The Way Forward for Renewable Energy in Central America

Status Assessment | Best Practices | Gap Analysis

Adam Dolezal, Ana Maria Majano, Alexander Ochs, and Ramon Palencia

June 2013

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The report is also available at www.worldwatch.org.

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Foreword

Three years ago, the Worldwatch Institute developed a holistic methodology to advise governments on designing national energy strategies that are built on a country's specific technical potentials; that consider the country's unique investment climate and financial barriers; and that are in the social and economic interest of its people. In designing these Sustainable Energy Roadmaps for many places around the world, we have found that clean energy solutions—renewable energy, energy efficiency, and smart energy distribution—are the approaches that are best equipped to create the sustained, reliable economic development that is critically needed to meet human needs and aspirations.

The Way Forward for Renewable Energy in Central America focuses on the status of renewable energy technologies in Central America and analyzes the conditions for their advancement in the future. It identifies important knowledge and information gaps and evaluates key finance and policy barriers, making suggestions for how to overcome both. As such, this study is a "roadmap of a roadmap"—it scopes the improvements that need to happen with regard to the key components of a sustainable energy system and establishes the necessary methodology and groundwork for comprehensive national energy strategies.

This report is the culmination of the first phase of the Worldwatch Institute's Central America Sustainable Energy Initiative, launched in partnership with the Latin American Center on Competitiveness and Sustainable Development (CLACDS) of the INCAE Business School. Further project phases will fill in the knowledge and information gaps identified here, as well as make more concrete suggestions for financial and political reform at the regional and national levels.

The ultimate goal of this initiative is to integrate and synchronize the available technical, socioeconomic, financial, and political expertise into one comprehensive energy planning tool. The resulting Sustainable Energy Roadmap for Central America will chart the course for a climate-compatible energy development path that enables a sustainable social, economic, and environmental future for the region. The insights and results from both our current and future work will be distributed widely—to targeted governments, non-governmental decision makers, industry and academic experts, community and local-level leaders, and the media and general public—to ensure that all Central Americans understand the many potential routes forward.

Alexander Ochs
Project Director and Corresponding Author
May 2013

Preface

Overcoming world poverty and managing climate change are the two greatest challenges of our times. In 2006, Lord Nicholas Stern made the economic links demonstrating that if we fail on one of these issues, we fail on the other, too. Today, it is clear that climate-related shocks and long-term changes are hitting sooner than expected, and that the poorest countries and people are bearing the brunt of the impacts. The need for action to address the challenge of climate change is more evident than it has ever been.

The Climate and Development Knowledge Network (CDKN) combines research, advisory services, and knowledge management in support of locally owned and managed policy processes. We are pleased to have the opportunity to support, jointly with the Energy and Environment Partnership with Central America (EEP), this work by the Worldwatch Institute and INCAE. We hope that this report, *The Way Forward for Renewable Energy in Central America*, and the engagement process that preceded it during the research phase, will help Central America's decision makers in the design and delivery of climate-compatible development.

Energy security is a common driver for the development of climate-compatible development strategies throughout the world, as the recent CDKN Working Paper, *Drivers and Challenges for Climate Compatible Development*, has shown. Most developing countries are net oil importers, and increases in oil prices can jeopardize their growth, leaving them uncomfortably exposed in their dependence on fossil fuel-producing nations. For that reason, countries are now trying to develop cheaper (in the long term), nationally managed, renewable energy sources through their climate-compatible development strategies.

However, the CDKN Working Paper also highlights how, again and again, there remains a lack of awareness or trusted information about uncertainties, risks, opportunities, and tradeoffs. A strong evidence base, and results communicated in a way that decision makers can engage with, are necessary. The present report tries to address such challenges.

This report presents several interesting case studies—such as the "Solar Women of Totogalpa" (Mujeres Solares)—of how the economic benefits of renewable energy and energy efficiency are improving the lives of the most poor and vulnerable. The question that remains is how to scale up similar initiatives, not only in Central America, but around the world. We hope that the launch of this report will help to address this question and contribute toward making climate-compatible development a reality.

Sam Bickersteth
Chief Executive, Climate and Development Knowledge Network (CDKN)

Preface

Since its beginnings at the United Nations World Summit on Sustainable Development (Rio+10) in Johannesburg in 2002, the Energy and Environment Partnership with Central America (EEP) has supported the countries of Central America—contributing to their sustainable development, poverty alleviation, and the mitigation of climate change.

EEP was launched with the support of the Ministry for Foreign Affairs of Finland in coordination with the General Secretariat of the Central American Integration System (SICA) and the Central American Commission on Environment and Development (CCAD). The incorporation of the Austrian Development Cooperation in 2007 and the European Union in 2010 has strengthened this effort. The participating countries in Central America include Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, and the Dominican Republic.

