GENI Global Energy Network Institute

Achieving 100% Reliance on Renewable Energy for Electricity Generation in Central America

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Table of Contents

Table of Figures

List of Abbreviations

Organizations

1. CRIE – Comision Regional de Interconexion Electrica
2. ECLAC – Comision Economica para America Latina y el Caribe
3. FDI – Foreign Direct Investment
4. IDB – Inter-American Development Bank
5. IFI – International Financial Institutions
6. JICA – Japan International Cooperation Agency
7. REO – Regional Operator Entity
8. RTN – Regional Transmission Network
9. SICA – Central American Integration System
10. SIEPAC – Sistema de Interconexion Electrica de los Paises de America Central
11. SWERA – Solar and Wind Energy Resource Assessment

Power Terminology

Power is the rate at which energy is generated or consumed. Watts per hour properly refers to the *change* of power per hour.

1. GWh – GigaWatt hour: The gigawatt is equal to one billion (10^9) watts or 1 gigawatt = 1000 megawatts.
2. kV – kiloVolt
3. kWh – kiloWatt hour
4. PV – Photovoltaic
5. MV –MegaVolt: A *megavolt* is 1 million volts in electronics and physics.
6. MW – MegaWatt: a megawatt is equal to one million (10^6) watts
7. MWe – MegaWatt electrical

Abstract

As Central American countries develop, they are faced with the burden of financing economic growth that is dependent on the importation of fossil fuels, which leaves them vulnerable to market fluctuations in oil prices. With the help of international aid donors, International Financial Institutions (IFIs), and bilateral agreements with individual countries and regions, Central America is striving to develop green energy policies and practices to support their economic growth and reduce reliance on imported fossil fuels. Because the region is wealthy in renewable resources means that it is poised to restructure its energy sectors, particularly in electricity generation, so as to be renewables-based. Becoming 100% reliant on renewable energy resources for electricity generation will increase economic and human security, prevent energy crises, lend itself to deepening regional integration, create jobs, increase human development, and aid in poverty alleviation. Developing renewables-based energy sectors has become central to the economic, development, and poverty alleviation strategies of all Central American countries. Regional interconnection and integration present a mechanism for the region to work together to increase economic and energy security, decrease reliance on foreign oil, develop with green economies, and decrease poverty.

This paper will explore the market structures of the countries, the strength and capacities of electrical regulatory organizations, harmonization of energy policies, and the goals of the Central American states to reveal the enabling factors and obstacles to the widespread adaptation of renewable energy resources in the region. There are many obstacles to the development of renewable energy in the region: capital constraints, institutional inadequacies, lack of private sector participation, and price distortion. These often prevent renewable power applications from gaining market share and maturing commercially. Each country needs to address major political, economic, social, and institutional barriers at a national and regional level before they can be successful in using 100% renewable resources for electricity generation.

Figure 1: Political Map of Central America[1]

Introduction

Located in the center of the American continent, the Central American isthmus is comprised of Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, and Panama. This sub region is the lowest point of the North American continent, sharing a border with Mexico to the north and Colombia to the south. Central America has an area of roughly 592,000 square kilometers and a population estimated to be 41.5 million. The climate ranges from dry and temperate to wet and tropical and is tempered by the proximity to the Caribbean and the Pacific as well as the altitude. A volcanic range runs north to south throughout the region, and roughly 80% of the region is mountainous, while the coastal areas are flat. The region is geologically active with both earthquakes and volcanic eruptions commonplace. These features make the region rich in natural resources with significant hydropower, geothermal, wind, solar, and biomass potential for generating electricity.

Central America is part of the Mesoamerican Biodiversity Hotspot and contains 8% of the earth's biodiversity. The region is prone to natural disasters, specifically, hurricanes, earthquakes, and floods.[2] Although Costa Rica and Panama are generally considered upper-middle income countries that have a high level of human development, Guatemala, Honduras, El Salvador, and Nicaragua are classified as lower income countries with significantly lower levels of human development.[3]

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1 Map of Central America. Web. http://geology.com/world/central-america-satellite-image.shtml

2 Central Intelligence Agency. World Factbook. Web. https://www.cia.gov/library/publications/the-world-factbook/wfbExt/region_cam.html

3 United Nations Economic Commission for Latin America and the Caribbean [ECLAC] (2010). *Escenarios de cambio*

3 United Nations Economic Commission for Latin America and the Caribbean [ECLAC] (2010). *Escenarios de cambio*

Political Situation

Political instability and economic inequality are trademarks of the region. Armed conflicts, authoritarian regimes, and, more recently, drug trafficking and gangs have plagued Central American countries. Guatemala, El Salvador, and Nicaragua were mired in armed conflict throughout the 1970s and 1980s, largely as a result of economic and social inequalities and repressive political regimes fueled by the policies pursued in the region by foreign powers. As a result of their proximity, Costa Rica and Honduras were affected by a stunted ability to transport goods and services, the menace of armed groups along their borders, and large populations of displaced peoples. In 1983-84, peace was negotiated, and by the 1990s, democratic elections, a growing participatory civil society, and the strengthening of parliament were favored over the authoritarian traditions.[4] Still today, rule of law remains weak. Widespread corruption, both public and private, detracts from economic and social development. Social inequalities, rural poverty, violence against women, migratory pressure, drug trafficking and gangs dominate the region and contribute to an overall sense of instability and insecurity.

Economic Situation

The economies of Central America are export-based, focusing on textiles, manufactured goods, and agricultural products. In recent years, there has been a shift towards tourism and hospitality, which was lead by Costa Rica's booming ecotourism industry. The region enjoyed flourishing economic growth from 2003-07, but suffered during the global economic crisis; it later rebounded in 2010 and has been seeing growth ever since.[5]

Two of the three poorest countries in the Americas are located in Central America, Nicaragua and Honduras. With the exception of Costa Rica and Panama, poverty rates are high and inequality is profound. It is estimated that 52.7% of the population lives below the poverty line, and 30.5% live in extreme poverty.[6] The region has some of the highest levels of economic inequality in the world. Per capita income ranges from below $1,000 in Nicaragua and Honduras to about US$2,000 in Guatemala and El Salvador and above $4,500 in Costa Rica and Panama. With the exception of Costa Rica, income distribution is highly unequal with the poorest 40% of the population receiving between 10%

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climático para Centroamérica. In: Economía del Cambio Climático en Centroamérica.

4 European Commission. (2007) *Central American Regional Strategy Paper 2007-2013.*

5 Guasch, J., Rojas-Suarez, L., Gonzales, V. (2011) *Competitiveness in Central America: The Road to Sustained Growth and Poverty Alleviation.* The Center for Global Development.

6 Ibid.

and 14% of total income. Approximately 7.7 million people in the region lack access to electricity.[7]

Every country in the region is a net importer of hydrocarbons. Central American countries spend much of their resources on importing hydrocarbons despite the fact that the region's main source of energy for household use remains firewood. According to the Central American Bank for Economic Integration, the region currently generates 45% of its electricity using oil, spending some $7 billion annually on imports. Costa Rica alone spends $2 billion annually on oil. Figure 2 shows, in millions of barrels, 2006 consumption levels of petroleum derivatives as total consumption, final consumption, and consumption for the generation of electricity, respectively.

ISTMO CENTROAMERICANO: CONSUMO DE DERIVADOS DE PETRÓLEO, 2006

(Miles de barriles)

	Consumo total	Consumo final	Generación eléctrica
Total	97 634	79 199	18 436
Costa Rica	16 776	15 696	1 080
El Salvador	15 433	13 756	1 678
Guatemala	26 238	21 982	4 256
Honduras	14 981	9 841	5 140
Nicaragua	9 144	5 850	3 294
Panamá	15 063	12 074	2 988

Figure 2: Central American Isthmus: Consumption of Petroleum Derivatives, 2006[8]

Figure 3 shows the per-capita electricity consumption of each Central American country, and the resources used to generate electricity. Thermal (red) and hydro (blue) dominate energy portfolios throughout the region. The high prevalence of thermal generation by fossil fuels is troubling because the price of oil is on the rise, and as the region develops, so too will its electricity demand. Rising demand and higher costs means the region will put pressure on government to allocate a greater proportion of funds to financing the importation of oil and less on social and economic development programs the region so desperately requires. The rising price of oil has caused Central America's fast-growing fossil-fuel-based economies to rethink their energy sector structures and portfolios and has made them consider transitioning to renewable energy, which could prove to be more financially viable than fossil fuels in the long-term.

7 Eguizabal, Cristina. (2011) "Central America's Energy Challenges." *Hemisphere*, Vol. 20, pp. 23.

8 Naciones Unidas Comisión Económica Para América Latina y el Caribe. (2006) *Estrategia Energética Sustentable Centroaméricana 2020.* Mexico D.F.

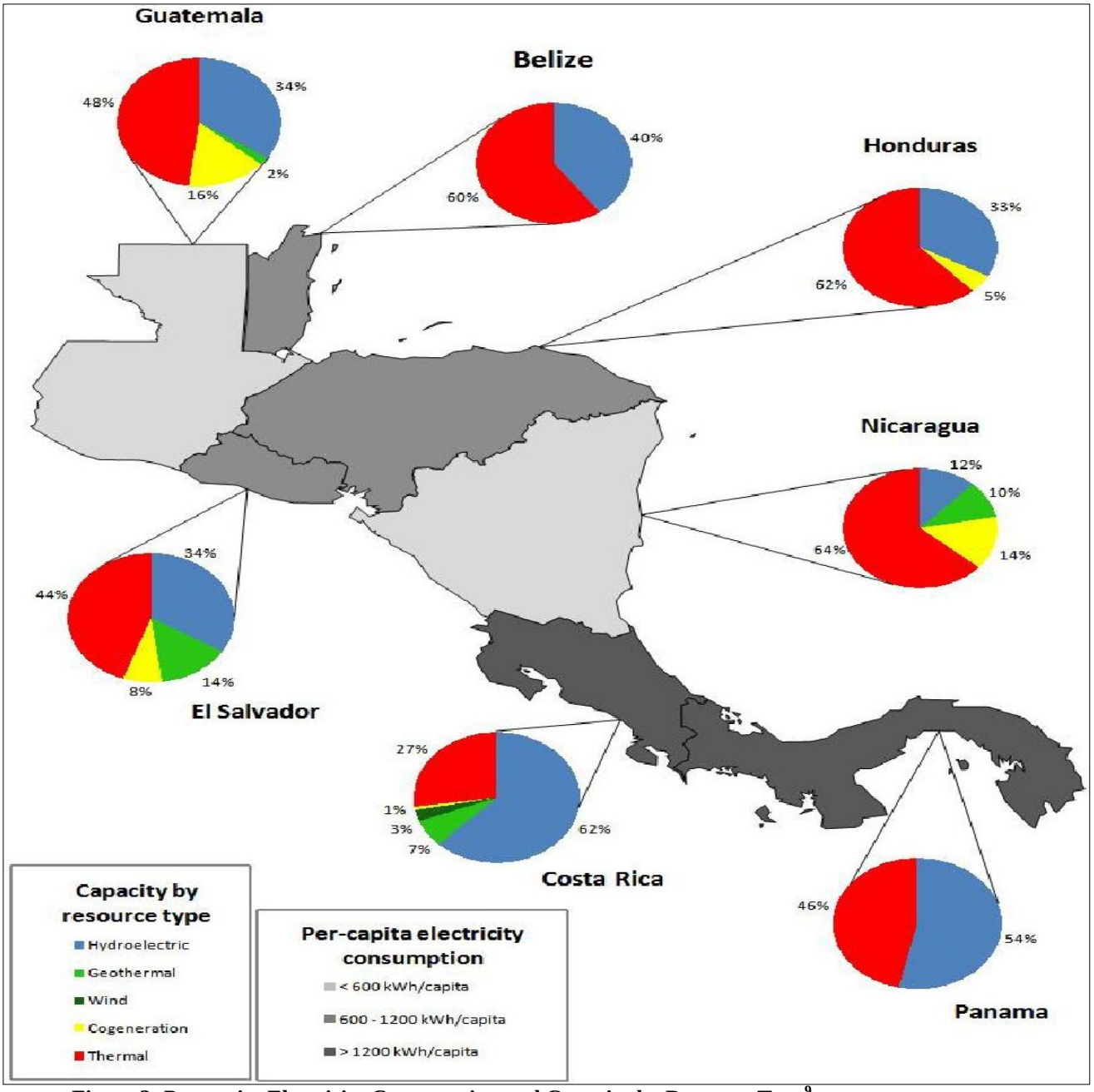

Figure 3: Per-capita Electricity Consumption and Capacity by Resource Type[9]

