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Overview of Renewable Energy Sources in Latin America

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Introduction

The present work deals with the situation of renewable energy in the Latin-American Region (LAR). Its main purpose is to give an overview of the conditions prevailing in the region, regarding those activities leading to the systematic process of adoption and use of renewable energy technology, as part of the energy supply mix in each individual country. This essay was elaborated on the basis of a limited literature survey, information provided to the author by colleagues from several countries in the region of study, plus the knowledge gained by the author from his work on some of these countries, concerning the development of renewable energy resources, mainly for rural electrification. One premise valid in general for the whole region of study is that information on the subject is by all means scarce, which basically reflects the early stages countries in the region are at in the process of adoption and use of this energy alternative. Hence, the reader is advised to take the statements and conclusions included in this report as indicative only. Further research on the subject is necessary to gain a better understanding of the actual situation with respect to renewable energy integration in the region. Although common circumstances and tendencies can be observed in some countries under study, few general conclusions, valid for the whole region, can be drawn. Reasons for this include the differences among individual nations in terms of country size and degree of economic development, as well as in the conventional energy resource base each country has.

In this study an attempt is made to focus on the following elements considered crucial in the process of adoption and use of renewable energy technology: *policy, institutional framework, technology stocks, financing schemes, the renewable energy resource base, and suitable local industrial infrastructure*. It is the understanding of the author that when these elements are properly established and harmonically put in place, the process of technology adoption can be accelerated towards the successful and sustainable internalization of renewable energy in the economy of each individual country.

Motivations to Use Renewables

The use of renewable energy is being promoted by the most advanced nations mainly as a means to ease global environmental problems, deriving from the intensive use of fossil fuels. At the regional level, however, other more pressing and shorter term needs could be addressed by using renewable energy. For instance, substituting imported oil by locally available renewable energy, which saves scarce foreign currency; or using the advantage of site-specific energy resources to cope with old and critical needs such as rural electrification. But the adoption of renewable energy could also mean additional benefits for the countries in the region, such as: creation of new jobs, revitalization of small and medium size industries, and solution of local environmental problems. The use of renewables in the region offers also the opportunity of using available human resources effectively, of putting the local R&D establishment to work after a common goal, and that of attracting new investments to expand the energy infrastructure of the individual nations.

The Energy Scenario in the Region

Energy supply in the region of study, as in other regions of the World, is basically depending on oil. However, only some countries, including Mexico, Venezuela, Colombia and Brazil have substantial oil resources to support their economies; the rest depend on imports. Hydropower resources are available in most countries. Brazil's huge electricity generating capacity and that of most Central American nations, is basically dependent on this resource. Natural gas is plentiful in countries like Argentina, Bolivia and Peru, but still needs to be developed in some of these countries. A good number of countries in the region have virtually no commercial fossil fuels.

Renewable Energy Resource Base

Contrary to the situation described above regarding conventional energy, all countries in the region are endowed with abundant renewable energy sources. Solar, wind, biomass, small hydro and other energy resources from the ocean, are available in the region in larger or smaller quantities, depending on the geographical location and morphology of the individual countries.

The force of winds can be used to produce mechanical power and electricity by means of commercially available and cost-competitive technologies. Southeast Mexico and most Central American and Caribbean countries are under the influence of Trade Winds, while Southern Mexico and Central America are also exposed to strong and almost constant thermally driven winds, which in the case of Mexico are known as *Tehuantepecer* [9], produced by the temperature difference between the waters of the Atlantic and the Pacific oceans. Windy places can also be found in the southern hemisphere. Low winds cannot be effectively used to produce power while excessively strong winds may be a major threat to wind generators. However, when properly characterized, wind has proven to become a reliable energy resource. Few countries in the LAR (basically Brazil and Argentina) have developed wind maps to guide project developers. A low resolution wind map of the region was developed over a decade ago by the Latin American Energy Organization (OLADE).

Solar energy is more evenly distributed, as good portions of the region lie within the so-called Sun Belt Region of highest solar radiation. Thus, except for site specific adverse microclimates, solar energy is a predictable and reliable resource, susceptible of being transformed to heat and electricity by means of several technologies in different stages of development and commercial availability. Solar irradiance maps are available for Mexico, Colombia, Brazil, Argentina and a few other countries.

