Natural gas has become the fashionable turn-of-the-century fuel, not only in Latin America but also throughout the world, even in countries that do not have reserves. This spectacular promotion of natural gas can be attributed to technological change in power generation, the fact that natural gas is the cleanest fossil fuel, deregulation of power and fuels markets, and regional economic integration.

The major technological breakthroughs in power generation in the past 50 years have occurred in the past decade, with the development of gas turbines and the so-called combined cycle gas turbines (CCGT). This technology, which applies developments in aviation turbines to electricity generation, has raised average energy efficiency from 22% with the gas turbines of the 1980s to close to 50% for simple cycle turbines and 60% for CCGT. At the same time, costs per installed kW have fallen to almost US$350 (today), less than 40% of the cost in 1985 constant dollars.

Even more important is the fact that these gains occur even for plants as small as 150 MW, much smaller than those previously envisaged, thereby practically eliminating the economy of scale problem that other generating technologies face. In addition, because less time is needed to make a plant operational (now approximately a quarter of the time needed for conventional thermal plants), expansion can be carried out module by module, more closely following demand and thereby fostering competition in the power generation market. In places where natural gas is available, the cost per kilowatt-hour of generating with CCGT has fallen to at least half the cost of the closest competing source. This progress in terms of efficiency, combined with the fact that natural gas is much cleaner than other hydrocarbons per unit heating values, means that atmospheric emissions per kilowatt-hour are substantially lower than with any other type of generation, except hydropower, renewable sources, and nuclear energy.

The liberalization of the natural gas industry, first in the United States and then in the United Kingdom, led oil companies to begin developing numerous fields that had been dormant and, for the first time, drilling for natural gas rather than oil became their main objective. In other words, the interaction of supply and demand broke through the vicious circle: no drilling for gas because there is no demand for it, and vice-versa. Since deregulation of the oil and gas market in Argentina, demand has increased considerably without this leading to a fall in reserves that could jeopardize meeting demand; indeed, Argentina has become the principal exporter of gas in the region. Recognition of the dynamic nature of the relationship between reserves and output means that the old static notion is no longer relevant as a measure of reserves. As a result of economic reforms and the opening up of economies in most of the world, the natural gas trade has grown tremendously, making it possible for many countries to import the resource and use it to transform their own energy sectors.

Known as the "dash for gas", this phenomenon spread very quickly from the United States and England to the Latin American and Caribbean region. Thus, in the 1980s, the only country where gas played a significant part in the energy matrix was Argentina. Today Argentina has raised the share of gas to around 51% of total energy use and exports natural gas to neighboring Chile, Uruguay, and Brazil. Brazil is aiming to increase the share of gas, from its own output and imports from Bolivia and Argentina, to 16% by the year 2006; while almost all new electricity generation in Mexico, Peru, and Colombia will use natural gas. Colombia has an aggressive drilling program aimed at increasing its natural gas reserves to serve possible markets in Central America and Ecuador. At the same time, it has actively deepened the natural gas market in such a way that by the end of the century approximately 60% of the country's population will have direct natural gas pipe connections. Venezuela has substituted gas for oil fuels in all its generating plants, and only exceptionally low-cost projects like the hydropower plants on the Bajo Caroní can compete with gas-fired generation projects. Ecuador is drilling for natural gas in the Gulf of Guayaquil and Central American countries are studying the feasibility of a gas pipeline that would allow them to import natural gas from Mexico or Colombia. If this trend were to continue, it would revolutionize energy sectors throughout the isthmus, since the gas would replace hydropower and coal-based thermal plants (which are expensive and environmentally problematic), and natural gas would replace electricity for cooking. In addition, it would contribute to the liberalization of oil and gas markets by getting rid of the inefficient, protected local refining industry.

In short, if current trends continue, new investment in electricity generation will be dominated by natural gas in the vast majority of countries in the region, except in the Caribbean island countries, which have no gas, and in Brazil,[4] whose huge needs and abundant hydropower resources imply natural gas will play a relatively moderate role.

