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The Energy Sector

Opportunities and Challenges

Ariel Yépez
Alberto Levy
Adriana M. Valencia J.

Energy Division
INE/ENE

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Introduction and Context

Energy is crucial to providing nearly all of the goods and services in the modern world. Stable, reasonably priced energy is central to maintaining and improving the living standards of billions of people.

Without heat, light, and power, it would be impossible to run factories, small and large businesses, and farms. And without those things, it would be difficult to provide energy for goods, jobs, and homes, or to enjoy other goods and services that improve the quality of life. Energy, economic growth, and poverty reduction are clearly connected.

Still, a large part of the world's population does not enjoy the benefits of modern energy. 1.2 billion people lack access to electricity and 2.8 billion people do not have adequate cooking facilities. In Latin America and the Caribbean (LAC), more than 26 million people, or 4% of the population, do not have access to electricity. Moreover, at least 87 million, or an alarming 15%, still rely on unsustainable biomass for heating purposes, with significant consequences for income, health, and gender disparities.

The United Nations (UN) General Assembly unanimously recognized that "energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive." The Sustainable Energy for All initiative (SE4All) was created based on this idea and aims to achieve the following three objectives by 2030: (i) to guarantee universal access to modern energy services;[1] (ii) to double the global rate of improvement in energy efficiency;[2] and (iii) to double the share of renewable energy in the global energy mix. Although Latin American and the Caribbean has a very high level of renewable energy already, it still lags in the other two objectives.

1 Access to modern energy is defined as access to electricity and cleaner and improved cooking and heating facilities/fuels, see OECD/IEA 2010.

2 According to the International Energy Agency (IEA), energy efficiency is a way of managing and restraining the growth in energy consumption. Something is more "energy efficient" if it delivers more services for the same energy input or the same services for less energy input (see http://www.iea.org/topics/energyefficiency).

Lack of energy access is just the tip of the iceberg. Energy not only has to be available and inclusive, it must be of adequate quality and, be reliable and affordable. That is, energy has to be available when needed and in the form needed, as well as at a price that is accessible to the general population. To deliver modern energy services, production, transport and distribution infrastructure needs to be in place. This infrastructure needs to be built in the most economical way, balancing short-term with long-term costs and positive and negative externalities. It has to minimize the impact on climate change and be adapted to it. Access is about providing services to those populations not connected and maintaining or even improving the quality, reliability, and affordability of service.

In addition, neighboring countries can benefit from working together and sharing energy sources. A larger, more integrated system reduces the requirements of reserves, takes advantages of diversity of sources and patterns of production and consumption, and is better positioned to absorb system fluctuations and variable generation. And since energy services have their own peculiarities that many times inhibit the working of efficient markets, institutions, regulation, policies, and information collection and diffusion mechanisms need to orient each of the participants in the sector about the benefits, requirements, and limitations that exist regarding their participation.

Based on these relationships, the IDB's goal in the energy sector is to increase access to efficient, sustainable, reliable, and affordable energy in Latin America and the Caribbean. The goal is to provide a diversified and secure energy source while reducing poverty, promoting an improved quality of life, and fostering competitiveness and economic growth and development.

This document presents a review of the findings of international studies regarding the efficacy of energy policies and programs and the challenges that Latin America and the Caribbean face according to recent research.

The analysis is informed by the particular circumstances and needs of each country, as well as by the goals of key regional energy integration initiatives. The energy sector is referred to here as all economic activities related to the use of renewable and nonrenewable resources for the production, delivery, and consumption of energy in its various forms, such as electricity, heat, or fuels for further processing, as well as the optimization of energy use through energy efficiency and conservation.

To approach this complex set of relationships, this document presents the challenges of the sector in the region, recognizing that they are interrelated and have varying levels of importance depending on the country in question.

Thematic lines, Challenges, and Opportunities

ENERGY ACCESS—
COVERAGE, RELIABILITY, AND AFFORDABILITY

ENERGY SUSTAINABILITY—
ENERGY EFFICIENCY, RENEWABLE ENERGY, AND CLIMATE CHANGE ADAPTATION

ENERGY SECURITY—
QUALITY OF SERVICE DELIVERED, ENERGY INFRASTRUCTURE, AND REGIONAL ENERGY INTEGRATION

ENERGY GOVERNANCE—
INSTITUTIONS, POLICIES, REGULATION, AND INFORMATION

Photo:
Solar off-grid project
in Coquimbo, Chile

ENERGY ACCESS— COVERAGE, RELIABILITY, AND AFFORDABILITY

Increasing electricity coverage: Electricity coverage in Latin America and the Caribbean was estimated at 96% in 2013, with 26.3 million people still lacking access. While the region's urban electrification rate is now 99%, rural electricity coverage is 82%. Except for a few countries that have low overall coverage, such as Haiti with 28%, most of the population lacking modern energy access is difficult to reach—the poor living in urban areas and on the periphery of cities, or people living in highly dispersed communities in rural or isolated areas. Energy access issues particularly affect women and children, as well as indigenous people and AfroCaribbean populations.

Table 1 presents data on energy access in a select group of countries. Note that 75% of people without electricity in the region are concentrated in seven countries: Haiti (7.5 million), Peru (3.0 million), Argentina (2.1), Bolivia (1.8 million), Brazil[3] and Colombia (1.7 million each), and Guatemala (1.6 million). In contrast, The Bahamas, Barbados, Brazil, Costa Rica, Uruguay, Paraguay, and Venezuela have achieved access above 99%. In terms of access to modern cooking and heating fuels, Argentina, the Bahamas, Barbados, Ecuador, Trinidad and Tobago, Venezuela, and Uruguay have reached 95% coverage. The challenge remains particularly significant in Haiti, where coverage is 9%, and in Guatemala, Nicaragua, and Honduras, where it is less than 50%. 80% of people in the region who use traditional fuels are concentrated in six countries: Mexico (16.5 million), Brazil (11.7 million), Peru (11 million), Haiti and Guatemala (9 million each), and Colombia (6.8 million).