9 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America*.

Energy and Sustainable Development

Energy, particularly electricity, is critical for sustainable socio-economic development. The lack of success in providing modern energy services has caused economic, social, and cultural lags; inability to participate in modern chains of production; reduced commercial benefits; and the reduced quality of educational and health services. Electricity access is needed to power income-generating machinery. Domestically, it allows for heating/cooling and refrigeration, extends the work-day, removes the time/labor necessity of gathering firewood, improves education and health care services. It is attractive to foreign investors who require affordable and reliable electricity for businesses. Universal electricity coverage is a goal of all the Central American nations.[10]

In the long run, renewable energy has been shown to be cheaper than traditional energy sources, attractive to foreign investors, and successful in creating jobs within the energy and energy technology sectors. Due to Central America's increased economic growth, the demand for energy has been steadily on the rise and will continue to increase in coming years.[11] Although the region's contribution to the emission of greenhouse gases and, therefore, global climate change is minimal, as their economies grow and demand more energy, so too will their carbon emissions. There is a dire need for the diversification of sources used for energy generation to ensure a dependable energy supply.[12] Latin American countries that have maintained consistent energy policy that sought to develop their energy sector, increase access, and diversify their energy portfolios have enjoyed reduced economic inequality.[13]

Rural Electrification

Rural electrification projects have been made central to each Central American country's development agenda, because governments understand that energy use, economic growth, and level of development are highly correlated. Traditional use of energy has an inherent gender bias, and electrification reduces labor time for women. Modern cooking appliances mean they no longer need to collect firewood and can spend less time cooking. Electricity use in rural homes is related to education levels, and because there is a relationship between education and lifetime earnings, use of energy that positively impacts education can be considered productive. Access to modern energy also has positive

10 Energy Sector Management Assistance Program. (2011) *Regional Power Integration Structural and Regulatory Challenges: Central America Regional Programmatic Study for the Energy Sector.* (Joint publication with the ESMAP and the World Bank)

11 Arriagada, Genaro. (2011) "Leading Energy Policy Issues in Latin America." *Hemisphere*, Vol. 20, pp. 7.

12 Las Naciones Unidas. (2011) *La economía del cambio climático en Centroamérica: Reporte técnico 2011*.

13 Bozo, Mauricio Garron. (2008) "Energy policies in Latin America and the Caribbean and the evolution of sustainability." *International Journal of Energy Sector Management*, Vol. 2, No. 1, pp. 8-35.

effects on health, reducing pulmonary illness by replacing traditional cooking methods with modern stoves, allowing refrigeration for rural clinics to store medicines and blood samples, and enabling rural clinics to utilize more modern technologies. Greater electrification is also necessary to attract businesses that are reliant on electricity to rural areas, which typically lag in investment.[14]

Governments have endeavored to expand electrical access to impoverished areas by attracting foreign donors to implement renewable energy projects, such as individual household or community-based solar, wind, or geothermal installations in rural areas. Governments under economic strain prefer these projects, because they require less financing than electrical grid extension. The utilization of renewable energy resources to electrify rural regions is not only cost-effective and environmentally sound; it empowers the community, particularly women. The most common applications of renewable energy for off-grid energy services are for cooking, lighting, and other small electrical processes in industry, water pumping, and heating and cooling. These access strategies are key for poverty alleviation, decreasing inequality, increasing electrical coverage, sustaining economic growth, and increasing human development.[15]

Climate Change and Foreign Donors

Energy policy plays a vital role in the mitigation of the impacts of global climate change. The adoption of renewable energy resources to supplant the use of fossil fuels effectively decreases greenhouse gas emissions that contribute to climate change. Although Central America's contribution to greenhouse gas emissions is low, estimated to be only .8% of the total global emissions, the effects of climate change pose a serious threat to the region vis-à-vis more frequent and intense hurricanes and storms, flooding, erosion, less predictable rainfall...etc.[16] The magnitude of these events is compounded by the fact that countries in this region lack the funds or the capacity to respond appropriately to these disasters. Increasingly, climate change will cause alterations in hydrological cycles that will impact agriculture, the region's most valuable economic sector, and pose a threat to human security as storms become more intense.[17]

Central American countries have bound themselves, by virtue of being signatories of

14 Agarwal, S., Barnes, D., Cabraal, A. (2005) "Productive Uses of Energy for Rural Development." *World Bank Annual Review of Environment and Resources,* Vol. 30, pg. 117.

15 Martinot, Eric. (July/August 2006) "Renewable Energy Gains Momentum: Global Markets and Policies in the Spotlight." *Environment*;,Vol. 48, No. 6, pp 26-44.

16 Las Naciones Unidas. *La economía del cambio climático en Centroamérica: Reporte técnico 2011.*

17 Da Silva Soito, J., Vasconcelos Freitas, M.A. (2011) "Expansion of hydropwer in Brazil: Vulnerability, impacts and possibilities for adaptation to global climate change." *Renewable and Sustainable Energy Reviews,* Vol. 15, pp. 3165-3177.

international climate change treaties and agreements, to climate change mitigation. As members of the United Nations Framework on Climate Change, Central American countries are obligated to contribute to mitigation of climate change when developed countries transfer technologies and financial resources. The Clean Development Mechanism laid out in the Kyoto Protocol, to which they are all signatories, to achieve sustainable development and prevent climate change has compelled foreign donors to invest in carbon emissions reductions programs in the region and environmentally friendly sustainable development initiatives particularly in rural areas.[18] Figure 4 shows the quantity and type of Clean Development Mechanism projects that have been accepted in Central America as of 2010.

País	Tipo de proyecto (solo incluye proyectos aceptados)							Total
	Hidroeléctricas	Energía eólica	Biomasa	Energía geotérmica	Aceite de palma	Bagazo de caña	Rellenos sanitarios y aguas residuales (Metano)	
Belice	0	0	0	0	0	0	0	0
Costa Rica	2	1	2	0	0	0	1	6
El Salvador	1	0	0	2	0	2	1	6
Guatemala	6	0	0	1	0	0	4	11
Honduras	9	0	1	0	4	1	1	16
Nicaragua	0	1	0	1	0	1	1	4
Panamá	5	1	0	0	0	0	0	6
Centroamérica	23	3	3	4	4	4	8	49

Figure 4: Clean Development Mechanism: Accepted Projects By Country and Type[19]

In line with UN Secretary Ban Ki-moon's 'Sustainable Energy for All' initiative, which calls for universal access to modern energy services by 2030, every Central American government cites expanding rural energy resource options as a national goal. Donor programs target energy efficiency, renewable energy, rural electrification, and power sector integration. Support has come in the form of capacity building and institutional development support, support for feasibility and other technical studies, grant resources for program implementation, project preparation, pilot projects, and commercial project implementation. The region should exploit these mechanisms to their advantage by utilizing them to attract investment, particularly to rural areas, which are supported largely by social safety-net programs that are not sufficient to foster economic or social development.

18 Las Naciones Unidas. *(2011) La economía del cambio climático en Centroamérica: Reporte técnico 2011.*
19 Ibid.

Central American Integration

Central American integration began in 1907 with the creation of the Central American Court of Justice. In 1951, the Central American states created the Organization of Central American States to promote regional cooperation, integrity, and unity in Central America. Integration continued at a slow rate until 1991, when the Central American Integration System (SICA) came into being as the institutional framework for regional integration. It oversees the Central American Electrification Committee and the Central American Hydrocarbons Cooperation Committee.[20] Economic integration has been, and continues to be, an over-arching goal for the region; trade barriers between the nations have been all but eliminated, but cross-border political tension, bureaucracy, and a lack of political stability have all hindered foreign investment, capital flow, and cooperation.[21]

Since the revitalization of the Central American integration process in the early 1990s, the regional integration has made relatively steady progress on all fronts. The 2001 Plan, Puebla Panama, a multi-country development initiative aimed at accelerating regional physical integration and sustainable development is a testament to the commitment to regional integration as a tool of socio-economic growth and poverty alleviation. It's principal goals fall under eight main headings: electrical interconnection, development of telecommunications services, roadway integration, sustainable development, human development, natural disaster prevention, trade facilitation, and tourism.[22]

Though skepticism concerning the successful integration of Central America abounds, there are clear signs of increased momentum. Advances made in the electrical sector in the past 13 years, through the construction of *The Central American Electrical Interconnection System*, or the *Sistema de Interconexión Eléctrica de los Países de América Central* (SIEPAC) in particular, give cause for hope for the integration process, and this interconnection could be a catalyst for further integration in Central America.