[4] Although there is some long-term speculation about building a gas pipeline which would serve the Puerto Rico and Florida markets from Venezuela, along with the other Caribbean island countries.

C. The role of end-use efficiency and new forms of renewable energy

Efficient use of energy by end-users and the utilization of renewable sources to generate power are the core options put forward at the Kyoto conference to combat climate change. Many authors consider that these sources would be competitive and would be adopted by the market were it not for the existence of rules of the game that discriminate in favor of investing in conventional energy supply options, in addition to other barriers and market flaws. [5] To overcome such barriers, over the past two decades electricity regulatory agencies in the United States and other developed countries have promoted instruments such as Demand Side Management (DSM) and Integrated Resource Planning (IRP) in the vertically integrated power monopolies in their countries. NGOs and some governments have lobbied in the 1990s for multilateral organizations to promote the adoption of such measures in developing countries as well. However, with market deregulation, both DSM and IRP have lost ground and countries are faced with the need to seek effective alternatives to foster the use of renewable sources and efficiency in end-usage in the new competitive environment.

Attempts to make energy consumption more efficient have not had much success in the region for various reasons; only Mexico and Brazil show significant energy savings. Apart from hydropower and geothermal energy, at the moment there are no renewable sources in the region that could be competitive on a significant scale. Renewable small-scale sources of energy are only competitive in certain niches, such as remote rural areas unconnected to the network, and as support for distribution networks in certain cases (what is known as distributed energy).

While the modernization of the region's economies, the shift toward services, and the incorporation of new, more energy efficient industrial equipment will reduce their energy intensity, countries wishing to promote the rational use of energy still face the challenge of overcoming barriers to energy-saving measures and the introduction of efficient appliances. In competitive markets, the main incentive for efficiency is the price signal, although the presence of barriers and market flaws slanted against it may argue a "provide a rational for" for careful market interventions to reduce anti-efficiency bias. These interventions range from the adoption of labeling and minimum efficiency standards for appliances and building codes; strategic partnerships with equipment suppliers through government incentives that reward the introduction into the market of more efficient models and/ or discourage imports of inefficient equipment; coordination with financial institutions and other market players in devising mechanisms to foster the establishment of energy service companies and/or other forms of reducing transaction costs for industrial clients; for instance, offering them a comprehensive package of services that raises their productivity and helps to improve their competitiveness; and supporting the creation of renewable energy markets in niches that may be price-competitive.

[5] See the plan of operations for the "Sustainable Markets for Sustainable Energy" technical assistance program.

D. Rural energy

Traditionally, rural electrification programs have been centrally planned with somewhat limited objectives. They involved large, often poorly targeted subsidies, and lacked sufficient community support and participation. The existence of State monopolies in electricity distribution meant that many countries in the region carried out expensive and inefficient expansions of their rural distribution networks, with goals that often had little to do with the sector itself. Yet this "hidden competition" in the form of a possible expansion of the network through generous subsidies constitutes a major barrier to the entry of other players that could supply electricity using alternative sources of energy at competitive prices.

Although the region as a whole has the highest electricity service coverage of any region in the developing world, it is also true that there are countries where less than half the population has access to those services and countries in which the expansion of electric power to rural areas was done inefficiently and at the expense of large subsidies that cannot possibly be continued. With restructuring, countries have the opportunity to correct these mistakes by taking advantage of the new arrangements and technologies available in decentralized markets. Nevertheless, such countries also run the risk that political pressures may lead to a perpetuation of subsidies for the network in some less than transparent form, which would restrict opportunities for other more efficient means of service delivery in these areas, such as decentralized systems based on renewable forms of energy. Ingenious ways have to be found to make access to electricity affordable to the poor without distorting the utility tariff signal. One such way might be to direct the subsidy toward the purchase of energy efficient (household and other) electrical appliances by low-income consumers.