EEP's efforts are oriented toward the objective of promoting sustainable development in the region through improved access to modern, reliable, and affordable energy services; increased energy security; and the reduction of negative environmental impacts, thus contributing to reducing poverty and diminishing the effects of climate change in the energy sector.

The present report, *The Way Forward for Renewable Energy in Central America*, contributes to one of EEP's primary expected outcomes: an "improved knowledge base and tools to support Renewable Energy project development and policy and legislative framework development." By supporting this study, EEP hopes to take a proactive role in contributing to the work of policymakers and other stakeholders who are interested in ensuring energy security.

The joint effort between EEP and the Climate and Development Knowledge Network (CDKN) to support the work carried out by the Worldwatch Institute and the INCAE Business School has been an important experience of coordinated and united action. We hope that this kind of partnership can be increased in the future.

Salvador E. Rivas
Regional Coordinator
Energy and Environment Partnership with Central America (EEP)

Executive Summary

Central America is at a crossroads. As the economies of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama expand, regional use of fossil fuels for transportation and electricity generation is on the rise, while the use of fuelwood, primarily for cooking, continues to be unsustainably high. These developments come at the price of rising greenhouse gas emissions, worsening air and water pollution, and significant health and societal costs.

Central American countries have committed to sustainable energy development to varying degrees; Costa Rica, for example, is leading the world in its ambition to be "carbon neutral" by 2021, with energy as an important element. The region, long a frontrunner in hydropower and geothermal energy, is exploring its potential for expanding these technologies in a more sustainable manner while also developing other renewable energy resources such as wind, solar, biofuels, and agricultural waste.

Key Gaps in Building a Sustainable Energy Future

Despite their sustainable energy ambitions and policy statements, the seven countries of Central America have been unable to comprehensively design, synchronize, and implement the program of work necessary to promote these solutions to their full potential. Governments, energy planners, international cooperation agencies, utilities, and others have undertaken important assessments of the region's technical potential for renewable energy deployment, with positive results, but many of these studies lack the necessary detail regarding specific technologies and geographic areas. Some assessments are outdated, and many are either publicly unavailable, fail to reflect likely future meteorological changes, or, most importantly, are not integrated with the broader energy system and with current and future energy demands.

Socioeconomic assessments of different energy pathways in Central America face similar challenges. Although considerable data are available and important work has been done in evaluating alternative scenarios, the full costs and benefits to society of specific energy development options remain unclear. What is evident, however, is that the region pays an enormous socioeconomic price for its reliance on fuelwood and imported fossil fuels. By integrating into the costs of various energy technologies some key externalities such as health and pollution costs, as well as lost economic opportunities such as job creation, the competitiveness of clean energy solutions becomes much clearer.

Despite the existing information gaps, most Central American countries have been able to greatly improve their investment climate for sustainable energy. Still, powerful financial barriers remain, ranging from the unavailability of capital and the lack of human expertise, to investment insecurity and costly administrative processes. On the policy side, while many countries have set ambitious goals for sustainable energy development, these visions often lack details, obligations, and concrete measures for

implementation. Where concrete policies and measures do exist, they often do not work properly, are not fully implemented, and/or compete with counterproductive instruments that encourage conventional, dirty energy practices.

Significant Renewable Energy Potential

Central America has seen promising new investments in renewable energy—both in large-scale and grid-tied technologies such as geothermal, biomass, wind, and solar energy, as well as in household-scale and off-grid technologies. But most countries in the region also have plans for increasing oil imports, and some are exploring greater use of coal and natural gas in their energy mix.

Central America has the potential to meet 100 percent of its electricity needs with renewable energy, provided that the proper policies, incentives, and political support are in place. The region's estimated geothermal power potential is more than 20 times the current installed capacity, and geothermal alone could satisfy nearly twice the region's predicted electricity demand through 2020. Existing regional wind power installations currently use less than 1 percent of the available resource potential, even in conservative estimates, and most Central American countries boast 2–3 times the annual solar radiation of world solar energy leaders such as Germany and Italy. There is also considerable regional potential for small hydropower, waste-to-energy, and bioenergy.

Although some existing research has assessed the role of individual renewable energy sources in the region's electricity sector, detailed resource data are not publicly available in most countries. In addition, there has been limited exploration and communication to address important information needs, including how renewable energy sources, energy efficiency, and smart grid solutions can be best integrated in comprehensive energy planning; how to best use renewable energy sources to provide access to energy in geographic areas far from the grid; what alternatives to the current practice of unsustainable household fuelwood use exist; and how to limit and/or substitute for rapidly growing petroleum use in the transportation sector.