EIGHT PRINCIPLES FOR SUCCESSFUL RURAL ELECTRIFICATION PROGRAMS

- Set up effective institutions to deal with problems.
- Ensure government commitment to fairness and transparency.
- Establish clear planning and selection criteria.
- Provide subsidies for capital costs.
- Charge a price for electricity that covers costs.
- Lower supply barriers, such as connection costs.
- Involve local communities to minimize friction and maximize benefits.
- Reduce construction and operating costs.

Source: Barnes (2007).

3 Given Brazil's large population, while the country has reached access rates above 99%, still a large number of people do not have access to electricity.

Table 1. Access to Modern Energy in select countries in Latin America and the Caribbean (2013)

Country	% with electricity	People without access to electricity (million)	% cooking with modern fuels	People using non-modern fuels (million)
Argentina	95	2.1	> 95	1.67
Bahamas	99	0.004	> 95	0.015
Belize	93	0.023	88	0.039
Bolivia	82.6	1.8	71	3.02
Brazil	99.1	1.7	94	11.71
Colombia	96.5	1.7	86	6.82
Costa Rica	99.4	0.03	94	0.29
Ecuador	97	0.5	> 95	0.61
El Salvador	92.5	0.5	78	1.41
Guatemala	89.6	1.6	43	8.85
Haiti	28	7.5	9	9.48
Honduras	89.2	0.9	49	4.12
Mexico	98.7	1.5	86	16.45
Nicaragua	76.2	1.4	46	3.22
Paraguay	99	0.1	51	3.34
Peru	90.3	3	64	10.99
Suriname	90.3	0.1	88	0.065
LAC	**96**	**26.3**	**85**	**87.4**

Source: IDB estimate based on OLADE electricity data; for non-modern fuels Global Tracking Framework (GTF) 2013.

The IEA forecasts that universal access to electricity in the region will be achieved by mid-2020, however continued intervention is needed to reach this goal. Fastmoving electrification programs include those in Brazil (see Box 1), Bolivia, Guatemala, Honduras, Paraguay, and Peru. However, once countries achieve about 95% coverage, reaching the remaining more remote households is difficult, costly, and slow.

Increasing access requires extending the interconnected grid where possible, while using isolated grids and off-grid technologies, ideally based on renewable energy for remote areas or dispersed populations, because it is often less costly than grid extension. Renewable energy technologies such as mini-grids that use hydro, wind, or hybrid systems and individual systems using solar PV or wind are technically sound and cost-effective. However, their delivery mechanisms need to be well established and regulated. Establishing reliable delivery mechanisms for isolated grid and off-grid service is essential to achieving universal access in the region. SE4All and the Sustainable Development Goals require that countries create universal access plans that indicate the timeframe and required investments to achieve access goals.

Increasing access to modern fuels for cooking and heating: 87 million people in the region still cook with traditional solid fuels such as wood and charcoal. It has been difficult to penetrate the market and promote the adoption of clean and efficient cook stoves for several reasons including the difficulty of introducing new technologies due to lack of information, or culture and traditions that restrict change. Brazil has increased access to LPG for cooking from 18% in the 1960s to 94% in 2012 by creating a national infrastructure for LPG distribution and a retail market with private entrepreneurs, as well as by providing subsidies, first through LPG subsidies to households and then via a specific subsidy targeting the poor as part of a broader social program.

The socioeconomic benefits of electricity include longer hours for indoor activities, higher educational attainment which later results in higher earnings, greater access to information via television, and greater productivity in home business activities. Public benefits include an increased sense of security, greater opportunities for social activities and services, and improved health (particularly important for maternal care) and educational facilities and centers.

Beneficiaries in poor urban and periurban areas have identified the following benefits of electricity access: increased household income due to paying lower energy prices, improved health due to the reduction in indoor pollution from kerosene or charcoal use, improved household security as a result of fewer fires and candles, and greater investment in housing improvements as security improves. Street lighting increases security benefits in public spaces and may decrease violence, especially against women. Increased access to information from listening to the radio or watching television may lead to greater empowerment.

ACTIONS TO IMPROVE ACCESS TO MODERN COOKING FUELS

- Build local value chains for improved cooking solutions;
- Raise awareness of the benefits;
- Invest in local supply chains for clean fuels;
- Develop standards for efficiency, emissions, and safety; and
- Design cooking appliances that meet consumer needs.

Source: United Nations (2012).

Additional investments are necessary to fully reap the development benefits of electrification. Productive-use programs can help increase income generation (e.g., the processing of agricultural goods or crafts for sale), thus giving communities a means to pay for energy. Indonesia and Peru have programs that use a business development services approach to promote productive electricity use and increase productivity via the use of electrical equipment such as lights; water pumps; processors of coffee, cacao, rice, grain, and dairy products; refrigeration; electric motors and saws, and more.

Affordability of electricity: Assisting the poor is crucial to ensure that they receive affordable and reliable electricity service to improve their economic well-being and quality of life. Many countries work to make electricity affordable for all consumers via cross-subsidies for different categories of consumer tariffs (e.g., residential and industrial), different income groups, and customers receiving electricity from different sources (e.g. the integrated grid, isolated grid, and off-grid). Households are often charged significant initial connection fees. It is less common to provide connection subsidies or financing, even though these connection fees represent a major barrier to poor households.

Electricity tariffs and financial sustainability:

The financial and operational viability of electricity providers depends on full cost recovery of an efficiently run operation that provides the right incentives to promote quality service. Electricity needs to be affordable for consumers and tariffs should be adequate to allow service providers to expand the grid, as well as to operate and maintain their facilities. Tariffs set below the costs of efficient operation (e.g. from untargeted subsidies for which the utility is not fully compensated) result in poor utility performance and electricity waste.

Access to modern energy for cooking/heating:

According to the World Health Organization (2014) 4.3 million people per year die prematurely from illnesses attributable to household air pollution caused by the inefficient burning of wood, charcoal, and other fuels. These illnesses could be avoided by switching to stoves that use cleaner, more efficient modern fuels, or by introducing improved stoves for traditional fuels, and/or improving ventilation. Environmental damage from deforestation, land degradation, and regional air pollution would also be reduced.