From State-Controlled to Free Market Electricity Sectors

Electricity planning was, for the better part of the twentieth century, the responsibility of, or heavily supervised by, the state, which formulated assumptions about demand-side trends, fuel costs, and other fundamental variables, while also establishing the target reserve margin, desired quality of service and so on. Their goal was to meet energy needs, optimize system performance, and minimize

20 Energy Sector Management Assistance Program. (2011) *Regional Power Integration Structural and Regulatory Challenges: Central America Regional Programmatic Study for the Energy Sector*. (Joint publication with the ESMAP and the World Bank)

21 Mattson, Sean. (2010) "Central America: New Hopes for Integration." *LatinFinance.*

22 European Commission. (2007) *Central American Regional Strategy Paper 2007-2013.*

the cost of production. In times of crisis, governments had to intervene directly and pour financial resources into the industry to prevent collapse. Lack of incentives for efficiency in the operation and expansion of the sector and the politicization of policy decisions and management of sector utilities resulted in high electricity losses and high administration, operation and maintenance costs, relatively low electricity coverage, electricity tariffs that did not reflect marginal costs, difficulties in mobilizing the financial resources required for the expansion of the power system, poor reliability of service, and recurrent financial losses of state-owned enterprises that finally were reflected in unsustainable fiscal deficits.[23]

Vertically integrated systems of government control of the industry soon felt the pressure of the enormous financial resources required to plan, manage, maintain, and regulate the sector, and the West began to push for liberalization of all sectors through a process of privatization.[24] The reform process often granted greater access for private sector involvement, though in many cases it neglected to address the strengthening of the institutional framework of the public sector.[25] The legitimacy of reform was undermined in some countries when the poor were not clearly the beneficiaries of the reform; even today, electricity access by the poor in rural areas is still low.[26]

Not all Central American nations opted for the decentralization and privatization advocated by market deregulation. El Salvador, Nicaragua, and Panama moved away from a vertically integrated monopoly structure, opening segments of generation, transmission, and distribution to competition. Honduras attempted to introduce similar reforms but remains a single buyer owing to failed privatization of distribution.[27] Costa Rica and Honduras preserved their vertically integrated structure, and the state utility acts as a single buyer, procuring additional generation from independent power producers. Each of the Central American countries lies in a different area of the regulatory spectrum that runs between state control and the free market, presenting difficulties for interconnection.[28]

Figure 5 shows the evolution of the liberalization of electricity market policies in the region, and

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23 Energy Sector Management Assistance Program. (2009) *Latin America and the Caribbean Region Energy Sector: Retrospective Review and Challenges*. (Joint publication with the ESMAP and the World Bank)

24 Batlle, C. Barroso, L., Perez-Arriaga, I. (2010) "The changing role of the State in the expansion of electricity supply in Latin America." *Energy Policy*, Vol. 38, pp. 7152-7160.

25 Bozo, Mauricio Garron. (2008) "Energy policies in Latin America and the Caribbean and the evolution of sustainability." *International Journal of Energy Sector Management*, Vol. 2, No. 1, pp. 8-35.

26 Energy Sector Management Assistance Program. *Latin America and the Caribbean Region Energy Sector: Retrospective Review and Challenges*, June 2009. (Joint publication with the ESMAP and the World Bank)

27 Batlle, C. Barroso, L., Perez-Arriaga, I. (2010) "The changing role of the State in the expansion of electricity supply in Latin America." *Energy Policy*, Vol. 38, pp. 7152-7160.

28 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America*.

illustrates the differences in the organizational structure of each country's electricity sector. These differences effectively create discordance amongst policies, private sector participation, the amount of government intervention, and the ability to harmonize policies at a regional level. Not until the vertically integrated energy sectors of Costa Rica and Honduras have been liberalized will electrical integration reach its full potential.

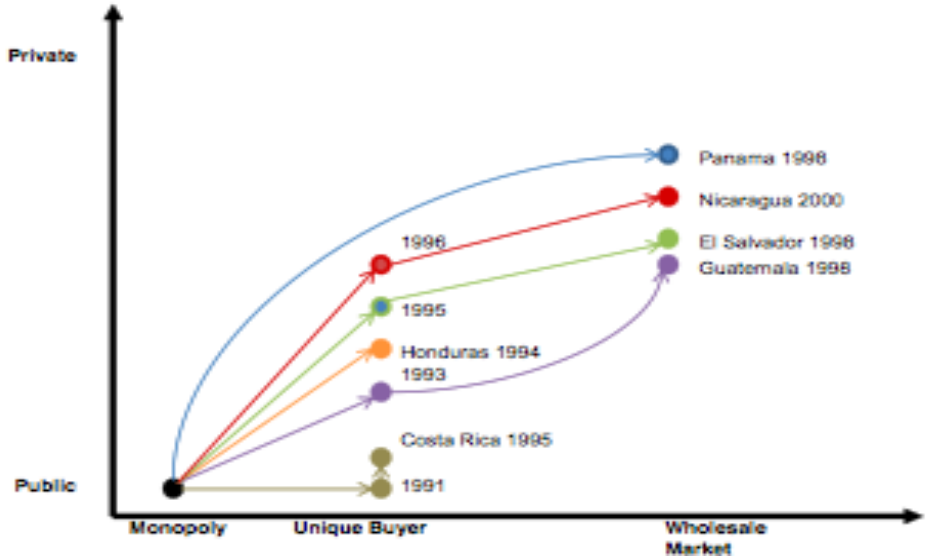

Figure 5: The Evolution of Central American Electricity Markets[29]

The Electricity Sector in Central America

It is estimated that 7 million Central Americans rely on fossil fuels for electricity generation.[29] Central America yields a primary energy matrix, which is indicative of developing countries that still lack penetration of modern technologies for power generation. The residential sector in Central America is the major consumer of fossil fuels with a 43% share in total consumption. Electricity generation capacity is around 9,700 MW. Electricity consumption per capita (780 kWh per year) exhibits substantial growth but continues to be low compared to developed countries, with wide variations within the region: yearly consumption in Costa Rica (1,832 kWh) and Panama (1,586 kWh) is substantially higher than in the other countries which consume less than 700kWh/yr in per capita terms.[30]

29 Inter-American Development Bank. (27 October, 2011) *Covelo Foundation to foster renewable energy use in Central America*. News Release. Web. http://www.iadb.org/en/news/news-releases/2011-10-27/microfinance-for-central-american-solar-power,9636.html

30 Energy Sector Management Assistance Program. (2011) *Regional Power Integration Structural and Regulatory Challenges: Central America Regional Programmatic Study for the Energy Sector.* (Joint publication with the ESMAP and the World Bank)

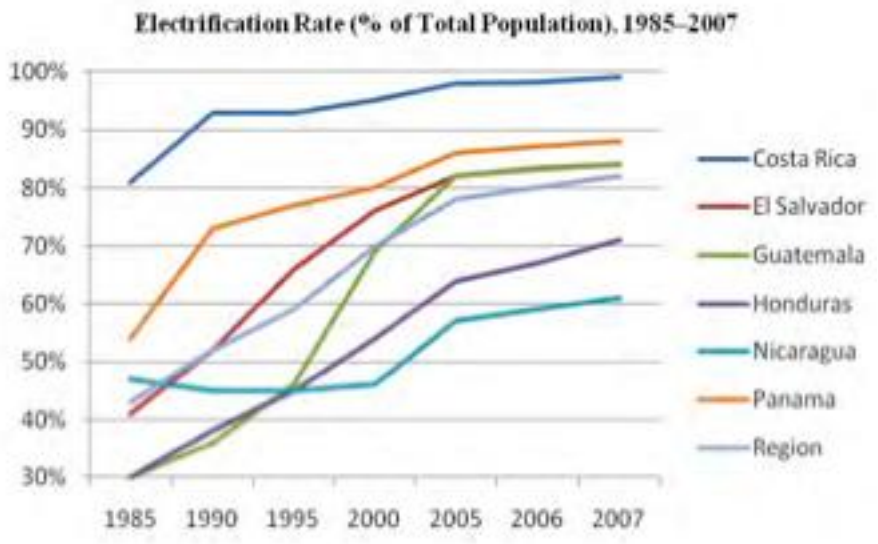

Figure 6: Electrification Rate as a Percentage of Total Population, 1985-2007[31]

Electrification in Central America is relatively high compared to other developing regions.[32] Figure 6 shows the evolution of electrification rates from 1985-2007, which illustrates the immense improvements most countries have seen in recent years. Nicaragua and Honduras still have significant ground to cover, while Costa Rica has nearly achieved 100% electrification. Since 2009, the expansion of rural electrification projects, largely small to medium scale renewable-based projects, will have a significant impact on these statistics in the coming years. Figure 7 shows electrification percentages per country in 2010.

Country	Electrification Coverage
Costa Rica	99.3%
El Salvador	91%
Panama	87%
Guatemala	85.3%
Honduras	77%
Nicaragua	72.1%

Figure 7: Central American Electrification Coverage, 2010[33]

31 Energy Sector Management Assistance Program. (2011) *Regional Power Integration Structural and Regulatory Challenges: Central America Regional Programmatic Study for the Energy Sector*. (Joint publication with the ESMAP and the World Bank)

32 Energy Sector Management Assistance Program. (2009) *Latin America and the Caribbean Region Energy Sector: Retrospective Review and Challenges*. (Joint publication with the ESMAP and the World Bank)

33 Ibid.

Figure 8 shows the breakdown of the energy matrix in Central America by resource in 1990, 2000, 2005, and 2008. One sees the gradual transition towards a more diverse energy portfolio during the last eight years represented: 3,014 MW of new capacity came online with fossil fuel resources accounting for 48%, hydropower another 31%, and wind, geothermal, and bagasse cogeneration facilities for the remaining 21%.[34]

Retail electricity prices in Central America vary according to two sets: the high-price countries (El Salvador, Guatemala, Nicaragua and Panama) with residential prices around US$0.16/kWh, and Costa Rica and Honduras with residential prices on the order of US$0.08/kWh. To avoid increasing prices, governments have resorted to instituting subsidies, with varying degrees of success; in Guatemala, El Salvador and Nicaragua, hydropower plants owned by state enterprises financed a substantial portion of the subsidies; in Honduras, Costa Rica and Panama, subsidies were financed directly through the national budgets. Targeting of subsidies has been diverse in the region.[35]

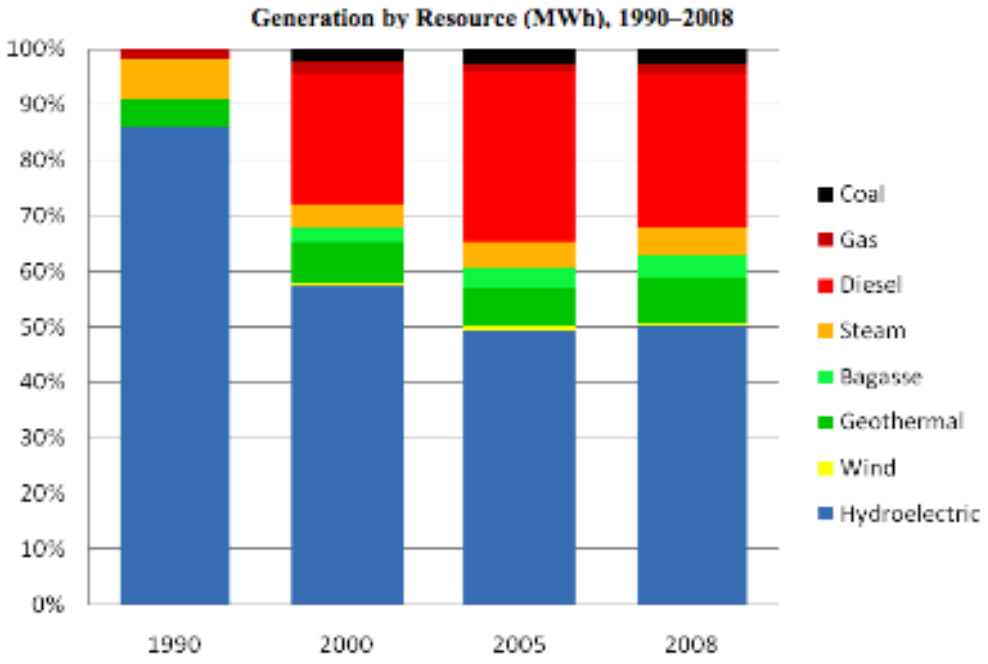

Figure 8: Electricity Generation By Resource, 1990-2008[36]

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34 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America*.