Importance of Renewables in Future Sustainable Development

This report finds that renewable energy will need to play a key role in sustaining human and economic development in Central America and in addressing key challenges, including:

- Across the region, an estimated 7 million people have limited or no access to electricity services. *Renewables are the only convincing and affordable solution to provide underserved communities that are far from existing grids with access to modern energy services.*

- As economies develop and populations grow, regional energy demand continues to rise, increasing 4.2 percent in 2011 alone. *Although energy efficiency and energy-saving measures are fundamental to keep the region's growing energy demand in check and to postpone some additional investments, renewable energy is best positioned to meet the important regional energy needs that remain.*

- Countries in Central America are increasingly reliant on imported fossil fuels, which now account for 45 percent of primary energy use and 70 percent of secondary energy use in the region. This comes at a

high social, economic, and environmental price, including to the global climate. *Renewables can reduce this growing fossil fuel dependence, boost national and regional energy security, and play an important role in reducing regional greenhouse gas emissions.*

The current energy system in Central America and a business-as-usual development scenario based on the unsustainable use of traditional biomass and the growth of petroleum-based energy has many social and economic downsides. Yet there have been no country-specific assessments of the full societal costs of conventional energy sources as compared to alternative, clean technologies. Full LCOE+ (Levelized Cost of Energy, plus) assessments that include health, environmental, and climate change costs would strengthen the acceptance and prioritization of sustainable energy sources among key decision makers and the general public. In most cases, the true societal costs of consuming fossil fuels can be assumed to be at least 8–11 percent higher than the fuels' current market cost.

In addition, impact assessments of different energy scenarios on key economic sectors as well as on the labor markets of Central American countries are needed to determine the full supply-chain and employment opportunities for renewable technology development in the region. Such assessments would also help with setting priorities for capacity-building efforts. The socioeconomic benefits of renewables are enormous, but they need to be better measured and communicated.

Strengthening the Investment Climate for Renewables

Tens of billions of dollars in new renewable energy investments will be necessary over the coming decades to harvest Central America's full renewable resource potential. Although important financial mechanisms to support renewables exist throughout the region, many of these face powerful investment barriers. The investment climate for renewables varies widely across the region, with some countries being more successful in attracting finance than others.

Investment in renewable energy is influenced heavily by a country's overall investment climate. Nicaragua, however, has overcome its low overall investment ranking by facilitating an emerging policy framework to support renewables and to improve legal security for investors in the sector. The existence of a dynamic and experienced microfinance industry has helped in the development of local businesses that offer small-scale solutions to households and commercial users.

Despite challenges in the regional investment climate, investors and lending institutions have shown sustained interest in providing loans and capital to renewable energy projects throughout Central America. The main challenge is fostering an environment that allows investors to assess and manage the risk. Important enablers include efforts to increase the information and human resource capacities of banks, in order to help them better understand the value proposition of renewable energy technologies; and improving the understanding among renewable energy developers of what banks require to approve a loan.

Additional research is needed to highlight successful business models that exist in the region or under similar conditions elsewhere in the world, and how these can be created, sustained, replicated, and scaled up. The role of international organizations and banks in reducing private financing risks (e.g., through loan guarantees) also needs to be better assessed, and concrete suggestions are needed to facilitate better cooperation between these institutions, governments, and the private sector.

Renewable Energy Targets, Policies, and Governance Structures

Although Central America has come a long way in its support of renewables and is committed to facilitating a further transition to these technologies, existing policies and governance structures are not sufficient to bring the region to its full sustainable energy potential.

To successfully develop their renewable energy resources, countries need policies and measures that are "loud, long, and legal," including effective targets, concrete policies, and well-functioning governance and administrative processes. All Central American countries have targets related to renewables, to varying degrees. Some, particularly Costa Rica and Nicaragua, rank high in their ambition to transition to renewable energy sources. However, many targets in the region lack clarity and are voluntary rather than mandatory.

Most countries in the region have concrete policy mechanisms in place for advancing renewables. Tax incentives are the most ubiquitous, but the region also has positive experience with tendering for renewable energy projects, with these two measures now being used in seven countries (data for Belize are not available). Newer mechanisms such as net metering, feed-in tariffs, and renewable energy production laws are just getting off the ground in Costa Rica, Guatemala, and Panama. Mandates for biofuel blending also exist in three of the seven Central American countries.

These policies and measures, however, are not always sufficient to level the playing field with fossil fuels, which are subsidized (directly and/or indirectly) in all Central American countries. Many policies are not cost efficient, and they are not robust enough to move the region to its full renewable energy potential. Additional mechanisms are necessary in countries like Belize, El Salvador, and Honduras, where newer renewable technologies such as wind and solar have yet to take off. These and other countries can draw from both regional and international experience, as well as from the large toolbox of existing mechanisms worldwide. Policies and measures should be evaluated at the country level, with countries adopting only those tools that work best within the given technical, regulatory, normative, and financial environment.