Energy, gender, and indigenous populations:

Benefits from electrification are especially important for women, children, and indigenous populations. Not burning biomass fuels has proven to benefit women and children who suffer the most from indoor air pollution from these cooking fuels, as well as from the risks associated with fuel collection and transport. Improved stoves provide women and children, the primary fuel collectors, with more time to participate in other activities.

Action is essential to address the barriers that women and indigenous populations face to participate in and benefit from energy programs. The indigenous population of Latin America is estimated at 28 million. To help them it is necessary to integrate a gender and cultural framework into government policymaking and planning; to support civil society organizations working on energy with women and indigenous populations; to train them on the design, installation, operation, and maintenance of renewable energy; and to incorporate gender components in the design and implementation of sustainable energy programs and projects.

REPRESENTATIVE PROJECT

THE NATIONAL SUSTAINABLE ELECTRIFICATION AND RENEWABLE ENERGY PROGRAM (PNESER) is a US$ 443 million Program in Nicaragua financed by the IDB, the Korean Kexim Bank, Central America Bank for Economic Integration, European Investment Bank, Japan International Cooperation Agency, OPEC Fund for International Development, the European Union's Latin America Investment Facility (LAIF), and Nordic Development Fund. The program covers the following areas: (i) rural electrification through distribution grid expansion, (ii) normalization of service in settlements, (iii) small renewable energy projects in isolated areas, (iv) pre-investment studies for renewable energy generation projects in the national interconnected system, (v) energy efficiency projects, (vi) strengthening the transmission system, and (vii) sustainability of existing isolated systems.

To date, the Program has disbursed 50% of the financing, achieving the following progress: (i) 55,500 new households connected, equivalent to 5.5% increase in electricity coverage; (ii) normalization of 23,500 household connections, equivalent to 2.3% of the system; (iii) 5,000 efficient public lighting fixtures replaced; and (iv) 40 km of new transmission lines built.

55,500
new households connected

5,000
efficient public lighting fixtures replaced

Photo:
Electricity Sector Support Program in Corinto, Nicaragua

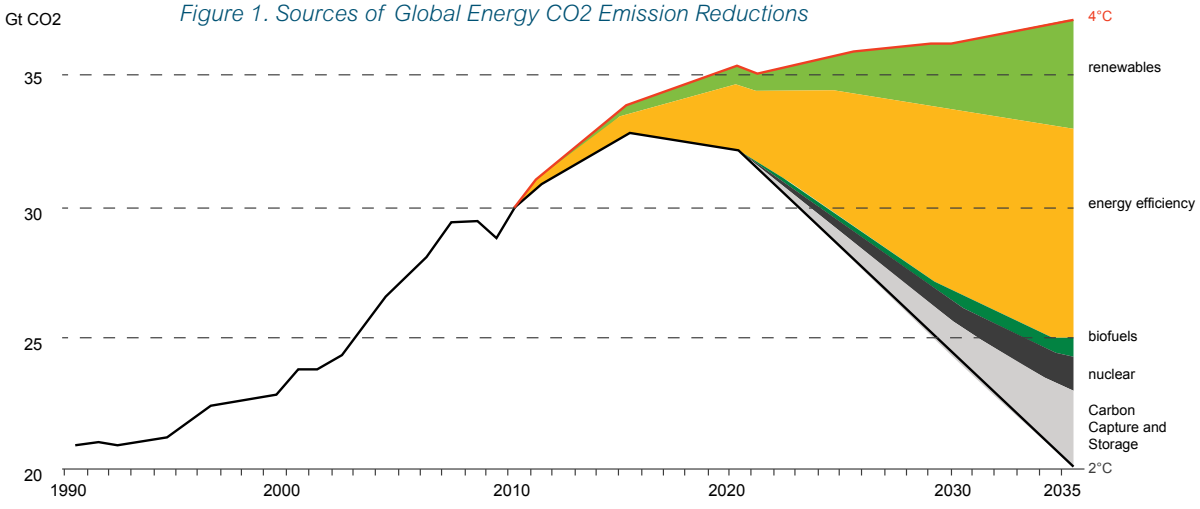
Photo:
Solar pannels in Barbados

ENERGY SUSTAINABILITY—
ENERGY EFFICIENCY, RENEWABLE ENERGY, AND CLIMATE CHANGE ADAPTATION[3]

The central challenge in the region is to ensure the environmentally sustainable provision of energy while still meeting social and economic objectives. Two of the main goals in the energy sector are to reduce the impact of energy on climate change and on urban air pollution. By promoting energy efficiency and renewable energy and supporting technologies such as smart grids, governments can take measures to increase sustainability.

In order to achieve the implementation of sustainable energy systems, it is necessary to change long-standing patterns of energy use and production. The IEA estimates that cumulative energy investments for the region to 2035 will be US$4 trillion. Achieving such a substantial shift in investment in 20 years will require sustained efforts by governments, industries, and consumers.

Figure 1. Sources of Global Energy CO2 Emission Reductions



Source: IEA (2012a).

3 According to the Integrated Strategy for Climate Change Adaptation and Mitigation, and Sustainable and Renewable Energy (GN-2609-1), sustainable energy refers to a sector focus geared toward: (i) promoting universal, reliable, and affordable access to energy services; (ii) supporting the long-run sustainability of energy projects to meet current and future demand; (iii) ensuring quality and promoting economic efficiency in the supply of energy services; and (iv) contributing to the reduction of environmental impact, including climate change. Sustainable energy is also aimed at reducing the vulnerability of national economies to the variability in prices and fuel supply on the global markets and at fostering technology-and employment-driven development that is both environmentally and socially sustainable.

Energy Efficiency: As shown in Figure 1, energy efficiency is the single most important measure that can be taken to increase energy sustainability and reduce energy related emissions. Energy efficiency creates the following benefits: increased GDP growth, improved trade balances, increased industrial productivity and employment, higher disposable household incomes, reduced carbon emissions and local pollution, and deferred investments in energy supply.

Energy prices can motivate energy efficiency, and external actors can play an important role in promoting and disseminating energy efficient technologies. To overcome the many barriers to energy efficiency investments, national governments need to implement energy efficiency programs that have set standards (e.g., for vehicles, equipment, and buildings); provide training, advice and promotional campaigns; and finance investments.