35 Energy Sector Management Assistance Program. (2011) *Regional Power Integration Structural and Regulatory Challenges: Central America Regional Programmatic Study for the Energy Sector.* (Joint publication with the ESMAP and the World Bank)

36 Ibid.

Residential tariffs remain relatively low, particularly in Honduras due to high subsidies and Costa Rica due to low generation costs and hidden subsidies. The existence of direct and indirect subsidies, the high cost of generating emergency electricity, and various imperfections or interventions in the mechanisms for transferring costs from generation to retail rates (especially in Nicaragua and El Salvador) have imposed a significant financial burden on governments in their utilities. Increases in electricity losses (not Costa Rica or El Salvador) have added to the financial burden of distribution companies. The World Bank estimated that the total deficit associated with insufficient tariffs totaled approximately $554 million in 2008; this figure did not include the effect of cross-subsidies or the cost of additional losses, so it should be considered a low estimate for the total cost of shielding consumers from the impact of higher electricity tariffs. Costa Rica, El Salvador, Guatemala, and Nicaragua, all use the economic rents generated by state-owned hydropower facilities to cross-subsidize thermal generation using fossil fuels, whereas Honduras and Panama have financed subsidies directly through the national budget.[37]

The liberalized model promotes the use of market prices for generation, tariffs to recover costs of service, and transparent subsidies. However, the threat of large tariff increases given rising petroleum prices compels governments to intervene in the market with subsides, which undermines the credibility of their commitment to market reforms and regulatory frameworks. Price controls and the implementation of vast subsidies have weakened energy companies' financial position and increased investment risk.[38] Figure 9 details the specific characteristics of each of the electricity markets.

37 World Bank Energy Sector Management Assistance Program. (2010) *América Central: Estudio Programático para el Sector Energético, Módulo de Aspectos Generales y Opciones*.

38 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America.*

Country	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama
First Year of Reforms	1998	1997	1994	2000	1995	1998
Market Environment						
Normative Entity	MEM	DGE	GE & SERNA	CNE (MEM)	MINAET	CPE
Regulator	CNEE	SIGET	CNE	INE	ARESEP	ERSP
System Operator	AMM	UT	ENEE	CNDC	ICE	CND
Market Administrator	AMM	UT	ENEE	CNDC	ICE	CND
Transmission Company	ETCEE	ETESAL	ENEE	ENTRESA	ICE	ETESA
Vertical Integration	No	Yes	Yes	No	Yes	No
Horizontal Integration	Yes	Yes	Yes	Yes, less 25%	Yes	G 25% D 50%
Industry Structure						
Market Model	Wholesale Comp.	Retail Competition	Integrated	Wholesale Comp.	Integrated	Wholesale Comp.
Generators	42	16	31	12	37	13
Transmitters	3	1	1	1	1	1
Distributors	17	5	1	5	1	3
Traders	14	11	0	0	0	0
Large Consumers	37	2	1	9	0	4
Wholesale Market						
Economic dispatch	Cost-based	Price bids	Cost-based	Cost-based	Cost-based	Cost-based
Spot Market Price	SRMC w/ no T Constraints	Average of prices based on bid prices of dispatched generators w/ T constraints	N/A	SRMC w/ no T constraints	N/A	SRMC w/ no T constraints

Capacity Price Long-term Contracts Contracts	Regulated Competitive biding Financial	N/A Negotiated Physical	N/A N/A N/A	Regulated Tender 80% Demand Financial	N/A N/A N/A	Market based Tender 80% Demand Financial
Limit of large consumers	100 kW	0 kW	1000 kW	2000 kW	N/A	1000 kW
Distribution Markets Obligation for contracts Pass-through costs Distribution charges Retail tariffs	Yes Contracts and Spot VADs Pass-through of efficient G-T-D costs	No Spot VADs Pass-through of efficient G-T-D costs	N/A N/A N/A Tariff schedule and adjustments	Yes Contracts and Spot VADs Pass-through of efficient G-T-D costs	N/A N/A N/A Cost plus methodology	Yes Contracts and Spot VADs Pass-through of efficient G-T-D costs

Figure 9: Central America: Characteristics of Electricity Markets[40]

40 Cespedes, R., Madrid, L., Calderon, Ed., Bustamante, A. (2004) *Integrated Information System for the SIEPAC Regional Electricity Market.* International Council For Large Electrical Systems (CIGRE).

The Regional Energy Market (MER)

In 1999, the Central American countries agreed to work together on the SIEPAC project to create an electricity market and to build the first regional interconnection line in Central America, reinforcing the pre-existing country-to-country electrical connections. The project includes the development of a regional transmission system and the formation and growth of a competitive electricity market. The Regional Electricity Market (MER is the Spanish acronym) will exist as a "seventh market" on top of the six national markets and will be governed by a single set of market rules. A regional regulatory agency and a regional market operating entity have been created for it. The basic instrument to advance in the creation of the MER is a Treaty of the Regional Electricity Market of Central America, subscribed by the Presidents of the six countries in December of 1996, and ratified by the six National Congresses.

The objective of the MER Framework Agreement is the "*gradual formation and development of a regional competitive Electricity Market...based on reciprocal non-discriminatory treatment that will contribute to the sustainable development of the region within a framework of respect for, and*

protection of, the environment (Section 1). MER will operate independently of the national markets and will be interconnected at the interchange points defined as boundaries between national markets and the regional market by the Regional Transmission Network (RTN). Initially, lines belonging to existing Central American transmission companies form the RTN. Then, transmission projects of a regional scale will be under the supervision of the Regional Entity Operator (REO). The REO will be responsible for the technical and commercial operations of the MER.[39]

Due to the small size of the individual energy markets of the Central American nations, there has been a dearth of investment in the region. The integration process and the creation of MER generates more interest for investors by creating a market of scale that can produce significant gains on investment that were previously impossible. The development of MER increases legal security for investors and facilitates access to financial sources, with lower intended rates of return and consequent reduction in electricity prices. It makes prospects for energy integration of the Central American isthmus with Mexico and Colombia feasible. Before achieving the objectives of integration, however, certain issues must be resolved. There must be coordination of the energy, macroeconomic, and public policies to prevent disparities that distort prices and payments. Incongruence in the orientations of national energy sectors hinders the realization of MER, because it is based upon market liberalization and requires that all countries involved liberalize their energy markets as well. Regional institutions require strengthening, capacity building, increased budgets, and regulatory unification, rather than the mere standardization of national policies.[40]

SIEPAC

The SIEPAC Project has two main objectives: (a) support the formation and gradual consolidation of a MER by creating and establishing the necessary legal, institutional and technical resources, to facilitate private sector participation in development additions of power generation and (b) establish the electric transmission infrastructure to allow power exchanges among participants in MER.[41] It is envisioned that MER will integrate concordantly with the schemes of organization of the electrical industry at a national level – through the coordinated operation of national systems and, in the long run, through the promotion of electricity generation projects of a regional character.[42]

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39 Cespedes, R., Madrid, L., Calderon, Ed., Bustamante, A. (2004) *Integrated Information System for the SIEPAC Regional Electricity Market.* International Council For Large Electrical Systems (CIGRE).

40 World Energy Council. (2008) *Regional Energy Integration in Latin America and the Caribbean*

41 Empresa Propietaria de la Red. Web. http://www.eprsiepac.com/descripcion_siepac_transmision_costa_rica.htm

42 Zalapa, R. (September, 1999) *Open Access for Electricity Transmission: Arrangements in Central America.* SIEPAC

The project includes building approximately 1,830 km of 230 kV transmission lines from Guatemala to Panama and the connections and transformation substations in each country. SIEPAC will provide Central America with a reliable energy transport capacity for approximately 300 MW and the new infrastructure will permit progressive development of MER. Construction of the transmission lines began in 2006, and it is expected to be completed in 2012.[43] Figure 10 shows the planned route for the interconnected line, which will span 1799kms across the Central American nations. The large yellow dots indicate the regional interconnection substations, and the smaller, red dots indicate national substations. It also indicates how many kilometers of the line will be installed in each country.

Figure 10: The SIEPAC Line, The First Regional Transmission System[44]

There are also plans for connections with Mexico and Colombia. The transfer from Colombia to Panama would be 300 MW and from Panama to Colombia 200 MW, with voltage between 250 and 400kV. Regulatory frameworks for these interconnections are still being drafted, however, they should be created in accordance with the rules and regulations of MER so that all Central American countries can benefit from the interconnections. These interconnections are valuable as they open prospects for energy integration with Mexico and the Andean countries to the south and could mean increasing the scale of transactions and extending benefits from the integrated energy area.[45]

Executive Secretariat.

43 International Confederation of Energy Regulators. (2009) *The Role of Energy Regulators in Guaranteeing Reliability and Security of Supply: The National, Regional and Global Dimensions. ANNEX H – Regional Energy Integration in Latin America and the Caribbean.*

44 Empresa Propietaria de la Red. Web. http://www.eprsiepac.com/

45 Ibid.

Critics fear SIEPAC will facilitate electricity exports to Mexico and Colombia but not expand access in Central America and lament the social cost of large hydroelectric power which is viewed as the pillar of energy production for the grid.[46] After three decades of discussions and now a number of years behind schedule, issues of land use, environment, and rights of way have caused construction to be postponed. The red tape for the completion of the project has not yet been completely dissolved. Another major obstacle to the success of SIEPAC is the lack of harmonization of regulatory policies of individual countries. Distributors call for greater clarity in the process of acquisition of transmission rights for the SIEPAC line.[47]

According to the IDB, which provided half of the funding for the $500 million project, the interconnected electrical grid promises to attract hundreds of millions of dollars in investment and substantially lower energy costs. The IDB estimates that once the grid is fully functioning, it could result in an energy savings of 20%.[48] Supporters of the project argue that interconnection of the grids will optimize shared use of hydroelectricity, reduce operating costs, and create a large enough market to attract foreign investment in power generation and transmission systems.

Renewable Energy Investment

Global investment in renewable power and fuels set records in 2010, and the margin over totals for previous years was wide, not narrow. Investment hit $221 billion in 2010, up 32% from $160 billion in 2009, and nearly five and a half times the figure achieved in 2004. There is strong evidence of a shift in activity in renewable energy towards developing economies. New financial investment was $143 billion in 2010, and more than $72 billion occurred in developing countries, $13.1 billion of it going to South and Central America. Much of the credit goes to the mainstreaming efforts of regional, national, and local level policies promoting renewable energy resources.[49] Governments have been quick to recognize the renewable energy sector as a cornerstone component of efforts to green their economies. As policy incentives improve and financing increases, while technology costs for new renewables go down, and foreign donors offer increasing sums for renewable energy development, market forces due to high oil prices will provide the motivation for countries to increase the use of alternative energy sources even more in the future.