D. The role of hydropower

Hydropower is not longer what it used to be during the golden seventies when the whole region was engaged in dash for hydro. Most of the best sites have already been developed and new sites face environmental restrictions so the long run marginal cost of hydropower has increased relative to other alternatives. Today hydro faces stiffer competition from thermal power as the high oil prices forecasted a couple of decades ago never materialized. Furthermore, the already mentioned technological change in gas-fired power generation technology has made a difficult case even worse. A key feature of investments in hydroelectric power generation projects is that they require long term loans with extensive grace periods because they are capital-intensive, have a long construction phase with significant risks and have a long useful life. Long term finance is a scarce commodity nowadays, no wonder new private developers prefer thermal plants. It is not only the environment that is conspiring against hydro development.

Nevertheless, there remain many instances in which hydro alternatives still may be the most economic way to produce power. As mentioned before, hydropower will most likely constitute the main source for Brazilian electricity for at least a decade, Venezuela still

has not completed its development of the lower Caroní River Basin and may have interesting sites in the upper basin, and there are other countries, such as Peru and Ecuador, which may either experience some delays in joining the dash for gas or may have important and competitive hydro developments available. While there are still some old faces in the pipeline of potential projects involving large dams, (some cheap and relatively problem- free like Corpus in the Paraná River, some more questionable like Boruca in Costa Rica), there are new sites like Cheves, a 520 MW high head project in the Huaura river in Perú, which for one reason or another didn't figure prominently in the old expansion plans of the golden age. Also, neglected by the earlier inventories are small and medium size sites or even scaled down versions of old projects. The development by the private sector of smaller, 25 MW, high head and relatively environmentally sound projects in Colombia and Costa Rica is an indication of what may lie ahead.

Furthermore, because of the still important role that hydropower may play in meeting some countries' needs it is clear that there is wide scope for using various instruments to support the development of the region's hydroelectric potential in ways that are both economical and sensitive to local environmental and social impact. The Clean Development Mechanisms of the Kyoto Protocol may well enlarge the list of hydro projects that could be competitive in the new energy markets of the LAC region.

4. The IDB and large dams

Since its inception in 1961 the Bank has made loans for dam-related projects of around US$8600 millions. As shown in the table below, most activity (83%)[6] was conducted in hydropower, dwarfing loan activity in other sectors like water supply and irrigation. Close to 75% of the loans for hydroelectric projects were made during the late seventies and early eighties and around 80% of it was concentrated in Argentina, Chile, Brazil, Colombia and Venezuela.

[6] While figures are in current dollars the percentages shown wouldn't change much if applied to constant dollars.

Table 1
Dam Projects Approved by the IDB 1960-1999
(By sector, in millions US$)

	1960-69	1970-79	1980-89	1990-99
Energy	183.30	1,932.40	3,396.71	1,657.00
Irrigation & Drainage	8.78	373.51	359.08	52.25
Water Supply	9.96	24.02	348.92	325.00
TOTAL	**202.04**	**2,329.93**	**4,104.71**	**2,034.25**

Most of the largest projects experienced delays and cost overruns; the Yacireta project in Argentina-Paraguay whose first loan was approved in 1979 is still unfinished. Despite a few big fiascos, like the above-mentioned Yacireta (2400 MW?) and the Guavio project (1000MW) in Colombia, riddled with scandal, cost overruns and many other problems, there were also many successes. The Arenal project in Costa Rica was a model for resettlement; the Playas project (340 MW) in Colombia was completed on time under budget, and without any environmental or social problems. Other projects like La Fortuna in Panama, Salto Grande in Argentina-Uruguay had relatively few environmental problems. The Segredo Project (1200 MW) in Brazil broke the oligopoly of the big Brazilian construction firms, to name just a few. In general, the environmental performance of Bank financed projects has improved with the passage of time[7], as concerns for the environment and social issues became part of the agenda pushed by NGOs and some governments. The creation of the Environment Division in the Bank in the late 1980s reinforced and consolidated this trend. One clear example could be noticed in the results of the study performed by the Sustainable Development Department of the Bank to evaluate the design and implementation of programs for resettlement of population in 18 Bank financed projects with information available.