Increasing the efficiency of energy use: It takes governments, investors, and users to achieve energy savings. Brazil, Chile, and Mexico have effective energy efficiency programs that include institutional frameworks, financing, and performance indicators. However, improvement is needed in the following areas (i) continuity of the institutions involved in energy efficiency; (ii) improved energy efficiency knowledge ; (iii) adequate regulations to encourage energy efficiency; (iv) energy prices that reflect costs; (v) lending institutions more willing to finance energy efficiency projects with attractive interest rates and/or less stringent requirements; (vi) more established energy services company (ESCO) market; and (vii) indicators and monitoring systems that measure the concrete results of programs.

ENERGY EFFICIENCY PROGRAMS IN BRAZIL, MEXICO, AND CHILE

Brazil's program aims to reduce electricity consumption by 10% by 2030. It includes a national energy conservation label for buildings, a mandatory appliance-labeling program, and vehicle efficiency standards, as well as efficient public transportation (IPEEC, 2012).

Mexico's program includes funding for research, development, and deployment; a training program for specialists in electricity efficiency; replacement of old refrigerators and air conditioners; efficient lighting and thermal insulation of homes; a voluntary appliance labeling program and an efficient public transit system, as well as standards for efficient vehicles (Mexico SENER, 2014).

Chile aims to reduce energy consumption by 12% by 2020 through a program targeting industry (cogeneration, voluntary accords, ESCOs), transport, appliance labeling, and lighting efficiency, among other actions (Chile Ministry of Energy, 2014).

Source: United Nations (2012).

Increasing the role of renewable energy: To improve environmental sustainability and meet growing energy demands, the region needs to increase its share of renewable energy. The renewable energy potential in Latin America and the Caribbean vastly exceeds demand. However, a significant increase in the role of renewable energy will require countries to develop appropriate and effective policy frameworks, regulations, and incentives.

Renewable energy, including conventional hydropower and non-conventional renewable energy (e.g. biomass, wind, geothermal, solar photovoltaic, solar thermal, and small hydropower) has various benefits, including: improved energy security due to a diversified energy supply and reduced fossil fuel imports; reduced GHG emissions and local pollutants; increased employment and sustainable economic growth; and increased access to modern energy in remote areas or areas with dispersed populations.

Hydropower is the largest renewable electricity source, and it accounts for 10% of primary energy demand and for over 60% of generation in the region. The IEA forecasts that hydropower will continue to dominate generation in the region over the next 20 years, and will require cumulative investments of more than US$250 billion. Latin America and the Caribbean have ample hydropower resources, 25% of which have been developed. Hydro reservoirs often deliver services beyond electricity, such as water supply, flood control, and irrigation.

However, the predominance of hydropower creates challenges. Variability in hydropower production has resulted in power outages and increased the market for natural gas and LPG. This variability is likely to increase with climate change and more competition for water among sectors and countries (in international basins).

Hydropower is technically mature and often economically competitive even though it faces increasing social and environmental challenges (such as methane emissions from reservoirs in certain conditions) that require mitigation and benefits sharing. Affected communities and environmental groups increasingly oppose large-scale hydropower reservoirs since these projects often require moving populations, affect ecosystems and land use, as well as change the flow and quality of water downstream. The development of future projects will require continually advancing sustainability guidelines and criteria, innovative planning based on stakeholder consultation, and the equitable benefit sharing with local communities.

Small hydroelectric plants with under 20 megawatts (MW) capacity and without storage have advantages over large hydro and fossil fuel based generation. Small hydro is often suited for rural areas; it can lower costs by avoiding the cost of fuel and can be maintained at a low cost by a local community. In addition, small hydro has lower GHG emissions compared to low-efficiency diesel generators.

Non-conventional renewable energy: The use of non-conventional renewable energy (wind, solar, geothermal, biomass, biofuels, small-scale hydropower, and marine) has increased significantly in Latin America and the Caribbean in recent years due to its many benefits. Global investment in non-conventional renewable energy has grown rapidly, from US$40 billion in 2004 to US$329 billion in 2015. Mexico and Chile led investments in renewable energy with US$4.16 billion and US$3.5 billion, respectively (Bloomberg 2016). Wind power has experienced the fastest growth in the region, with Brazil adding 2.4 GW, Mexico 522 MW, Chile 506 MW, and Argentina 53 MW in 2015. Mexico and Central America lead in geothermal capacity, with 1 GW and 500 MW respectively. Solar PV, while important in off-grid and rural areas, has experienced a shift in focus from small domestic applications to large-scale power plants, including in Chile and Mexico.

Non-conventional renewable energy is increasingly competitive for electricity generation in the region, even without support mechanisms. Recently in Brazil, wind projects won contracts in nine general auctions by pricing below coal and natural gas projects, which reflects favorable conditions for renewable energy, including good wind regimes and efficient planning procedures with little opposition and backup from hydro storage. In many Caribbean countries, renewable generation can compete with fossil fuels for high priced non-baseload power. In Mexico, wind projects in Oaxaca are competitive with natural gas and are a useful alternative for large consumers. Solar thermal collectors are spreading beyond Brazil, one of the world's top markets. Chile's mining sector is installing solar thermal systems (parabolic trough and flat plate collectors) to meet heating needs in remote locations.

Eleven countries in Latin America and the Caribbean have mandated the use of biofuels in transportation,[4] including the world's second largest producer, Brazil, where biofuels account for 13% of transportation fuels. Argentina was the fifth largest biofuel producer while Colombia was the thirteenth. For biofuels to play a larger role, countries need to harmonize standards to adapt existing and future vehicles to blends, and to develop the manufacturing, import, and export of flex fuel cars and biofuel technologies. Additionally, countries need to pay attention to land use changes, competition with food production, and water use. Further developments in more advanced biofuels such as ligno-cellulosic biomass, waste, or non-food feedstocks could address the competition with food production.