As a natural consequence of the solar radiation available, photosynthetic activity in most of the region of study is rather high, and hence the high production of biomass. On top of that, many countries in the region have an economy based on agriculture, so that agricultural waste, forest residues and other residues from animal raising, which constitute another form of biomass, is also abundant. These resources are difficult to evaluate, so that information in aggregate and analyzed form is scarce.

Most countries in the region use already a good portion of their hydraulic potential to generate electricity. However, most operations lie in the multi-megawatt range, seeking economies of scale characteristic of hydroelectric technologies. This practice has left a large portion of the small hydroelectric potential yet to be exploited. Given the high rainfall indices and the rough topography of many countries, small hydropower offers a good alternative to supply electricity, especially in remote sites.

Wave and tidal power, along with other forms of energy available in the ocean, represent an enormous energy potential for countries in the region, especially when one considers the large coastline to inland ratio of most countries under consideration. Unfortunately, technologies to tap such energy resources are still far from commercialization.

The down side of the renewable energy resource scenario in the region of study is the fact that little has been done to properly measure and characterize these resources. In the event of project development, available information on the local energy resource is at best limited, if not unreliable. In most cases,

however, information is non-existing, which represents a major barrier to the incorporation of this alternative as part of the national energy inventories and planning exercises.

Policy Framework

Legal, regulatory, institutional and financing schemes to foster and facilitate the use of renewables for electricity generation are at different stages of development in the LAR. Even though there are common denominators among different countries in the region, no integration of renewable energy policies can be observed. The purpose of this section is to quickly review the different legal schemes emerging in the LAR to foster renewable energy. The following initiatives with specific reference to renewables could be identified: The Electricity Law in Bolivia; Law 10.438 in Brazil; Law 143 in Colombia; Law 7200 in Costa Rica; the Regime Law for the Electrical Sector in Ecuador; Decree 93-96 in Guatemala; the Framework Law for the Electricity Sub-sector in Honduras; the Energy Sector Program 2001-2006 in Mexico; the Law for the Electric Industry in Nicaragua; the Executive Decree Number 22 in Panama; the Electric Regulatory Framework for the Paraguay Republic; and the Project for the Organic Law of the National Electricity Service in Venezuela. Most of these initiatives deal renewables mainly in the context of rural electrification, which is a major concern in the region. They are described next.

Bolivia. Article 61 of the Electricity Law charges the State with the responsibility of electrifying small townships and rural areas, which could not be served by private companies. According to this Law, financial resources for this purpose must be delivered by the Government through the National Development Fund. It is also established the Executive should propose energy policies and strategies allowing the use of alternative energy sources, within the general framework of the development policy for the energy sector.

Brazil. Law 10.438 deals with the supply of electric energy and extraordinary tariff schemes. By this Law, the Incentives Program for Alternative Sources of Electric Energy (PROINFA) is created, along with the Budget for Energy Development (CDE), and mandates on the universality of the public served with electricity. This Law amends a number of similar laws previously issued, both national and provincial,

Colombia. Article 40 of Law 143 sets a target for the next 20 years in which equal levels of energy coverage in the whole country must be achieved. The Colombian Institute for Electric Energy is charged with the responsibility of formulating an off-grid National Energy Plan. This Institute is also responsible for the execution of the corresponding alternative energy projects, explicitly small hydroelectric power plants in substitution of fossil-fueled generating units.

Costa Rica. Law 7200 deals with autonomous or parallel generation, defined as that produced by power stations of limited capacity, owned by private companies with more than 65% of Costa Rican capital, or rural electrification cooperatives. Incentives of different kinds are awarded to these companies, plus the right of selling electricity to the Costa Rican Electricity Institute, as long as the power is produced from small hydroelectric and non-conventional energy sources.

Ecuador. Article 5 of the Regime Law for the Electrical Sector deals with rural electrification issues, preferential tariffs for low income sectors, and incentives to the development and use of non-conventional energy resources. This Law has provisions on project financing (Articles 37 and 62) and priorities for rural electrification projects with renewable energy in the Amazon region and Galapagos Islands

Guatemala. Decree number 93-96, also known as the General Electricity Law, empowers the State to provide resources to finance, fully or partially, rural electrification projects outside the concession territories. The Law does not specifically addresses renewable energies, but in practice projects of this kind are more suitable in rural areas not served by the grid.