Governance and administrative efficiency can be improved throughout the region. In most countries, government offices dedicated specifically to new renewable energy technologies have emerged only in the last five years. Many of these institutions have had a steep learning curve and still lack the necessary resources to perform more effectively. The excessive bureaucratic steps that private developers must take to advance renewable energy projects, as well as the lack of transparency, reliability, and accountability of the process, are major barriers that strain scarce financial and time resources. Establishing a "one-window stop" for renewable energy permitting would help enormously, creating a forum where key private stakeholders can communicate their resources and needs with governments, and vice versa.

The Way Forward for Renewable Energy in Central America

This report identifies four areas for improvement in knowledge and communication to more effectively advance renewable energy use in Central America:

1. Produce additional, detailed assessments of renewable resource potentials in the region and make them publicly available;

2. Assess renewable resource technical potentials against existing and future electricity load curves, and harvest renewable resources in tandem with energy efficiency and smart grid solutions, via an integrated energy planning approach;

3. Assess and communicate widely the full socioeconomic impacts of different energy scenarios, including impacts on local economies and job creation; and

4. Increase efforts to support national and regional renewable energy research; boost public awareness of renewables; and strengthen the related knowledge and human resource capacities of the government, banking, and private industry sectors.

The report also identifies four areas for improvement in finance and policy to enable countries to more rapidly and more effectively realize sustainable energy systems based on renewable resources:

1. Mainstream renewable energy policies and goals among the diverse government agencies;

2. Evaluate existing policy instruments related to renewables and, where necessary, refine the policy mix;

3. Streamline administrative processes for developing new renewable energy projects and make them less costly and time intensive; and

4. Establish clear indicators for measuring, evaluating, and reporting progress on renewable energy policies and investment environments.

Central America has tremendous potential to become a world leader in renewable energy, despite the fact that the concrete design of a sustainable energy system based on renewable technologies, energy efficiency, and smart options for transmission, distribution, and storage is only gradually becoming visible. The social, economic, and environmental benefits of a regional transition to sustainable energy are obvious but have not yet been assessed fully and communicated broadly. Renewable energy investments are increasing within the region, but existing financial and political support mechanisms remain insufficient to develop the full potential of all countries.

Central America can power its economies in large part with renewable energy sources, helping the region to address some of its most pressing development challenges. What is needed now is the continued, collaborative effort of researchers, governments, and the private sector to help realize this goal.

1 | Developing a Regional Renewable Energy Roadmap

Central American governments are increasingly aware of the importance of renewable energy as a critical means to achieve key development goals, including improving energy access in underserved communities, meeting rising energy demand, and reducing growing dependence on imported fossil fuels. But while many countries have issued ambitious policy statements to advance renewables, the lack of coherent strategies, concrete policy and financial mechanisms, and effective administration impedes full implementation.

Worldwide, renewable energy has shown remarkable growth in recent years. Renewable energy, not including the use of traditional biomass*, currently makes up 8.2 percent of global final energy consumption.[1†] In the electricity sector, approximately 20 percent of the world's power is now supplied by renewables.[2]

Between 2000 and 2010, global installed renewable electricity capacity (excluding hydropower) more than quadrupled worldwide.[3] In 2011, nearly half of the world's newly added electricity capacity was renewable, with wind power and solar photovoltaics (PV) each representing 30 percent of new additions.[4] Eighty-three countries now generate wind energy on a commercial scale, and more than 100 countries produce electricity from solar PV.[5] More than half of today's solar PV in operation was added in just the last two years.[6]

Central America is part of this global transition to renewable energy. The region is a worldwide leader in hydropower and geothermal energy, and most Central American countries are implementing or developing wind power projects. The region's first utility-scale solar projects were built in 2012 in Costa Rica and Nicaragua, and solar systems are producing electricity or heating water at both the household and commercial levels, including in remote areas with no access to the grid. Countries are using agricultural biomass and biogas for electricity generation and cooking, and biofuels for transportation. Alternatives to inefficient household use of fuelwood are also gaining traction. Yet the region is far from developing these sustainable energy technologies and practices to their full potentials.

Central American governments are aware of the importance of renewable energy as a means to reduce traditional dependence on unsustainable large hydropower and rising reliance on imported fossil fuels; to meet the region's growing energy demand; and to provide energy access to currently underserved communities. Countries in the region have issued ambitious policy statements that express political will for the further advancement of renewables. In many cases, however, they lack long-term renewable energy goals, coherent low-emissions development strategies, and concrete mechanisms to apply these policies, and administrative ineffectiveness impedes full implementation.

* Traditional biomass is defined as the use of fuelwood, charcoal, manure, or crop residues for cooking and heating.
† Endnotes are grouped by section and begin on page 73.

This report is modeled on the Worldwatch Institute's "Sustainable Energy Roadmaps" methodology, an approach that is currently being implemented in countries and regions around the world. (See Figure 1.) Although the research timeframe did not allow for a comprehensive roadmap exercise, the goal of this study was to prepare a "roadmap for a roadmap" for the advancement of renewable energy in Central America, with a focus on the electricity sector. Future research is needed to address energy efficiency and grid solutions for a more integrated electricity sector analysis, to investigate solutions for the transportation sector, and to explore further the areas of socioeconomics, finance, and policy discussed here.