Renewable energy has not competed with conventional energy on a level playing field. One of the reasons is related to fossil fuel subsidies. Eliminating subsidies for fossil fuels reduces wasteful energy use and creates a more conducive environment for investment in energy efficiency and renewable energy. The variability of

> *Local renewable energy development is a high priority in Caribbean nations since they are vulnerable to oil price volatility. However, they face difficulties due to the small size of their markets. A study of renewable energy in island states identified the need to foster renewables via institution building and training to create specialized skills, technology transfer and the removal of import duties on technologies, and the aggregation of projects to develop ownership between islands.*

4 Argentina, Brazil, Colombia, Costa Rica, Ecuador, Guatemala, Jamaica, Panama, Paraguay, Peru, and Uruguay.

non-conventional renewable energy generation and its distributed location have challenged its large-scale integration into electricity systems. In order to address the variations in generation from technologies such as wind and solar PV, complementary infrastructure needs to be implemented. These include hydro generation combined with storage, fast response combined cycle gas turbines, hydro pumped storage, and other storage technologies such as flywheels, batteries, and cold or heat storage. Modern forecasting and control systems allow fast response to variations.

Small-scale distributed generation by the final user requires adequate regulatory frameworks, streamlined permit procedures, financing tools, standards for grid access, affordable installation costs, and tariffs that permit the sale of surplus energy. Each country needs to review the amount of distributed generation that the grid can handle and the responsibility for payment for increased management and additional grid reinforcements.

Many countries in the region have taken action to increase the share of renewable energy in the energy supply mix. By early 2014, 19 countries had renewable energy policies and 14 had targets for electricity generation including Costa Rica with a 100% target by 2021, Guatemala with 80% by 2027, Honduras with 60% by 2022, Nicaragua with 90% by 2020, and Uruguay which already surpassed its goal of 90% in 2014. Many Caribbean islands are aiming to derive 15 to 30% of their electricity from renewable energy by 2020–2029. However, policies and targets are not enough; many barriers to the adoption of renewable energy need to be removed to ensure that targets are actually met.

The Multilateral Investment Fund's 2015 Climatescope report ranked the ability of 55 developing countries to attract clean energy investments based on four parameters: enabling frameworks, finance and investment, value chains, and GHG management activities. Ten countries in Latin America and the Caribbean were in the top 20 including Brazil (2 after China), Chile (3), Mexico (7), Uruguay (8), Honduras (14), Costa Rica (15), Peru (16), Guatemala (18), Colombia (19), and Argentina (20).

Various innovations in policy mechanisms and financing structures, including portfolio approaches, have made renewable energy projects more bankable. Common elements in renewable policies include feed-in tariffs for electricity, auctions to contract renewable electricity at premium prices, renewable portfolio standards, tradable green certificates, net metering that permits self-producers to sell to the grid, and mandated blending of biofuels with fossil fuels as well as tax incentives, in combination with policy targets and support for training and research and development.

Photo:
Yacyretá, Hydroelectric power
station, Argentina & Paraguay

Smart Grids: A smart grid is an electricity network that uses advanced telecommunications and control technologies to coordinate all generators, grid operators, end-users, and electricity stakeholders efficiently. Smart grids are powerful tools for achieving energy security, affordability, and sustainability because they help: (i) manage the energy flowing from renewable distributed generation; (ii) improve energy efficiency and minimize costs by managing consumption using storage devices; (iii) improve system stability, resilience, and reliability by helping to regulate power flows; (iv) reduce transmission and distribution losses by optimizing system configuration; and (v) optimize the use of infrastructure to meet peak demand (Institute of Engineering and Technology, 2013 and 2013a; WEF, 2012). Examples of the use of smart grids in the region include: (i) Chile is developing distributed generation, net metering, and smart grid technologies; (ii) Brazil is also moving on smart grids, including the Cidade Inteligente Buzios Project, which will serve 10,400 customers and aims to make the city a model of energy efficiency; and (iii) Panama is studying the legislative, regulatory, and operational actions needed to adopt smart grids. Wider implementation of smart grids requires policies and regulations, including standardization and certification, system testing, and consumer participation and financing. Large amounts of funding are needed throughout the lifecycle of smart grid development.

Ensuring climate change adaptation: To improve the climate resilience of energy systems, governments need to promote the quality and reliability of energy supply and demand-side adaptation, while the private sector needs to consider these impacts on its operations. Energy system vulnerabilities include: sudden and destructive effects to facilities caused by extreme weather events, such as flooding, destabilization of the hydrological cycle in major basins, the recession of glaciers in the tropical Andes, and variability in the availability of water for hydropower generation and for thermal generation plant cooling. Other impacts are gradual, such as changes in heating and cooling demand, and rising sea levels that affect coastal infrastructure. Caribbean countries and coastal areas less than 10 meters above sea level are particularly vulnerable. Many actions to increase a system's resilience can be implemented at a relatively low cost. To achieve mainstream climate adaptation into the sector, increased awareness, knowledge, and capacity are essential.

REPRESENTATIVE PROJECT

WIND

EURUS is a 250.5 MW wind farm with 167 wind turbines located in Oaxaca. Eurus is one of the first wind farms in Mexico and the largest one operating in Latin America. It sells energy primarily to Cemex under a PPA at a fixed price; any excess is sold to the Comisión Federal de Electricidad, the national electrical utility.

Total project costs were financed with US$375 million debt comprised of IDB A and B loans and seven co lenders including IFC, CAF, DEG, ICO, Proparco, Bancomex, and NAFIN. The IDB lent money to this project in 2009 when credit was scarce in the wake of the 2008 Global Financing Crisis, and at a time when the local banking sector was inexperienced in financing such technologies and private international lenders were not available.

Note: delays due to land registration continue to be a fundamental issue in Mexico and the rest of Latin America and the Caribbean. The IDB must work with governments to improve land title and registration at the policy level, an issue that is extremely important for large infrastructure projects.