[7] See Inter-American Development Bank. 1990. "Summary report on environmental planning and management for water impoundment projects." Office of the Controller. Operations Evaluation Office. Washington, D.C.

.

Table 2
Evaluation of Design of Resettlement Programs in Dam Projects Approved by the IDB 1960-1999
Number of Projects

Category	**1960-69**	**1970-79**	**1980-89**	**1990-99**
I (Satisfactory)		1	3	1
II (issues addressed but little consultation)		1	2	
III (plan but major issues no addressed)		4	1	
IV (no plan included)	1	4	1	
Total	**1**	**10**	**7**	**1**

The same trend is observed in the implementation of the resettlement plans. Out the twelve projects in the seventies nine were in category 4, which means that serious problems were observed with not actions taken by the borrower, the remaining three were in category 1 or satisfactory implementation. During the eighties only one out of three projects remained in category 4.

During the first half of the nineties lending for hydropower slowed down as many countries privatized their power sectors but loans included the 2200 MW Caruachi project in Venezuela, the 340 MW Porce III project in Colombia and the 1400 MW Segredo project in Brazil. During the second half of the nineties the public window of the Bank didn't make any loans for hydropower, while the private window made one loan for the Ita project in Brazil and has a couple of others in its lending pipeline.

5. Highlights of the New IDB's Energy Strategy

The Bank has recently completed a new energy strategy to position itself in the new energy markets at the dawn of the new century. The overall challenge facing the Bank is to help countries reform their sectors so that they could be developed in an economically, environmentally, socially and politically sustainable way. The challenges faced by the countries fall into five major areas:

- consolidation of the structural reforms and the new institutional and regulatory frameworks started during the nineties;
- provision of access to modern energy to all citizens;
- development of energy consumption and production patterns compatible with the environment;
- integration of regional energy markets; and
- mobilization of financial resources.

To help countries to meet these challenges the Bank will center its activities around the consolidation of sector reform, seeking to agree with countries requiring its assistance on a specific strategy tailored to their needs but encompassing all five challenges in an integrated manner. Also, the Bank will try to use all its instruments and its activities in energy consuming sectors to help countries not only in the supply side but also in the management of the demand.

In this context the Bank will place special emphasis on addressing the urban transportation needs of the most urbanized region of the developing world, help countries in the development of markets for sustainable energy, energy efficiency and cleaner energy by seeking partnerships with strategic allies for technical cooperation and using its experience with small and microenterprises to foster the creation of energy services companies. Also, the Bank will support the development of decentralized solutions based on renewable energy for rural areas and will seek new ways of providing energy services to the poor. The Bank will continue to support the development of integrated regional energy markets for electricity and natural gas. The Bank will continue to help private developers with the financing of generation projects and will seek new financial instruments that suit better the needs of energy projects, including hydroelectricity and energy efficiency. Finally, the Bank will help countries interested in finding ways to develop hydroelectric projects that are environmentally, socially and economically sustainable.

6. Summary and Conclusions

LAC countries enter the new century in the middle of a tremendous transformation of their energy sectors with new actors, new challenges and new technologies. Better energy efficiency certainly will help, but it is not a panacea and the new renewable energies still are too expensive for massive implementation. While natural gas may provide the bridge to the cleaner and cheaper energies of the future, hydropower still has a role to play in this transition, particularly if the Clean Energy Mechanism becomes a reality. While it may be true that the development of new hydro resources faces many environmental challenges, it is also true that this is not a zero sum game and there are many opportunities for win- win solutions. The IDB's experience shows steady progress in addressing the local environmental problems of hydro developments. There are still many resources to be tapped, and it is up to the countries and the Bank to cooperate in developing them in ways that are socially and environmentally feasible.

Jaime Millan 7/26/99 10:21 AM