Honduras. Article 42 of the Framework Law of the Electricity Sub-sector creates a fund for projects of social interest and gives facilities so that electricity distributors can generate electricity with isolated off-

grid systems. As in the Guatemalan case, the Law does not specifically addresses renewable energy, but implies its use.

Nicaragua. Article 6 of the Electric Industry Law sets provisions for the financing of off-grid projects in rural areas. The government has the National Energy Commission, responsible for the elaboration of rural electrification plans, the administration and ruling of the National Fund for the Development of the National Electric Industry, mainly to finance rural electrification projects, and to implement policies and strategies that allow the use of alternative energy sources for electricity generation.

Mexico. Mexico's Energy Sector Program 2001-2006 sets targets for the implementation of grid-connected renewable energy projects and outlines strategies to achieve these targets. Renewables are the preferred option for off-grid projects in remote rural areas, albeit they are not mandatory. Regional development plans by some state governments also incorporate the use of renewables.

Panama. Article 5 of Executive Decree 22 creates the Office of Rural Electrification which, among other things has the following responsibilities: Identification of priority rural areas not served by the grid and not included in concession areas; evaluation of technological options to serve those areas; evaluating options for application of new technologies for rural electrification; and carrying out regional studies to identify possibilities for the use of renewables.

Venezuela. No provisions are made for renewables in the Project for the Organic Law of the National Electricity Service in this country. However, specific off-grid project are good candidates for the use of renewables.

The Use of Renewables in the Region

Main off-grid Programs

Electricity from renewables can be produced in both on-grid and off-grid installations. Criteria for on-grid projects normally include cost-competitiveness with conventional resources and other strategic elements. Off-grid projects are usually socially-oriented and respond to poverty alleviation programs. This section reviews the main off-grid renewable energy programs in the Latin American region, namely PAEPRA in Argentina, PRONER in Bolivia, PRODEEM in Brazil, and PRONASOL (and subsequently named programs) in Mexico. Tens of thousands of solar home systems plus thousands of renewable-powered schools, rural clinics and communal services have been constructed in the region using different implementation models, from fully subsidized government or donor-led projects, to privately driven business as usual projects. On-grid renewable energy programs are at an earlier stage of development in the region than off-grid programs. Some examples are included in the next section.

PRODEEM. Rural electrification programs with renewables in Brazil date back to 1992/93 through pilot projects in cooperation with the German and US governments. Around 1500 solar home systems were installed with the participation of local electricity distribution companies in several states. These companies were responsible for systems installation, maintenance and performance monitoring. The Brazilian Government launched two new initiatives in 1994. First, a commission was created to develop operational guidelines applicable to the Brazilian Program for the Dissemination of Renewable Energies. This commission produced the Short Term Plan of Action for renewables. Then, a Permanent Forum was created to implement this Plan of Action, along with a Reference Center called Sergio de Salvo Brito, for the dissemination of information on solar and wind technologies (CRESESB).

In a second initiative the Brazilian Government established the Program for Energy Development of States and Municipalities (PRODEEM). This program has been coordinated by the ministry of Mines and Energy with the purpose of delivering electricity to rural communities not served by the grid, by means of locally available renewable energy resources. PRODEEM seeks the social and economic development in rural areas, directly impacting job creation and reducing rural migration to the cities. Several states, including Minas Gerais, Sao Paulo y Paraná, followed suit and created their own photovoltaic rural electrification programs.

Brazil is the only country in the region where commercial manufacturing of photovoltaic cells and modules took place with indigenous technology.

PAEPRA. In the modernization process of the electrical sub-sector, the Argentinean Government split the provincial electricity markets in two fractions: concentrated and dispersed markets. Each of these fractions has its own structure, mission, distinctive characteristics and operational schemes. The Program for Electricity Supply to the Rural Population of Argentina (PAEPRA) was launched in 1994 by the Ministry of Energy of that country. The goal of this program is the supply of electricity to 1.4 million people and to around 6,000 public services in remote areas of low population density, where supply from the grid is too costly. The objective of this program is to prevent rural migration to the cities and to open opportunities for the private sector to provide electrical services through rural energy concessions in each province. The Provincial Electricity Regulatory Body remains in charge of the service quality. Additional benefits sought from the PAEPRA program include job creation, the use of renewables in a sustainable fashion, and to assure a good performance of the private supplier with a minimum amount of subsidy.