250.5
megawatts
wind

Photo:
Eurus Windfarm in Oaxaca, Mexico
© Fuphan Chou, IFC
CC BY-NC 2.0

REPRESENTATIVE PROJECT

Photo:
Hydroelectric Power Plant in Reventazón, Costa Rica

HYDROPOWER

An innovative financing structure attracted US$135 million in senior secured debt from institutional investors, crowding-in a new investor class to long dated infrastructure projects. The project also set a new standard for environmentally sustainable hydropower projects in the region. Environmental components included: (i) a river habitat offset that helps protect river eco-systems and native fish species; and (ii) the construction of a wildlife corridor that allows jaguars and other large mammals to move freely throughout Central America.

In 2012, the IDB approved a package to finance the design, construction, operation, and maintenance of the 305.5 MW Reventazón hydroelectric plant and its associated facilities. This package included US$903 million in financing, anchored by a US$200 million NSG loan and US$98 million in SG financing to ICE, as part of the CLIP, to be used as equity contribution for the project's special vehicle. Once completed in 2016, the project will represent approximately 10% of total installed capacity in the country and be the largest renewable energy project in Central America.

Sustainable Energy Facility (SEF) for the Eastern Caribbean. Financed through a global credit loan to the Caribbean Development Bank (CDB), with an approved package of USD$71.5 million in loans and grants ($20M BID, $19M CTF, $3M GEF, $29M CDB) for the following six countries in the Eastern Caribbean: Antigua & Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines. The facility aims to promote energy efficiency and renewables, focusing on geothermal power. The SEF expects to achieve tariff reductions of 20% to 30% and CO2 emission reductions of up to 10 million tons over the duration of the project. SEF could be a transformational instrument that will unlock the geothermal potential of the Eastern Caribbean and transform it into up to 60 MW of clean, renewable, and baseload power. It would provide the ability to export power to neighboring islands in the near future. The SEF is expected to save at least 1 million oil barrels per year, which is equivalent to US$56 million per year, and to reduce approximately 10 million tons of CO2 over the lifetime of the project.

ENERGY SECURITY— QUALITY OF SERVICE DELIVERED, ENERGY INFRASTRUCTURE, AND REGIONAL ENERGY INTEGRATION

Energy security encompasses the management of the sustainable energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of energy providers to meet current and future demand. Energy infrastructure is key to competiveness and development, and it requires steadily increasing investments from both the public and private sectors. Regional integration contributes to energy security at national and regional levels.

Energy infrastructure and competitiveness: There is a strong relationship between the quality of energy infrastructure, competitiveness, and economic growth. Poor quality electricity has negative effects on productivity, operating costs, and the competitiveness of firms. Blackouts and brownouts are very costly and are a disincentive to invest in manufacturing, while the investments required to provide back-up generation lead to increased costs. Fluctuations in voltage and power frequency also cause machine damage, financial and economic losses, and variations in product quality. Quality energy infrastructure and reliability of service are therefore crucial for competitiveness.

Electricity loss reduction and improved electricity quality:

Electricity loss is a key measure of the efficiency and sustainability of the power sector. Transmission and distribution losses are made up of: (i) technical losses (related to flow of electricity current, such as poorly designed and/or maintained transmission lines, as well as long distribution circuits with inappropriate cable sections and overloaded transformers); and (ii) nontechnical losses (due to illegal connections, non-payment, or billing errors). Therefore, maintenance, metering, billing, and collection to prevent losses are integral to the efficient management of an electricity utility and its financial viability.

Electricity losses in Latin America and the Caribbean averaged around 17% between 2007 and 2011, which is almost triple the 6% OECD. Eleven countries have losses above this average. After allowing for technical losses, this ratio translates into 100 TWh lost in 2012, which represents US$11-17 billion in revenue losses for the sector. In spite of the economic and environmental importance of energy losses, there have been no reductions in the regional ratio over the last three decades. Note that private utilities tend to have lower distribution losses.

Reducing losses and improving electricity quality in a number of countries in the region requires improved corporate utility governance, together with investments in transmission and distribution systems, including the introduction of advanced metering systems and improvements in commercial systems and maintenance. In countries with significant non-payment and theft, creating a culture of payment is crucial to reinforcing these advancements.

One of the greatest challenges in the region is ensuring a secure, reliable, sustainable energy supply in order to meet energy demand. This is a particularly difficult

Table 2. Electricity Losses in Transmission and Distribution in Latin America and the Caribbean (%)

Country	% loss T&D
Argentina	15[b]
Bahamas	12[c]
Barbados	6[b]
Belize	12[b]
Bolivia	14[c]
Brazil	15[b]
Chile	7[d]
Colombia	20[c]
Costa Rica	12[b]
Dominican Republic	32[a]
Ecuador	16[a]
El Salvador	12[b]
Guatemala	13[b]
Guyana	32[c]
Haiti	60[d]
Honduras	32[b]
Jamaica	26[b]
Mexico	16[c]
Nicaragua	21[a]
Panama	12[b]
Paraguay	27[b]
Peru	7[b]
Suriname	8[c]
Trinidad and Tobago	5[c]
Uruguay	19[b]
Venezuela	33[c]
LAC average (exclude Haiti)	**17**
OECD average	**6**

Notes:
Letters correspond to latest available year: (a) 2014; (b) 2013; (c) 2012; (d) 2011.

Sources:
ENE calculations based on information from government agencies, ECLAC and the IEA.

task given significant shifts in technology combined with a commitment to universal access and sustained if moderate economic growth. The following four areas are particularly important to the region's energy security: (i) improving electricity quality and reducing losses; (ii) developing natural gas production and transportation systems; (iii) greater regional energy integration; and (iv) increasing energy infrastructure investments and their efficiency.

Natural gas systems: Natural gas represented 26% of the region's primary energy demand in 2012. Natural gas can serve as a transitional fuel—a bridge from fossil fuel-based energy to a sustainable future based on renewables. Combined-cycle gas turbines are the cheapest and cleanest-burning type of thermoelectric plant, though it is important to note that the environmental benefits of natural gas are under evaluation, in particular the production of shale gas using hydraulic fracturing.

The IEA estimates that the region requires investments totaling between US$435-US$537 billions over the next 20 years, The expansion of gas markets will require additional domestic transportation capacity in countries like Mexico, as well as regional gas pipelines to connect importing and exporting countries, and/or LNG terminals for gas in countries like Chile, Colombia, and Uruguay and in Central America. Since 2008, inter-country gas trade in the region has developed mainly in the form of LNG rather than physical pipelines, a higher-cost option. LNG imports in Latin America increased by nearly 50% in 2012 alone.