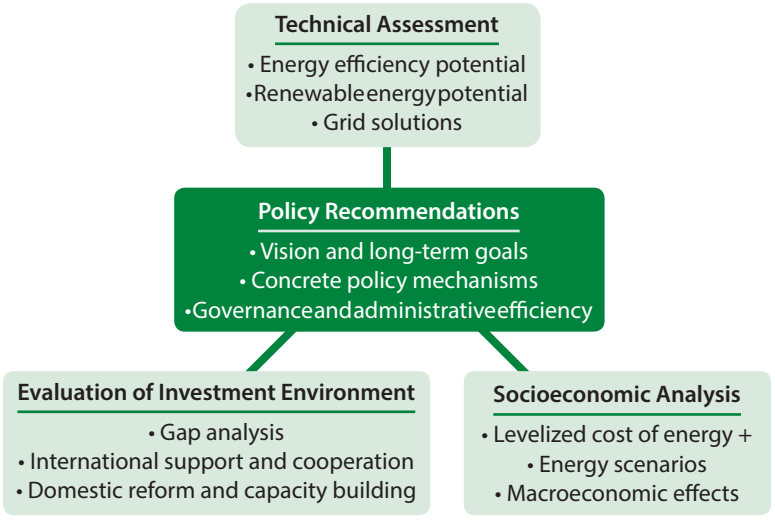

Figure 1.

Sustainable Energy Roadmap Methodology

Moving forward, Central America will need to address four critical, high-impact areas as it embarks on an energy transition:

1. Expanding access to sustainable energy in underserved communities through distributed renewable energy. Across Central America, an estimated 7 million people have limited or no access to electricity services.[7] Because many live in remote areas far from electricity grids, it is unlikely that centralized power systems will ever reach them. Distributed renewable energy technologies employed at the household level, as well as in mini-, micro-, and local grids, are not simply an "alternative"—they may in fact be the only option for electrification that is technically, economically, socially, and environmentally viable.

2. Substituting the region's rapidly rising fossil fuel use with renewable energy sources. Despite new investments in large-scale, grid-tied renewables—such as geothermal, biomass, wind, and solar energy—many countries have plans for increased importation of oil, coal, and natural gas. Today's energy decisions will lock in the technologies to be used for decades to come, and the economic, social, and environmental advantages of choosing renewables over fossil fuels are enormous, although they are rarely explored in detail and are under-communicated to decision makers, the media, and the general public.

Studies indicate that if electricity prices in Central America were to reflect the full health and climate change costs of fossil fuel-based generation, the costs of consuming these fuels would increase 8–11 percent through 2020, bolstering the attractiveness of renewable energy options.[8] Resilient renewable technologies will also help the region adapt to unpreventable future climate change and reduce the costs of climate adaptation.

3. Curbing the unsustainable use of fuelwood for cooking and heating. This is a challenge in both under-electrified areas and areas that currently have access to electricity. Alternative sources of biomass as well as better harvesting and consumption practices are one step; renewable energy technologies are another.

4. Slowing the region's rapidly rising use of energy for transportation. In some countries, the transportation sector already contributes the highest share of carbon dioxide (CO_2) emissions. Although Central American governments are undertaking measures to slow energy consumption and reduce greenhouse gas emissions, as well as to diversify fuels in the transportation sector, these efforts need to be scaled up enormously if climate and development goals are to be met.

This report draws on the latest available data to offer the most comprehensive study of renewable energy in Central America to date, providing key recommendations for moving forward and highlighting important knowledge gaps and action steps in the areas of technology, socioeconomics, finance, and policy.

Chapter 2 highlights the current status of non-renewable and renewable energy in the seven Central American countries of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama, as well as the vast renewable resource potential that remains unused. It also identifies important data and knowledge gaps.

Chapter 3 outlines the social and economic downsides of the current energy system and of a business-as-usual development scenario that further increases unsustainable biomass use and petroleum-based electricity generation. Although country-specific assessments of the full societal costs of alternative energy sources are not yet available—an important area of future research—the analysis reveals the clear socioeconomic promise of renewables.

Chapter 4 describes the financial mechanisms currently available for renewable energy development and deployment in Central America, as well as the investment environment surrounding them; it also identifies important investment barriers.

Chapter 5 examines whether the existing policy framework in Central American countries includes the key components necessary for successful renewable policy advancement. Among these are a "loud, long and legal" vision, including concrete targets, effective policies and measures to achieve the vision, as well as working administrations and procedures to oversee the implementation of these policies and measures.