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46 Eguizabal, Cristina. (2011) "Central America's Energy Challenges." *Hemisphere,* Vol. 20, pp. 23.
47 Mattson, Sean. (2010) "Central America: New Hopes for Integration." *LatinFinance.*
48 Mattson, Sean. (2010) "Central America: New Hopes for Integration." *LatinFinance.*
49 Bloomberg New Energy Finance. (2011) *Global Trends in Renewable Energy Investment 2011: Analysis of Trends and Issues in the Financing of Renewable Energy*. (Joint publication with BNEF and United National Environment Programme)

Latin America saw the biggest absolute increase in renewable energy investment among the regions of the developing world in 2010. Overall, new investment in renewable energy of $211 billion was up 32% from 2009 levels, and nearly seven times the figure for 2004.[50] In countries where renewables are seen as an engine for green economic growth, as they should be in Central America, governments expect countless green collar jobs to be created at home, and countries are increasingly looking to local content rules to ensure this is the case.[51]

Recent investment in renewable energy projects in Central America by IFIs has increased dramatically. One of the goals set in the IDB's capital increase agreement calls for 25% of the Bank's lending portfolio to support climate change and environmentally friendly initiatives, including renewable energy. In 2011, the IDB approved $736 million in financing for private sector environmentally friendly projects, compared with the $663 million invested by the IDB between 2000 and 2010. For 2012, the IDB expects to approve more than $700 million in financing for private sector renewable energy projects, particularly wind, solar, and hydropower plants, though geothermal is also on the table considering the large geothermal capacity in the region. In 2012, IDB and the Japan International Cooperation Agency signed a framework agreement that will provide up to $600 million in financing for renewable energy and energy efficiency projects in Central America and the Caribbean over the next five years.[52] Investment in renewable energy is on the rise, and the region needs to focus on implementing policy to foster this investment, as it will aid in their overall economic growth and the achievement of sustainable development goals.

Renewable Energy Resources in Central America

The Central American Energy Strategy 2020 outlines major goals for the region's energy development to ensure access to the parts of the population with the least resources, utilization of renewable energy, and addressing climate change. The region hopes to achieve 90% electricity coverage in each country. It also aims to increase the use of renewable energy in the production of electricity by 11%, mainly through the construction of hydroelectric projects. They want to reduce greenhouse gas emissions by 20%, maximizing the application of certificates of carbon reduction. The strategy also has the goal of reducing the losses in the electrical systems to less than 12%.

50 Ibid.

51 Local content rules are a popular device governments have used to ensure that jobs associated with investment in clean energy are created in the home country, not overseas.

52 Inter-American Development Bank. (2012) *IDB ramps up financing for green projects in Latin America and the Caribbean.*

Figure 11 shows us the installed capacities of hydroelectric, geothermal, steam, diesel, gas, carbon, and wind for electricity generation in each Central American country. It also shows the amount of electricity generated by each source in each country in 2010. Figure 12 graphically illustrates the region's electricity generation by source and by country. It is clear that hydropower is still the largest player in the region, followed by diesel. But it also indicates that four countries have already exploited geothermal, and development of this resource is expected to increase. Wind is also another resource that more countries in the region, in the years following this data collection, began to exploit, so its share in the energy mix will also increase. Solar is not shown in these figures, as the high initial investment cost was a major deterrent, so it did not play a significant role in the region; however solar costs have recently fallen dramatically and the utilization of solar in rural areas, and even in poor urban areas, has increased significantly.

CENTROAMÉRICA: OFERTA Y SUMINISTRO DE ENERGÍA ELÉCTRICA, 2010

	Total	Hidroeléctrica	Geotérmica	Vapor	Diésel	Gas	Carbón	Cogeneración	Eólica
Potencia instalada *(MW)*									
Centroamérica	**11 205,4**	**4 490,7**	**506,8**	**616,2**	**3 605,0**	**913,1**	**167,0**	**723,8**	**182,6**
Costa Rica	2 605,3	1 553,2	165,7	0,0	379,0	347,7	0,0	40,0	119,6
El Salvador	1 481,1	486,5	204,4	0,0	675,0	16,2	0,0	99,0	0,0
Guatemala	2 474,5	884,7	49,2	12,5	746,7	250,9	159,0	371,5	0,0
Honduras	1 610,4	526,4	0,0	0,0	912,0	72,5	8,0	91,5	0,0
Nicaragua	1 060,1	105,3	87,5	169,8	433,7	79,0	0,0	121,8	63,0
Panamá	1 974,0	934,7	0,0	433,9	458,6	146,8	0,0	0,0	0,0
Generación neta *(GWh)*									
Centroamérica	**40 668,2**	**20 974,4**	**3 131,1**	**1 581,9**	**11 129,1**	**474,6**	**1 082,1**	**1 775,9**	**519,0**
Costa Rica	9 503,0	7 261,7	1 176,1	0,0	392,6	248,7	0,0	65,3	358,7
El Salvador	5 877,6	2 145,4	1 427,5	0,0	1 997,6	24,4	0,0	282,7	0,0
Guatemala	7 914,1	3 767,0	259,3	7,8	1 861,9	3,5	1 035,6	978,9	0,0
Honduras	6 721,8	3 080,2	0,0	0,0	3 441,1	11,9	46,5	142,1	0,0
Nicaragua	3 403,2	499,2	268,2	535,4	1 629,5	3,6	0,0	306,9	160,3
Panamá	7 248,5	4 220,9	0,0	1 038,7	1 806,4	182,4	0,0	0,0	0,0

Figure 11: Central American: Supply and Demand for Electricity, 2010[53]

53 Comisión Económica Para América Latina y el Caribe. (2010) *Centroamérica: Estadísticas del Subsector Eléctrico, 2010.* Mexico, D.F.

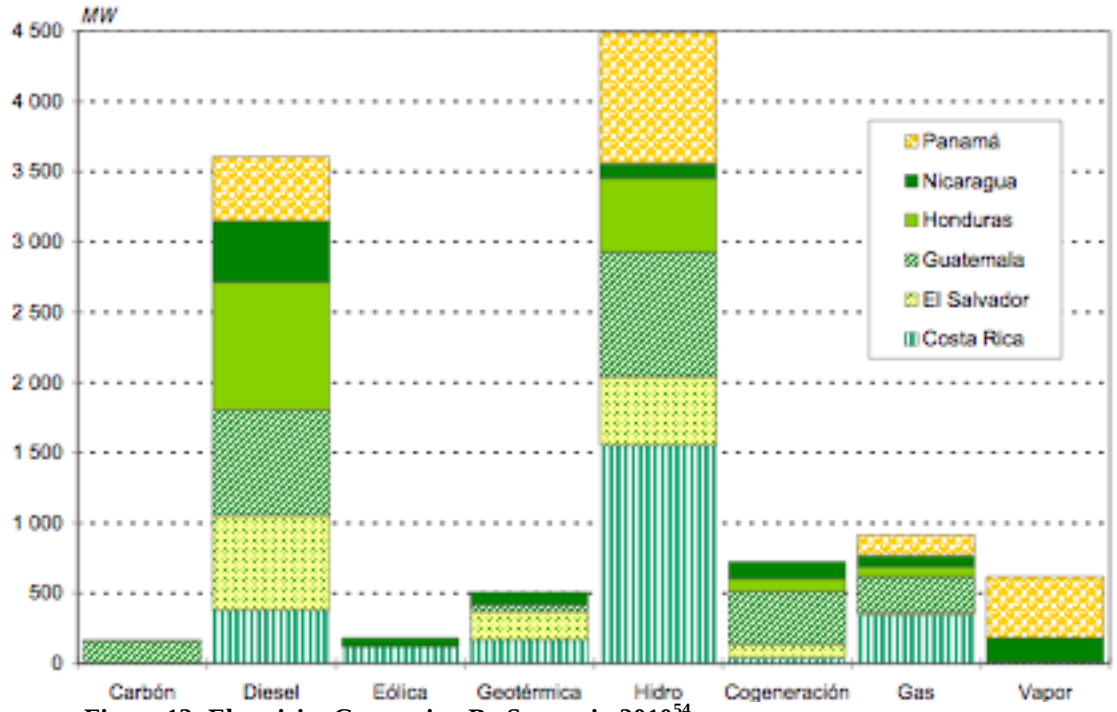

Figure 12: Electricity Generation By Source in 2010[54]

Hydropower

Hydroelectricity, administered by the state through public utilities and transmission companies, has long dominated electricity generation in the region. In the 1980s, 75% of the region's energy came from hydroelectric dams; that percentage has now dropped to less than 50%. According to ECLAC, in 2009, 47.5% of electricity was generated by hydraulic power. Due to the failing political economy of large-scale hydro in Latin America in recent years given the negative environmental impacts and the displacement of peoples, particularly indigenous communities, medium to small-scale run-of-river dams have been favored in recent years. Small run-of-river plants offer little operational flexibility and are more vulnerable to climatic variations. Reservoir storage capacity can compensate for variations in inflow and act as a buffer storing potential energy and aid with adapting to climate change.[55]

Undeveloped but viable hydroelectric resources have been estimated at 18,000 MW. Development of new hydroelectric power systems is controversial due to their effects on local populations and fragile ecosystems. The political economy of large-scale hydro is very poor in the region and brings about protests and roadblocks, as were seen in 2012 in Panama. One potential, partial

54 Ibid.
55 Schaeffer, R. et al. (2012) "Energy sector vulnerability to climate change: A review." *Energy*, Vol. 38, pp. 1-12.

solution being explored consists of re-powering existing hydropower installations.[56] Figure 13 shows the total estimated hydroelectric potential, uninstalled capacity, and installed capacity, respectively, in each country in 2004.

ISTMO CENTROAMERICANO: POTENCIAL DE LOS RECURSOS HIDROELÉCTRICOS, 2004

País	Potencial total		Por desarrollar		Instalado	
	MW	GWh	MW	GWh	MW	GWh
Centroamérica	22 068	94 171	18 271	78 110	3 797	16 061
Costa Rica	5 802	29 660	4 499	23 163	1 303	6 497
El Salvador	2 165	9 483	1 723	8 050	442	1 433
Guatemala	5 000	17 107	4 360	14 451	640	2 656
Honduras	5 000	21 900	4 525	20 499	475	1 401
Nicaragua	1 760	5 767	1 656	5 456	104	311
Panamá	2 341	10 254	1 508	6 491	833	3 763

Figure 13: Central American Isthmus: Potential of Hydroelectric Resources, 2004[57]

Hydropower plants depend not only on the installed capacity but also on the variation of water inflows to reservoirs. Global climate change is altering the hydrological cycle and the water regime and availability of water in drainage basins. The changes in temperature lead to changes in atmospheric pressure and wind patterns; therefore, changes in rainfall patterns are to be expected. The predicted changes may have a negative effect on the flow of rivers and on the refilling of groundwater reservoirs and aquifers. Natural climate variability already has great influence on the planning and operations of hydropower systems, which are built based on historical records of climactic patterns. Studies on predicting and evaluating climatic vulnerability in the generation of electric power in Central America, with an emphasis on the assessment of water flow to hydroelectric power plants, and consequently power shortage risks, should be undertaken before breaking ground on new hydro projects.[58]

The adverse effects of hydroelectric dams and reservoirs on ecosystems and human communities suggest the need to transition to more sustainable forms of renewable energy. Countries with heavy reliance on hydro need to develop plans for de-hydrofication of their energy matrices, as Costa Rica is doing, due to their extreme need to diversify their matrix and the ever changing hydrological patterns due to global climate change.