Venezuela accounts for 70% of Latin America and the Caribbean's conventional gas reserves, followed by Brazil, Argentina, Trinidad-Tobago, and Peru, which each represent about 5%. Conventional gas reserves increased by 10% in the last ten years, while production increased at twice that rate, resulting in a declining reserves/production ratio. 42% of technically recoverable gas resources are unconventional, including shale gas, tight gas, and coalbed methane.

Although the region accounts for only 4% of the world's conventional gas reserves, it accounts for 22% of shale gas resources, with Argentina at 11%, Mexico at 8%, and Brazil at 3%. While promising, development of the region's high cost shale resources is a difficult task because producing unconventional gas has been shown to impose a larger environmental footprint than producing conventional gas. Serious hazards, including the potential for air pollution and the contamination of surface and aquifer/groundwater from additives and chemicals, as well as induced seismicity, must be addressed. The technologies and know-how have been developed to meet these challenges, but the industry needs to meet rigorous environmental and social standards. Governments need to devise appropriate regulatory regimes, based on high-quality data, and to have sufficient staff to comply with those regulations. They should also guarantee public access to information.

For ease of transportation, natural gas can be converted to Liquefied Natural Gas (LNG), and this creates the potential to link markets and reduce price differentials when fossil-fuel prices are high. LNG represents 30% of the international gas trade, and it has grown at three times the rate of natural gas since 2000.

Regional energy integration: Regional energy integration is a cross-cutting theme. While regional energy integration faces challenges that include concerns about energy independence and sovereignty, it has been shown to create substantial benefits such as: (i) a reduction in wholesale electricity prices; (ii) wider choice of energy suppliers to consumers; and (iii) improved infrastructure and cross-border trade

in gas and electricity. Regional integration could take advantage of the region's rich but unequally distributed resources, especially hydropower and natural gas. However, this integration can take decades to come to fruition which requires persistence and flexibility. Integration requires finding the right level of integration, optimizing investments on a regional basis, developing appropriate regional institutions, technical and regulatory harmonization, power sector reform and integration, and defining the role of financing agencies.

The most important requirements for increased regional energy integration include: (i) long-term availability of electricity and gas from exporting countries in excess of domestic needs; (ii) harmonization of electricity and natural gas regulatory regimes among countries; (iii) a regional accord to guarantee that energy supplies channeled through pipelines and transmission lines will not be arbitrarily cut, similar to that of the EU; (iv) stable energy policies and regulations that encourage both public and private investment; and (v) long-term commitment to integration projects that extend beyond the life of particular governments.

Significant efforts have been made toward regional energy integration with promising results. One notable example, supported by the IDB, is the Central American Electrical Interconnection System (SIEPAC) connecting Guatemala, El Salvador, Honduras, Costa Rica, Nicaragua, and Panama. SIEPAC has two parts: (i) a regional electricity market based on a standard set of rules, a regional regulator, and a transmission operator; and (ii) a high-voltage transmission line (230 kV) and transformer substations, extending over 1,800 km. Begun in 1987, SIEPAC entered into operation in 2013. Issues related to long-term transmission rights and guarantees of capacity are still being resolved, limiting transactions. Other initiatives, such as the US$1.5 billion, five-project Andean Countries Interconnection (SINEA) that would connect Colombia with Chile through Ecuador and Peru, are being sponsored by the IDB. Many other opportunities for regional integration have been identified. For example, the IDB has been supporting studies for interconnection between Panama and Colombia, between continental Caribbean countries and Brazil, and between Belize and neighboring countries.

Other opportunities for regional integration exist in the Caribbean, which may help to reduce energy costs. For example, if appropriate resources are identified and exploited, geothermal energy in the Eastern Caribbean could provide sufficient energy to these countries and excess power could even be exported to nearby island states through undersea cables. Opportunities for regional energy integration also exist with natural gas if countries are able to aggregate demand. Liquefied natural gas use is being explored in Jamaica, for example, so that it or another country in the region could serve as a regional hub for LNG. This could help diversify the Caribbean energy mix.

Increasing energy infrastructure investments and their efficiency:

A major challenge for the region will be to increase both the amount and the efficiency of investment in energy infrastructure in order to meet growing demand and improve quality. In a 2013 study the McKinsey Global Institute concluded that infrastructure investments could be cut by 40% through measures including: improving project selection and optimizing infrastructure portfolios, streamlining project delivery (including speeding up approvals and land acquisition), investing in early stage project planning and design, and making the most of infrastructure assets through improved maintenance and demand-side management.

Decisions to invest in the energy sector have been shaped by government policy measures and incentives.

In order to mobilize private sector investment, political and regulatory uncertainties must be addressed. Public development banks that can leverage public and private financing as first lender or a second-tier lender have also invested in the energy sector. They are an effective mechanism when there is close coordination between the financing mechanism and sector authorities, especially those responsible for planning. This public–private sector partnership has proven necessary for financing large investments such as hydroelectricity construction. The public sector has a greater role in regulating and guaranteeing construction, and the private sector deals with long-term construction and operation contracts.

Private sector participation is critical to incorporating new technologies and operating arrangements, as well as to improving the management and execution of projects in the energy sector. Private sector investments also reduce the financial burden on government budgets.

Capitalintensive projects, like large hydroelectric, geothermal, and gas projects, often benefit from a public–private partnership (PPP) that helps manage risks: the private partner provides the management and technical skills and secures funding, while the public partner secures timely licenses and permits, facilitates environmental mitigation and social benefit plans, and provides guarantees and other forms of credit enhancement to reduce project, market, and country risks.

Operation and maintenance (O&M) and rehabilitation practices are crucial for investment. Best practices in O&M include preventive rather than remedial maintenance; O&M should be ongoing, count on adequately trained staffed and financial resources and should be performed in compliance with the highest safety and public security standards in order to minimize the social and environmental impact.