Chapter 6 draws from the findings of the preceding chapters to identify four areas for improvement in knowledge and communication, as well as four areas for improvement in finance and policy, that are needed for countries to realize a sustainable energy system based on renewable resources.

2 | Conventional vs. Renewable Energy in Central America: Status and Potential

Currently, 62 percent of the electricity fed into the Central American grid comes from renewable sources, primarily hydropower. As interest in large hydropower wanes, however, the use of fossil fuels for power generation has increased rapidly, and all countries plan to increase imports. The region has only recently begun to harness other large-scale, grid-tied renewable energy sources such as wind and solar. Although important studies of the technical potential of renewables exist for some parts of the region, many assessments are not publicly available or are limited in the specific technologies or communities studied. Research and communication on how best to address key regional energy challenges, such as the lack of energy access in remote areas and the unsustainable use of fuelwood and petroleum products, has been insufficient. What is needed is an integrated, holistic approach that encompasses the key components of a sustainable energy system and that is informed by a broad range of stakeholders.

Central America's energy mix is dominated by imported petroleum products, used for transportation and other purposes, and by traditional biomass (primarily fuelwood), used for cooking; these account for 45 percent and 38 percent of final energy consumption; respectively.[1] Electricity represents about 12 percent of final energy consumption, a relatively small share by international comparison and a consequence of the region's prioritization of agriculture, commerce, and tourism over energy-intensive industry and manufacturing.[2] Still, electricity generation is of growing concern, as both the demand for energy and the volume of fossil fuels supplying it increase rapidly.

Central America has been a global leader in generating power from renewable sources. Currently, 62 percent of electricity fed into the grid in the region is from renewables, with large hydropower playing a dominant role.[3] The situation is evolving rapidly, however, and fossil fuel generation has been on the rise since the late 1990s. But there is good news as well: on a capacity basis, renewables have grown faster than fossil fuels in the region's electricity mix over the last three years.[4]

The seven countries of Central America cooperate politically and economically, yet their geographical, cultural, social, economic, and political circumstances vary significantly. Opportunities, barriers, and priorities in the energy sector sometimes align, but they often differ.

If traditional biomass is included, Guatemala, the region's most populated country, uses the most energy overall, at nearly 65 million barrels of oil equivalent annually; if transportation is included, Guatemala also consumes the most oil.[5] (See Table 1.) Costa Rica generates the most electricity, and while the country's fossil fuel consumption is rising rapidly, it also produces the highest share of electricity from renewable sources—91 percent, much of it from large, sometimes controversial, hydropower.[6] Electricity use has increased dramatically in Honduras, El Salvador, Nicaragua, and Panama over the past decade as these economies develop and as the demand for energy increases.

Table 1. Key Energy Statistics for Central American Countries

	Total Energy Use (2010)	Total Electricity Generation (2011)	Increase in Electricity Use (2000–11)	Oil Use (2011)	Increase in Oil Use (2000–11)	Share of Renewables in Electricity Sector (2011)
	million barrels of oil equivalent	gigawatt-hours	percent	million barrels per year	percent	percent
Belize	1.9	483	—	1.2	-28	60
Costa Rica	27.2	9,760	42	18.3	42	91
El Salvador	20.1	5,813	72	15.4	10	63
Guatemala	64.7	8,147	35	25.3	17	64
Honduras	27.4	7,127	91	18.2	77	44
Nicaragua	15.8	3,567	70	10.4	25	33
Panama	24.8	7,703	61	22.5	104	53

Note: For Belize, data on total electricity generation and share of renewables in electricity sector are from 2010; data on increase in electricity use are not available.
Source: See Endnote 5 for this section.

As Panama's economy surges, its domestic use of oil has increased more rapidly than that of any other country in Central America; however, Panama also is home to the region's most ambitious wind power development. In El Salvador, geothermal development has kept the rise in oil use at bay. These, and many other differences, equate to a diversity of energy challenges within the region.

2.1 Growing Dependence on Fossil Fuels

Prior to 1990, thermal power generation from fossil fuels was almost nonexistent in Central America. During the two decades between 1990 and 2010, however, the region's electricity sector shifted from relying almost exclusively on hydropower to producing a significant share of electricity from fossil-based fuels such as diesel, heavy fuel oil, and coke. Fossil fuel generation peaked in the mid-2000s at nearly 40 percent of the regional electricity mix, and has since declined slightly to 38 percent.[7] (See Figure 2.)

In absolute capacity numbers, renewable energy continues to grow in the region. The share of renewables in total installed power capacity is currently at 55 percent.[8] (See Figure 3.) Fossil fuel capacity is increasing as well, however, and actual electricity generation from fossil fuels is growing faster than that from renewables, with the consequence being rising dependence on fossil fuel imports.