56 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America*.

57 Ibid.

58 Da Silva Soito, J., Vasconcelos Freitas, M.A. (2011) "Expansion of hydropwer in Brazil: Vulnerability, impacts and possibilities for adaptation to global climate change." *Renewable and Sustainable Energy Reviews*, Vol. 15, pp. 3165-3177.

Geothermal

Central America is located along the Pacific Ring of Fire and has been affected by intense seismic and volcanic activities, resulting in catastrophic events that have affected the economic, social and cultural development of the region, but at the same time, this natural phenomenon has created excellent conditions for development of geothermal resources. Currently, a relatively small percentage of geothermal potential in Central America has been used to generate electricity, an average of 13%. Geothermal provides significant savings of fossil fuels, especially in countries like El Salvador and Costa Rica contributing 26% and 14%, respectively, of total electricity contribution in each country.[59] According to ECLAC in 2009, 7.9% of electricity generated in Central America was from geothermal sources.

Figure 14 shows how the Cocos Plate, Caribbean Plate, and North American plates come together, pushing the Cocos Plate under that of the Caribbean plate. It also shows the active volcanic range. It is this interaction that causes the large amount of geothermal activity in the region.

Figure 14: The Tectonic Setting of Central America

Currently, the region has an installed capacity of 506.6 MW, generating an annual average of 417.5 MW. Geothermal generation capacity in Central America in 2009 was 2887 GWh, which was equivalent to 7.6% of total electricity generated by different energy sources. The potential resources in

59 Montalvo, Francisco. (January, 2011) *Current Status of Geothermal Resources Development in Central America. Paper presented at the Short Course on Geothermal Drilling, Resource Development and Power Plants*, Santa Tecla, El Salvador.

Central America have been estimated very close to the total amount currently used in electric power of about 4513 MW. A large share of this remaining potential may not be exploited due to environmental impact concerns. Costa Rica, for instance, has 865 MW of remaining potential geothermal power, but only 69 MW are available for development, because most potential sites are located in national parks.[60]

Country	Installed Capacity (MWe)	Available Capacity (MWe)	Annual Energy produced (GWh/y)	National participation rate (%)
El Salvador	204.4	183.3	1421.0	26
Costa Rica	165.5	156.0	1186.0	13
Nicaragua	87.5	42.0	271.6	8.7
Guatemala	49.2	36.2	280.0	3.7
Total	506.6	417.5	3159.0	

Figure 15: Central America: Geothermal Power Generation, 2009[61]

Figure 15 illustrates the installed and available capacities, annual energy produced, and the percent of participation of geothermal in the energy matrix for each country in 2009. Figure 16 shows the specific details concerning power plants installed and available capacity, and annual generation in 2009.

Figure 16 details all of the major geothermal facilities, their installed capacities, available capacities, and electricity generation by year. This chart indicates that there is 417.5 MWe of capacity that could still be exploited by these facilities.

As regional electricity interconnection is achieved, geothermal will be invaluable during the dry seasons when hydro is incapable of providing enough electricity. Countries such as Guatemala and El Salvador could then sell geothermal electricity to countries like Costa Rica, which suffers from blackouts during the dry season due to heavy reliance on large-scale hydro. Aside from generating electricity for the grid, smaller geothermal projects can be used to support agriculture, lighting, and heating in rural areas. The low cost and incidence of maintenance also makes geothermal installations attractive.

60 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America.*

61 Montalvo, Francisco. (January 2011) "Current Status of Geothermal Resources Development in Central America." Paper presented at the Short Course on Geothermal Drilling, Resource Development and Power Plants. Santa Tecla, El Salvador.

Country	Geothermal power plant	Initial operation	End of operation	Installed capacity (MWe)	Available capacity (MWe)	Annual generation (GWh)
El Salvador				**204.4**	**183.3**	**1421**
	Ahuachapán I-II-III	1975	***	95.0	79.0	665.3
	Berlin Boca Pozo	1992	1999	-10.0	0.0	0.0
	Berlin I-II	1999	***	56.2	54.4	441.0
	Berlin III	2007	***	44.0	41.4	264.0
	Berlin CB	2009	***	9.2	8.5	50.0
Guatemala				**49.2**	**36.2**	**280.0**
	Zunil (8)	1998	***	24.0	16.1	125.8
	Amatitlán	2006	***	25.2	20.1	154.1
	Amatitlán	2006	2007	-5.0	0.0	0.0
Costa Rica				**165.5**	**156.0**	**1185.7**
	Miravalles I	1994	***	55.0	55.0	420.3
	Miravalles II	1998	***	55.0	55.0	403.3
	Miravalles Boca Pozo	1998	***	5.0	5.0	16.0
	Miravalles III (BOT)	2000	***	29.5	26.0	237.15
	Miravalles V	2003	***	21.0	15.0	109.0
Nicaragua				**87.0**	**42.0**	**271.6**
	Momotombo (3)	1983	***	77.0	35	199.1
	San Jacinto Tizate (2)	2005	***	10.0	8.0	72.5

Figure 16: Central American Geothermal Power Plants, 2009[62]

Wind

The Solar and Wind Energy Resource Assessment (SWERA) program estimated that an onshore area of nearly 13,000km² in the region offered good or excellent wind resources. The capacity as of 2010 was 180 MW; however, based on the data, a minimum of 500-1,000 MW could be developed in the near future. According to SWERA's assessment, Nicaragua offers the most good-to-excellent potential with an estimated 200 MW of potential. Panama, El Salvador and Honduras also offer promise for wind installations.[63] According to ECLAC, a mire 1% of the electricity generated in the region in 2009 was wind-powered. Figure 17 illustrates the potential for electrical generation from wind power in the Central American countries that have the greatest wind capacity.

62 Ibid.

63 United States Department of Energy. (2012) *Central America Wind Energy Resource Mapping Activity.* Solar and Wind Energy Resource Assessment. (Joint publication with USDE and the United Nations Environment Programme.)

Country	Class 3 (km^2)	Class 4 (km^2)	Class 5 (km^2)	Class 6 (km^2)	Class 7 (km^2)	Good to Excellent Potential (MW)	Moderate to Excellent Potential (MW)	Good to Excellent Percent Windy Land	Mod. to Excellent Percent Windy Land
Belize	497	234	6	0	0	1,200	3,685	1.1%	3.3%
El Salvador	1,195	750	313	269	44	6,880	12,855	6.6%	12.4%
Guatemala	1,877	1,003	320	200	45	7,840	17,225	1.4%	3.1%
Honduras	2,880	1,211	485	355	121	10,860	25,260	1.9%	4.5%
Nicaragua	6,821	4,058	1,859	1,469	227	38,065	72,170	5.9%	11.2%
Total	13,270	7,256	2,983	2,293	437	64,845	131,195	3.3%	6.7%

Figure 17: Central America - Gross Wind Electrical Potential[64]

The largest wind farm in Central America, 102 MW Cerro de Hula, which comprises 51 turbines over an area of 6,500 hectares, started commercial operation in December 2011.[65] In early July of 2012, Panamanian President Ricardo Martinelli announced a $445 million wind energy farm, scheduled to come online in 2013 that will supply approximately 7% of Panama's electrical needs.[66] El Salvador has announced plans to auction development rights for a 42 MW wind farm in 2014.[67] Nicaragua had 40 MW of installed wind power as of 2009, and another 215 MW of wind power projects are in various stages of planning.[68]

Figure 18 shows a map of SWERA's estimates of wind capacity in Central America. The greatest potential lies in the southwest of Nicaragua, in the central mountain ranges and, to a lesser degree, on the Caribbean coast of Nicaragua and Honduras.

64 Ibid.

65 Revista Eólica y del Vehículo Eléctrico. (15, August 2011) *First wind farm in Honduras.* Web. http://www.evwind.es/2011/08/15/wind-energy-in-honduras-the-first-wind-farm-in-september/

66 United Press International. (2012) *Major wind farm project begins in Panama.* Web. http://www.upi.com/Business_News/Energy-Resources/2012/07/06/Major-wind-farm-project-begins-in-Panama/UPI-79741341591492/

67 United Press International. (2012) *El Salvador aims high, expands solar power.* Web. http://www.upi.com/Science_News/Technology/2012/07/10/El-Salvador-aims-high-expands-solar-\ power/UPI-79331341943167/

68 Bennett, Colin. (September/October 2010) "Latin American Wind Takes Shape." *Renewable Energy Focus*.

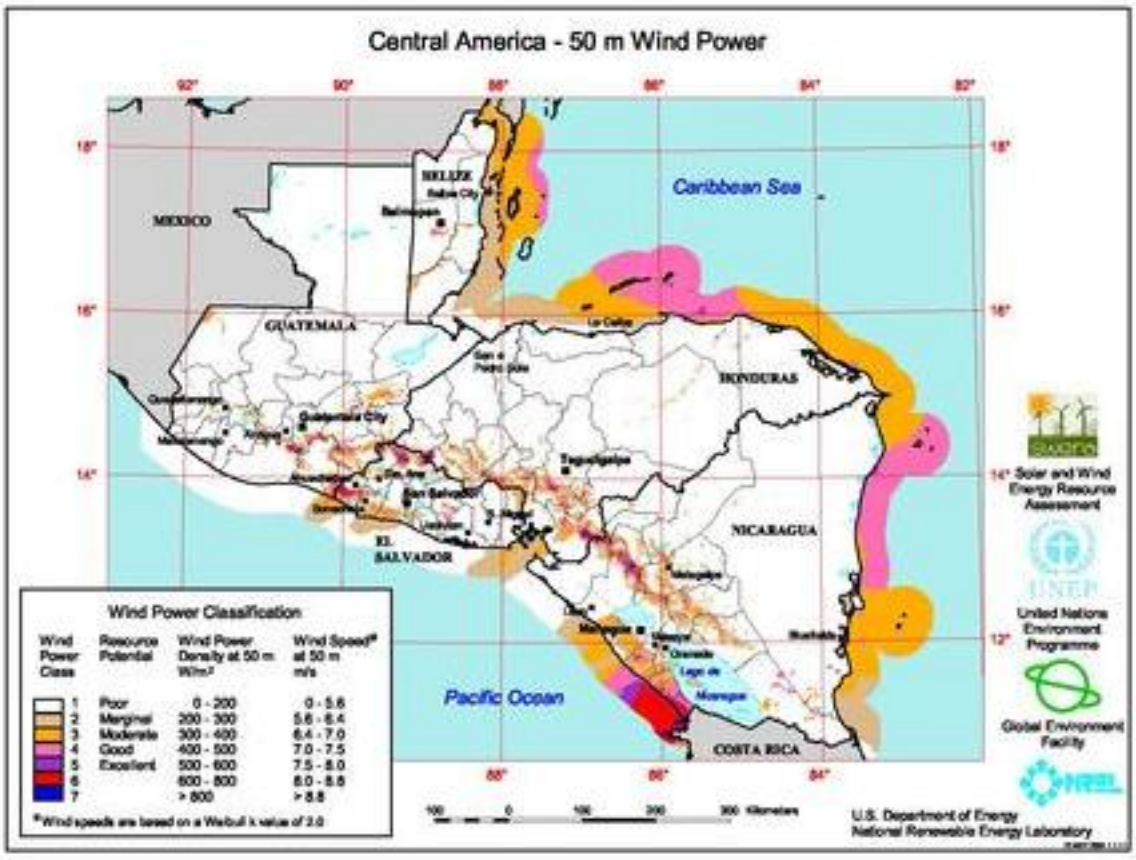

Figure 18: Central American Wind Capacity[69]