PRONASOL. Access to electricity is considered a right of every Mexican Citizen. Grid coverage reaches over 95 percent of the population, leaving around five million Mexicans living in small and dispersed communities without access to the grid in very remote regions. The massive use of renewables for rural electrification started in 1989, as part of a larger poverty alleviation program called PRONASOL, which has changed its name in subsequent administrations. Government-financed projects coexist with private sales. A total of around 90,000 solar home systems and hundreds of other systems for a variety of applications such as water pumping, including several mini-grids powered by solar-wind hybrids, are estimated to have been installed in Mexico. This program has been characterized by the active participation of the national electric utility as technical normative agency to assure the quality of the installations.

PRONER. The National Rural Electrification Program (PRONER) was created with the purpose of promoting and supporting economic development to improve living conditions in rural areas. The goal is to provide 100,000 households with basic electricity services within five years. PRONER is expected to open ways for the application of renewables in a reliable, high quality and long-term sustainable way, while saving fuel and avoiding air pollution at the same time. This program seeks to develop integral sustainability schemes, including adequate institutional, financial, technological and environmental frameworks. The first phase of the program will be carried out by the Bolivian Government with financial support from the UNDP/GEF. Its main objective is to remove financial, institutional and technical barriers to assure the successful application of renewables in rural areas. The original plan called for 22 projects in five municipalities, which meant 3200 solar home systems.

On-grid Projects

Few countries in the region have undertaken formal on-grid renewable energy programs. Several countries, including Brazil, Costa Rica, Argentina and Mexico are entering this field of applications, as described next. Beyond Brazil's biofuels program, wind power is currently the preferred technology.

Brazil. Sugar cane-derived gasohol, wind power and grid-connected photovoltaics are the main activities of on-grid non-conventional renewables in Brazil (large-scale hydropower excluded). Gasohol has been fully commercial for a number of years and is a well known experience in the World. Commercial wind power is in its early stages of development: a few installations can be observed (see table), while commercial ventures are known to be underway. A number of grid-connected photovoltaic installations are being used mainly for research or demonstration purposes.

Costa Rica. Costa Rica is the regional leader in the implementation of wind power. Several medium size

wind farms are already in commercial operation, as shown in table 1. Prospects for the implementation of more wind farms are under consideration.

Argentina. Small wind power installations can be found in the south of the country, with plans for larger capacities.

Mexico. Several green power projects are in progress with financial support from the Global Environment Facility (GEF). The following are being implemented by the World Bank in association with Mexican Agencies: a) A gas-fired combined cycle power plant of around 240 MW, which may incorporate a fraction of no less than 25 MW using solar concentrators. As of this writing, a call for bids to build this project in northwest Mexico was in progress; b) Electricity production with biogas from sanitary landfills, executed by the municipality of Monterrey in northern Mexico. This project is already on line; c) A new initiative under development with the Energy Secretariat seeks to establish a green fund to foster green power projects. The United Nations Development Program (UNDP) is implementing jointly with IIE the GEF-supported project "Plan of action for removing barriers to the full-scale commercial implementation of wind power in Mexico", which includes the creation of the Regional Wind Energy Technology Centre in south Mexico.

Concluding Remarks

The Latin American region shows large disparities in terms of availability of conventional energy resources. At the same time, the region is endowed with abundant renewable energy resources, albeit up until now grossly underutilized. The main reasons for this situation are found in the lack of the proper elements for the large scale and sustainable deployment of the technologies necessary to tap these resources. Few countries in the region are actively working to develop policies, institutional settings, financing schemes, industrial infrastructure, human resources and other necessary elements, to facilitate the introduction of renewable energy as part of their energy supply options. Joint collaborative activities between two or more countries to achieve this objective are even more difficult to find. The largest efforts in this respect are being induced by international organizations or bilateral aid agencies through a number of programs, aimed at identifying and removing the barrier that impede the use of renewables in the region. Results to date have been modest, but encouraging.

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