2.1.1 Rapid Increase in Oil Imports

As part of its growing reliance on fossil fuels, Central America is importing increasing amounts of oil, both for use in transportation and to generate electricity in power plants. The region's transportation sector relies almost exclusively on oil and consumed 54 percent of total oil imports in 2011.[9]

Oil and other petroleum derivatives now represent the largest source of final energy use in Central

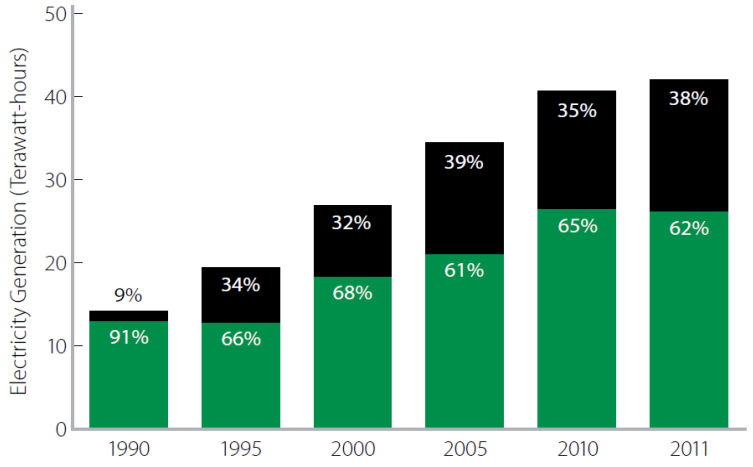

Figure 2.

Fossil Fuel vs. Renewable Share of Total Electricity Generation in Central America, 1990–2011

Note: Data exclude Belize.
Source: UN-CEPAL

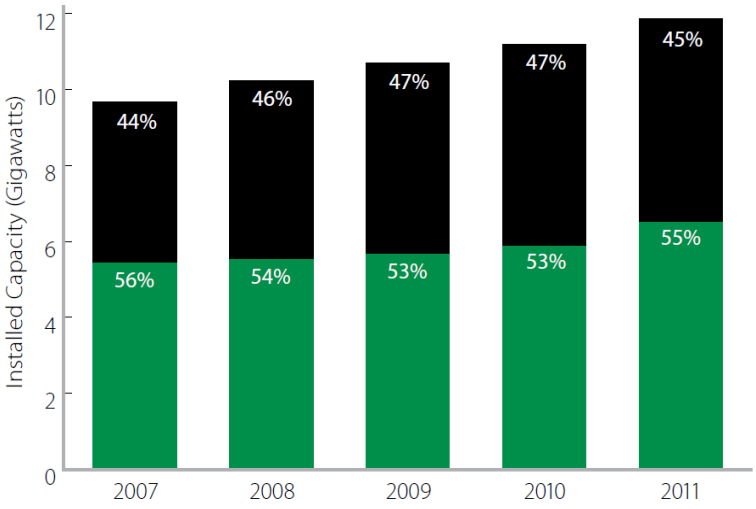

Figure 3.

Fossil Fuel vs. Renewable Share of Installed Power Capacity in Central America, 2007–2011

Note: Data exclude Belize.
Source: UN-CEPAL

America, accounting for some 45 percent of primary energy consumption and 70 percent of secondary energy consumption.*[10] Some countries depend far more heavily on petroleum than others: in Panama, it represents as much as 69 percent of total energy consumption, whereas in Guatemala the share is only 35 percent, a consequence of both economic and societal developments.[11]

Almost all of the oil used in Central America is imported. Both Guatemala and Belize produce small amounts of domestic oil, but in 2011 this amounted to only 3.9 million barrels and 1.7 million barrels, respectively.[12] Because neither country has refining capabilities, all of this oil is exported as crude. Although Belize produces more oil than it consumes, in Guatemala, domestic oil production amounted to roughly 15 percent of consumption in 2011.[13]

* Primary energy is energy embodied in sources that involve human extraction or capture in order to make the energy available for use. Secondary energy is energy that comes from human-induced transformation.

In 2010, petroleum imports in Central America totaled $13.3 billion, or just under 8 percent of the region's gross domestic product (GDP), with domestic shares ranging from 5.3 percent in Costa Rica to 16.7 percent in Nicaragua.[†14] Only three countries in the region—Nicaragua, El Salvador, and Costa Rica—have the ability to refine petroleum; as a result, only an estimated 10 percent of the oil imported in 2011 was unprocessed crude.[15] This means that countries are paying a premium for importing primarily refined oil, footing the bill for both processing and transport costs.