Wind energy dominates globally in terms of RE investment, with $94.7 billion invested worldwide in 2010, without counting small-scale projects. Wind turbine prices have fallen 18% per MW in the last two years, reflecting fierce competition in the supply chain.[70] Recent unstable weather patterns due to climate change – namely rainfall, which affects water supply for hydro projects – has made wind a higher priority for regulators and investors in the region. Wind energy is quickly gaining momentum as it can be generated in large-scale farms or in small-scale projects for rural areas.

Solar

Solar power has great future potential, even though in 2010 it only covered .05% of the total primary energy supply globally, and Photovoltaic (PV) power generated less than 1% of total electricity supply. This is largely because solar power is still considered the most expensive of all renewable

69 United States Department of Energy. (2012) *Central America Wind Energy Resource Mapping Activity.* Solar and Wind Energy Resource Assessment. (Joint publication with USDE and the United Nations Environment Programme.)

70 Bloomberg New Energy Finance. (2011) *Global Trends in Renewable Energy Investment 2011: Analysis of Trends and Issues in the Financing of Renewable Energy*. (Joint publication with BNEF and United National Environment Programme)

energies. The price of PV modules per MW has fallen by 60% since the summer of 2008, putting solar power for the first time on a competitive footing with the retail price of electricity in many sunny countries. Today, however, solar may very well constitute the best solution for decentralized energy supply. According to the 2010 BP Statistical Energy Survey, the world cumulative installed solar energy capacity was 22928.9 MW in 2009, a change of 46.9% compared to 2008. SWERA estimates a solar potential of 250 MW for the Central American region with Nicaragua having the highest kWh/M²/day of solar potential.[71] For this reason and considering the high cost of grid extension, Nicaragua has put greater emphasis on solar arrays in rural areas. One such project is in rural Diriamba where they are completing a 1.38MW project, which is partially funded by $12 million from JICA, will power 1,200 homes, and will be the largest solar installation in Central America.[72]

High investment costs and the absence of specific policies promoting solar energy were traditionally barriers to its widespread adaptation; however, conditions have improved, and it is infiltrating the Central American energy market, particularly, as noted above, in rural areas. Because of increased government focus on renewable energy sources and the significant price decreases in PV modules, 2011 saw record market growth in PV energy, since this drop in price increases attractiveness to investors and accelerates the technology's drive towards competitiveness with conventional electricity sources. Several countries have the ability to produce photovoltaic electricity at a cheaper price than grid electricity: El Salvador in the residential segment and Guatemala, Honduras, Nicaragua, and Panama in the commercial/industrial segments.[73]

Figure 19 shows the global horizontal solar radiation map of Guatemala, Honduras, El Salvador, and Nicaragua. It indicates that the Pacific Coast is where the concentration of solar radiation is the highest. Some inland areas also have moderate to good levels of solar radiation as well.

71 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America.*

72 Williams, James. (April, 2012) "Nicaraguan Government to Develop the Country's First PV Project." *PVTECH.* Web. http://www.pv-tech.org/news/nicaraguan_government_to_develop_countrys_first_pv_project

73 European Photovoltaic Industry Association. (2011) *Global Market Outlook for Photovoltaics until 2016.*

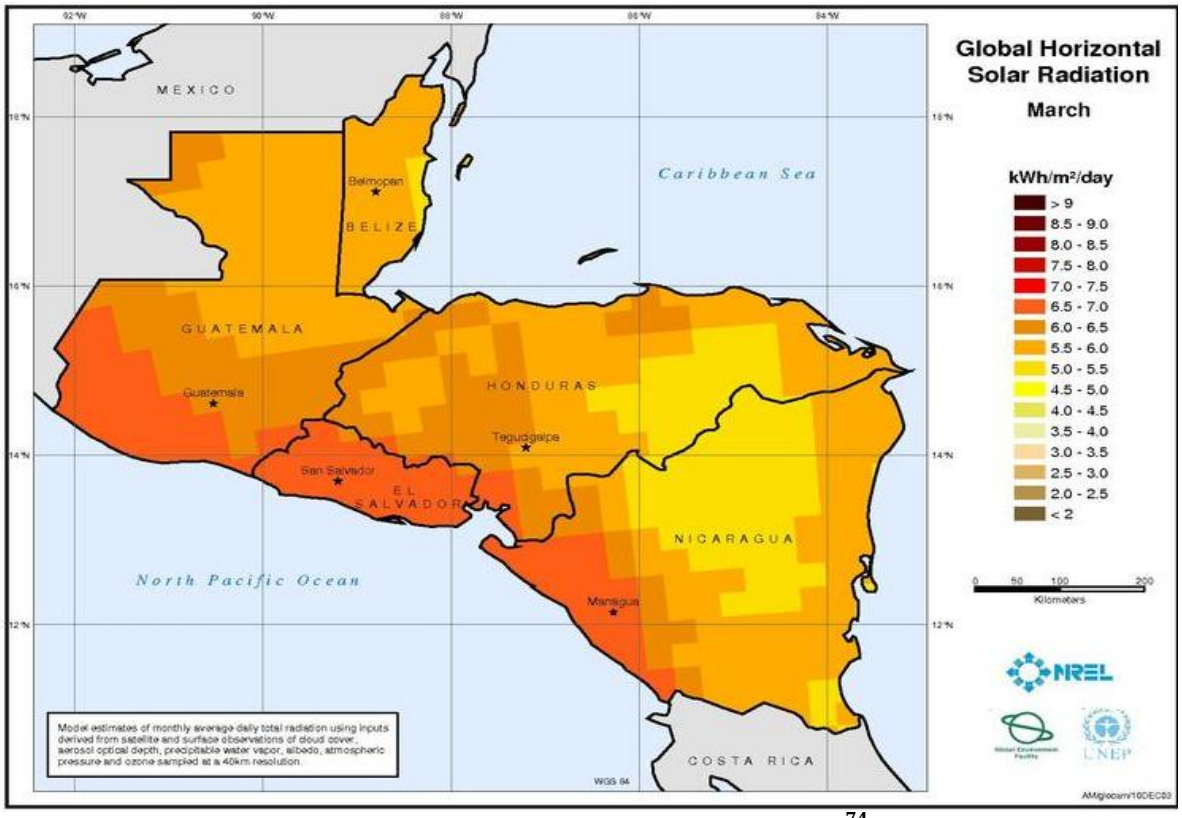

Figure 19: Global Horizontal Solar Radiation[74]

Biomass

Biomass is biological material from a living thing that is used directly or converted to another energy product to be used as an energy source. In Central America, biomass is used mostly in cogeneration projects which use agricultural refuse and, through thermal conversion, converts it into energy. These projects are mostly small-scale. Given the strong presence of agriculture in the region, biomass has the potential to play a much larger role in energy generation.

Costa Rica has 127 MW of biomass potential that has yet to be exploited. The majority of cogeneration projects are generated by sugarcane, pineapple, sorghum, and coffee refuse. Biomass generates 1% of the electricity in Costa Rica each year. Their goal is to increase biomass usage by 1.6% for electricity generation in the next 20 years[75]

Guatemala has the largest sugar cane mills and plantations in Central America. Guatemala took special measures to encourage the development of co-generation, which consisted of favoring long-

74 United States Department of Energy. (2012) *Central America Wind Energy Resource Mapping Activity.* Solar and Wind Energy Resource Assessment. (Joint publication with USDE and the United Nations Environment Programme.)

75 Ministerio de Medioambiente, Energía y Telecomunicaciones de Costa Rica. (2011) *VI Plan Nacional de Energía*. San Jose.

term electric power purchases within a dual generation scheme that also permitted production outside of the sugar cane season.[76]

The sugar industry in Honduras has good potential for electricity production with a capacity to generate 163 MW for self-sufficiency and 42 MW to export to the grid. African palm production has a 62 MW potential from organic waste and a 9.5 MW from capture of methane. There is also significant energy potential from coffee production; however, there are no records of its use thus far.[77]

It is estimated that Nicaragua has an additional 100 MW of potential that is not yet exploited. Currently there are no large-scale biomass projects in Nicaragua, but there are a few cogeneration projects that generate electricity through the burning of bagasse from sugarcane and eucalyptus. Some feel that investing in cogeneration projects with coffee or cacao producers would be lucrative investments.[78] Some speculated that the use of biomass could reduce up to 50% of the costs of electricity generation in Nicaragua.[79]

Existing Renewable Energy Policies

Costa Rica

Costa Rica's National Energy Strategy states that it should enforce the strategic objectives enumerated in the National Plan for Development of 2010-2014; those objectives support the increased participation of renewable energy in the energy matrix in a way that fosters sustainability and competitiveness. The National Strategy for De-carbonization of the Economy advocates using renewable energy as the model for national development. An amendment to the tax exemption act (Law 7400) promotes the use of renewable energies by eliminating 13% of the tax burden previously levied on solar panels and solar-powered kitchens, refrigerators, and heaters, as well as on devices that run on wind, and hydroelectric power. The government will also provide incentives for companies and homes that install solar panels and biomass generation systems. Household and company power systems will be connected to the national grid, enabling individual users to exchange their excess power for discounts on their electricity bill.[80]

76 Renewable Energy and Energy Efficiency Partnership. (2012) "Policy DB Details: Guatemala." Web. http://www.reeep.org/index.php?id=9353&text=policy-database&special=viewitem&cid=22

77 Aguero, S. (2009) *Diagnosis of Biomass.* Database of DGE-Honduras.

78 Jochem, Fabian. (2005) *El mercado de Energías Renovables en Nicaragua: Informe de Investigación.* Deutsche Gesellschaft fur Tecnhische Zusammenarbeit (GTZ).