REPRESENTATIVE PROJECT

ENERGY SECURITY AND REGIONAL ENERGY INTEGRATION

The emblematic SIEPAC project mentioned above, represents an example of advances in integration, and provides lessons on the coordination and investments required.

The regional electricity infrastructure cost US$ 494 million dollars, of which the IDB contributed US$ 253.5 million in financing, while the remaining funds were provided by the Central American Bank for Economic Integration (CABEI), BANCOMEXT, the Latin American Development Bank (CAF), and share capital and loans from shareholders.

Highlights include:

- Three Regional institutions operating
- Six interconnected countries
- Regional regulations approved, current
- Regional Electricity Market operating
- 111 generators enabled
- 1369GWh traded in 2015

Photo: SIEPAC

Photo:
Mexico City at night

ENERGY GOVERNANCE— INSTITUTIONS, POLICIES, REGULATION, AND INFORMATION

While the situation varies from one country to another, stronger governance is required at international, regional, and national levels, including defining a coherent and predictable energy policy; implementing stable regulatory and legal frameworks to support long-term investments; and encouraging public and private initiatives that enable innovation, improve sector information and analysis, and foster research, development, and demonstration.

Strengthening energy institutions: Strong and stable public-sector energy institutions operating within a clear legal and regulatory framework are essential for effective energy policies. Although reliance on market forces produces the optimal allocation of scarce resources, strong competition is lacking in many countries in the region, particularly in small, isolated, lower income, or island-states. Therefore, energy markets need to be complemented with administrative tools to allocate incentives and manage risks in the most effective way. While energy provision and delivery is organized through energy markets and regulated only to the extent needed (that is, avoiding excessive regulatory burdens), strong energy institutions are essential for developing and implementing energy plans, policies, and regulations to ensure effective operation of the sector and its infrastructure and encouraging investment.

To varying degrees, countries in Latin America and the Caribbean need to build capacity in ministries, regulatory bodies, and local governments. Ministries should be able to develop sector policy and shape and oversee the legal, financial, and technical aspects of the sector, as well as concessions and contracts, including risk management. Regional and municipal authorities also need to strengthen government capacity since they control a growing share of infrastructure as a result of decentralization. Policymakers need to engage with the energy and financial sector on emerging technologies, financial opportunities, and effective regulatory frameworks to meet energy goals.

Developing long-term energy policies and plans: In order to make decisions on major energy infrastructure investments, long-term, predictable, and transparent energy policies and plans should be developed and implemented in countries that lack such policies. Energy policies should define objectives, as well as provide specific mechanisms to achieve them for the short, medium, and long-term. Policies are most effective when developed in consultation with stakeholders. Policies should address issues such as energy security, energy equity, and environmental sustainability.

Energy subsidies: General energy subsidies without full compensation to suppliers undermine the performance and sustainability of energy suppliers. The IMF estimated that energy subsidies in Latin America and the Caribbean amounted to about 1.8% of the GDP annually in 2011-2013. Including forgone tax revenue and the cost of negative externalities, this would bring the region's energy subsidy bill to about 3.8% of the GDP. Generalized subsidies promote changes in resource allocation by encouraging excessive energy consumption, promoting capital-intensive industries, reducing relative incentives for investment in renewable energy, and accelerating natural resource depletion. They can also lead to lack of revenues due to low tariffs, to a reduction in spending on maintenance and to situations that prevent utilities from making investments to replace necessary equipment. Targeted and temporal subsidies for marginalized populations or to provide support after external shocks may prove necessary and beneficial, if well managed and revised over time.

Oil price volatility: Concern about oil price volatility is a policy issue that can threaten investments in energy efficiency and renewable energy, unless strong policies are in place to direct markets. Paradoxically, to protect against high price volatility, shortterm risk management options include energy efficiency, the use of local renewable energy, and increased regional integration with countries that have more diversified portfolios. To counter volatility, supply-side policies can integrate action on oil supply chain management and a facilitating framework for renewable electricity and fuels, as well as demand-side policies like the end of subsidies and tax incentives that favor oil.

Building regulatory capacity: Effective energy regulation contributes to ensuring that prices reflect costs, that energy is supplied in an affordable and sustainable manner, and that companies comply with performance standards. Effective and predictable regulation by an independent regulator is an important determinant of sector performance and sector investments. Experience has shown that regulatory agencies should be formally separate from ministries and should have sufficient financial resources. Accountability and staffing by competent professionals are also essential.

Improving energy information:

Data and information on the energy sector are essential for analysis and planning, the development of energy policies, and investment decisions. Availability of information on the energy sector varies by country and by subject, and unfortunately there is a lack of systematic and reliable data collection in the sector, especially in the Caribbean. Areas in which data availability needs to be improved include the production and use of traditional cooking fuels, decentralized renewable energy installations, unsatisfied energy demand, energy efficiency, energy prices, and the quality of energy infrastructure and services. The region should also improve data generation and collection mechanisms and provide disaggregated information on income and gender.

Studies show that private sector energy infrastructure investment is based on access to information regarding regulations, statistics, and general government services. Welldeveloped e-government services are particularly valuable for improving access to information and for processing permits and licenses more efficiently.

REPRESENTATIVE PROJECT

The IDB has supported Latin America and the Caribbean with technical and financial assistance to improve the corporate governance of public companies, such as in the case of Honduras where there have been substantive energy sector reforms, including revisions to subsidies. IDB financing was also used to support Colombia's Empresas Públicas de Medellín, to address corporate governance and promote support and collaboration in areas such as transparency, international standards, and external auditing, which are necessary for the services the company now provides internationally.

Photo:
Monte Quemado substation in Santiago del Estero Province in Argentina

In brief, daily life depends on access to modern forms of energy, and such access should be a basic right. Providing access to modern energy requires enormous investments in capital, infrastructure, and human resources. It also requires a focus on quality, affordability, and environmental sustainability so that current and future generations will have a reliable energy supply.

We believe it is important to provide background information outlining the challenges that currently exist and examples of the methods available to overcome these challenges. To learn more about the work of the IDB and other partners in the region to improve lives, please visit: www.iadb.org

Design and layout:
Cecília Reifschneider, cica@pigmentd.com

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