79 Central American Integration System. (June, 2003) Web. http://www.cepredenac.org/05_nove/a_prensa/2003/julio_03/julio_31f.htm

80 Renewable Energy and Energy Efficiency Partnership. "Policy DB Details: Costa Rica." Web. http://www.reeep.org/index.php?id=9353&special=viewitem&cid=172

El Salvador

El Salvador's 2007 National Energy Strategy supports the diversification of energy sources and increased generation capacity with renewables. Besides hydroelectricity and geothermal energy, the government foresees the addition of 50 MW of renewable generation in the next 10 years in the form of wind, solar, biomass, and mini-hydroelectric plants. In November 2007, El Salvador approved the Fiscal Incentives Law for the Promotion of Renewable Energy whose framework includes incentives such as a 10-year tax exemption for projects below 10 MW of generation capacity. In addition, the System for the Promotion of Renewable Energy established the creation of a Revolving Fund for the Promotion of Renewable Energy that provides soft loans and guarantees and assists in the financing of feasibility studies for new projects.[81]

Guatemala

In November 2003, the Guatemalan Congress approved the Renewable Energy Project Incentives Act. This law instructs the Ministry of Energy and Mines to assess renewable energy resources and projects, study their investment requirements and award incentives: exemptions from customs tariff and value-added tax, income tax and tax on mercantile and farming firms during the first ten years of commercial operation. Guatemala also embarked upon the development of a new rural electrification program to mainstream renewable energy as a standard option of rural electrification efforts. This effort has led to major advances, paving the way for accelerated growth in rural electrification coverage from 53.3% in 1996 to 83% in 2002.[82]

Honduras

Honduras' Legal Framework and Reforms of the Energy Sector Law and its Incentives Law for Renewable Energy Generation of 1998 provide incentives for the development and generation of energy by means of renewable sources. Decrees No. 85-98 and 267-98 promote the development of renewable energy-generating plants. The decrees include tax breaks to developers and a secure buyer for energy at prices equivalent to the system's short-term marginal cost.[83]

Nicaragua

The principal legislation governing renewable energy generation in Nicaragua is Law 532 for

81 Renewable Energy and Energy Efficiency Partnership. "Policy DB Details: El Salvador." Web. http://www.reeep.org/index.php?id=9353&text=policy-database&special=viewitem&cid=20

82 Renewable Energy and Energy Efficiency Partnership. "Policy DB Details: Guatemala." Web. http://www.reeep.org/index.php?id=9353&text=policy-database&special=viewitem&cid=22

83 Renewable Energy and Energy Efficiency Partnership. "Policy DB Details: Honduras." Web. http://www.reeep.org/index.php?id=9353&text=policy-database&special=viewitem&cid=24

the Promotion of Electric Generation from Renewable Sources. Among others, it promotes full exemption from taxes on the sale of carbon bonds; exemption from taxes that might exist for the exploitation of natural resources for a maximum of five years after the start of operations; and exemption from payment of customs duties and value added tax on imports, machinery, equipment, and all materials intended solely for the pre-investment and construction of the sub-transmission line for the national interconnection system. These legal securities along with fiscal incentives led to $670 million in FDI in the energy sector between 2007-2010. As of 2011, energy projects were viewed as a major driver of FDI in the country. These policies will assist in the Nicaraguan government's ambitious goal of increasing renewable energy generation capacity to meet 80% of the country's electricity needs by 2014.[84]

Panama

The main legislation in Panama regarding renewable energy is contained in article 55 of Law No. 6 of 1997, establishing that it is in the governments interest to promote the use of renewable energy to diversify energy sources, mitigate adverse environmental effects, and reduce the country's dependency on traditional fuels. A 5% discount on the evaluated price is granted to renewable energy in each of the competitions or auctions carried out to buy energy and power. The National Assembly approved two renewable energy incentive laws, which include import-tax and other tax exemptions on equipment, as well as a credit equal to 5% of the value of civil works that are for public use. Finally, all wind developers are now able to take advantage of an existing law, under which they are eligible for a 25% repayment of their investment based on carbon credits. Until now, this has been limited to projects under 10MW and large hydropower schemes.[85]

While these policies are promising, institutional and regulatory frameworks for renewables are in their nascent stage in almost every country in the region. Legal frameworks for renewables tend to emphasize incentives over requirements, which are not likely to shift the energy matrix significantly away from fossil fuels. Institutional capacity is a major hindrance across the region. Government agencies, utilities, and regulatory bodies suffer from frequent turnover and a lack of funding.[86] Another barrier to a transition to renewable energy is the special lending through the Petrocaribe agreement that Honduras and Nicaragua enjoy, which offers them oil imports at a rate that is cheaper than it is on the

84 PRONicaragua. (2012) "Nicaragua Powers Up on Green Energy." *Renewable Energy Focus,* Vol. 13, No. 1, pp. 22-23.
85 Renewable Energy and Energy Efficiency Partnership. (2012) "Policy DB Details: Panama." Web. http://www.reeep.org/index.php?id=9353&text=policy-database&special=viewitem&cid=161
86 United States Agency for International Development. (2010) *Promoting Sustainable Energy Integration in Central America.*

global market. The high cost of thermal generation leads to high electricity prices, which will increase as the cost of oil goes up. The high cost of electricity is a disincentive for attracting foreign or domestic companies to the region. Moreover, lack of specific provisions for the purchase of renewables in certain countries means renewables will not be able to compete effectively in the energy markets.

Conclusions and Recommendations

In order for Central America to fuel its continual economic growth, reduce its dependence on oil, increase energy security, create a market of scale that is attractive to investment, reduce carbon emissions, and develop sustainably, they must take a regional approach to developing renewable resources for electricity generation. Transitioning to green energy economies will create jobs, be more financially sustainable, and environmentally friendly in the long run, and can be funded in part by countries fulfilling the requirements of international climate change treaties and agreements. The region must work together to attract investment from IFIs and foreign donors for the development of their renewable energy sectors, particularly in rural areas. Grid extension and rural electrification programs utilizing renewable energy are key aspects of a green energy policy that would support economic growth and reduce fossil fuels consumption and carbon emissions while providing greater electricity access. The goal for the region should be to create and implement a regional renewable energy strategy that meets the demand of the region, fuels economic growth, harmonizes policies, respects national interests, protects the environment, and fosters poverty alleviation. The following recommendations will support the region's transition to 100% renewable energy for electricity generation.

Regional Energy Planning

- **Regional energy planning and a regional energy strategy to strengthen the electrical integration process and regional electricity planning**. This tool would be particularly useful for the diversification of energy resources and should foster support for regional generation projects, not only national projects. The plan must identify and accommodate the differences in interests and goals of each country; however, it should enforce the ideals of a regional mindset, which may at times supersede the interests of individual countries.
- In order to increase energy security, attract investors, and decrease carbon emissions, **SIEPAC countries must strive to diversify their energy matrix, keeping in mind the social, political, economic, and environmental effects of energy policy**. Diversification will also aid in climate change adaptation as hydrological cycles change with less constant and unpredictable rainfall,

and countries are unable to rely on hydroelectricity. Each country may find a different equilibrium for their energy matrix given their resource endowments, capacities, and funding.

- **Feed-in-Tariffs** should be adopted by each country as they provide effective and efficient electricity largely due to the combination of long-term fixed price or premium payments, network connections, and guaranteed purchase of electricity generated. Tariffs should be based on the cost of generation and differentiated by technology type and project size. Policies should streamline administrative and application processes, define clear connection standards and procedures to allocate costs for transmission and distribution. Attention should also be given to exempted groups, for example, low-income and vulnerable customers.
- **Bilateral agreements** with Mexico/Colombia should be coordinated with MER regulations, so all countries in the region can benefit from the interconnection.

Regulatory and Institutional Policy

- **Costa Rica and Honduras must adopt policies that move them towards a more liberalized and open energy market**. The differences in the national markets prevent regional or national generators from contracting electricity directly for potential distribution, commercialization, or with large consumers, because every power operation in these two countries is required to pass through the state monopoly. This represents a lack of reciprocity, which can only be remedied by market reforms in Costa Rica and Honduras that develop clear rules for agents other than public utilities to participate in MER.
- **Countries must complete regulatory harmonization with MER**. This is needed to facilitate market operations and regional long-term firm power contracts between agents. This process must focus on the standardization of terms and conditions in long-term regional contracts and the institutionalization of regional competitive processes and mechanisms for the consolidation of regional coordinated contracts by multiple agents.[87]
- **Regulatory frameworks must move away from favoring domestic market supply**, because it discourages inter-regional trading. Risk of government intervention and potential cuts in exports to meet domestic needs discourages large plants from offering power to other countries in the region.
- **Countries must abandon price controls in domestic markets, so electricity rate structures**

87 Lopez, H., Shankar, R. (2011) *Getting the Most Out of Free Trade Agreements in Central America.* The World Bank.

and fossil fuel prices reflect the marginal costs of production. Countervailing subsidies for renewables are not a substitute for energy price reform.

- **Long-term transmission rights (10-15 years) must be implemented to create security for investors.**
- **The Comisión Regional de Interconexión Eléctrica (CRIE, the regional regulator) must be strengthened to prevent national interests from prevailing over regional ones**.[88] Limited capacity and resources at CRIE makes it vulnerable to national interests. Lack of technical staff and technology resources means they have been unable to create a strategy that takes into account national views and interests.

Rural Electricity Policy

- **All countries in the region should establish targets, incentives, and programs to develop renewable energy in rural areas**. Any subsidies for these areas must be targeted well and monitored thoroughly.
- **Rural off-grid electricity production based on renewable energy sources should get priority focus over extending the electrical grid for the purpose of rural electrification**. Biogas digesters, small hydropower projects, rooftop solar arrays, and small wind installations are all viable possibilities that are already being utilized in the region and have seen excellent results in providing access for the most marginalized sectors of society.
- **Countries should seek assistance from IFIs** to aid in financing studies to assess the potential of renewable resources, finance off-grid rural energy programs, provide technical assistance to revise legal and regulatory frameworks and reduce barriers to the development of renewable resources in rural areas, and set up carbon finance for renewable energy projects. Assistance from IFIs in rural renewable energy development is a particularly high-priority for countries with low to medium electricity coverage like Honduras and Nicaragua.

Foreign Donors and IFIs

- Donor support for renewable energy has tended to be more significant at the national level, as opposed to the regional level, and distribution of grants and lending has been uneven. The

88 Energy Sector Management Assistance Program. *Regional Power Integration Structural and Regulatory Challenges: Central America Regional Programmatic Study for the Energy Sector*, January 2011. (Joint publication with the ESMAP and the World Bank)

emphasis on national-level programs is not conducive to the achievement of regional environmentally sustainable and extensive economic development in the long term. Only a regional approach will create an economy of scale that will facilitate investment; create an attractive market for suppliers of green technology; permit the effective exploitation of energy resource diversity; and generate quantities of emissions reductions that will be marketable in the international carbon market.

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