Following the global trend, Central American countries are taking early steps to reduce their dependence on oil for transportation.[16] Panama has begun to electrify its public transport, deploying a handful of electric buses, and is developing long-term plans for electric trains.[17] There is also growing regional interest in electric cars and other vehicles. Between 2006 and 2011, Costa Rica added nearly 3,000 clean technology vehicles, including electric and hybrid cars and motorcycles.[18] The country is also exploring the use of compressed natural gas in transportation and implementing fuel-saving measures, such as adjusting the timing of streetlights to increase fuel efficiency and prohibiting driving on designated days based on odd or even license plate numbers.[19]

Outside of transportation, the bulk of imported oil in the region is used in the power sector. Of the seven countries, Nicaragua relies most heavily on petroleum for electricity generation, with nearly 67 percent of its power in 2011 coming from the burning of primarily diesel and bunker fuel in highly polluting and inefficient generators.[20] (See Figure 4.) But the country is investing strongly in renewable energy sources, and, by the end of 2013, the electricity sector's dependence on oil is expected to fall to 53 percent.[21]

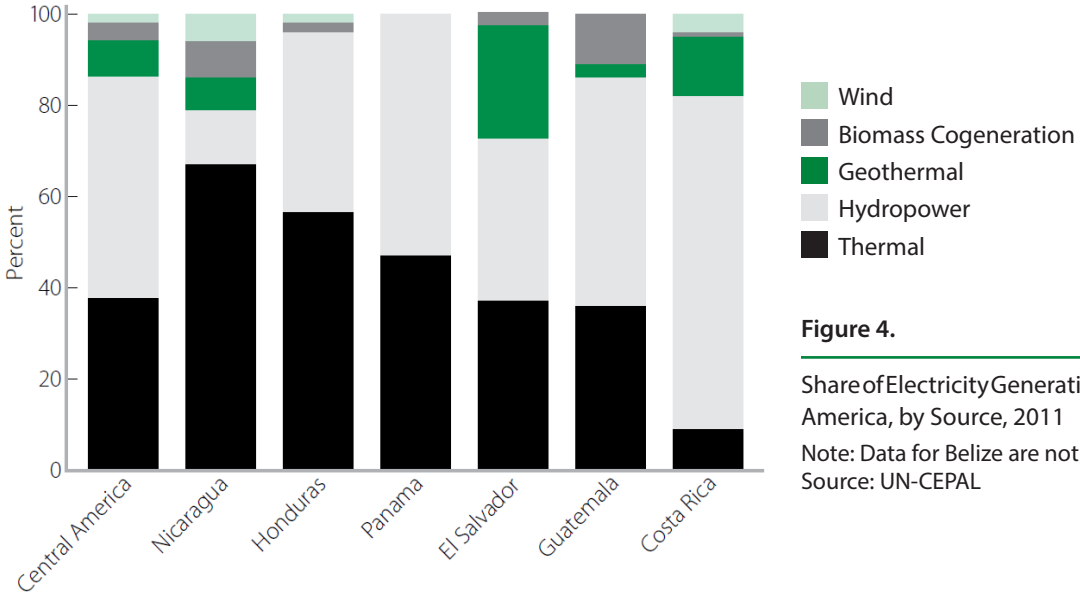

Figure 4.

Share of Electricity Generation in Central America, by Source, 2011

Note: Data for Belize are not available.
Source: UN-CEPAL

As awareness of the risks of oil import dependence grows, Central America has started to develop alternative strategies in both the transportation and electricity sectors. But these efforts are scattered, and measures that are currently being implemented and envisioned will likely not result in significant change

† All dollar amounts are in U.S. dollars unless indicated otherwise.

from the current trend.

2.1.2 Uncertain Future for Coal and Natural Gas

At 3.9 percent, coal accounts for only a small fraction of Central America's electricity generation.[22] All of the coal used in the region is imported. Although Costa Rica and Panama have small quantities of proven coal reserves, neither country is currently extracting this resource.[23]

Guatemala, Honduras, and Panama are the only countries in the region that operate coal-fired power plants, with a combined capacity of 388 megawatts (MW).[24] Some countries have shown interest in developing new coal plants as a way to diversify their energy mix. Guatemala, the region's largest coal consumer, expects to commission three new plants—with a total capacity of 435 MW, or about 17 percent of today's total capacity—in 2013 or 2014.[25]

The region's use of natural gas is also low, but it may be growing in the near future. Currently, only Belize relies on natural gas, producing an estimated 7 million cubic meters and consuming an estimated 5 million cubic meters in 2011.[26] Over the past decade, however, several countries have begun exploring the use of natural gas as an option to address future electricity needs. According to national electricity expansion plans, both El Salvador and Costa Rica intend to build liquefied natural gas (LNG) terminals and natural gas-fired power plants.[27]

In El Salvador, the U.S. company Cutuco Energy is in the initial feasibility and financing stage for developing an LNG facility that would include a terminal, regasification plant, combined-cycle power plant, water desalinization plant, and system of pipelines and transmission lines.[28] Costa Rica, meanwhile, plans to introduce LNG into its transport sector, and Panama is converting some of its thermal power plants—traditionally fueled by diesel or bunker fuel—to natural gas.[29]

Generating electricity from natural gas can be more flexible than coal or nuclear, making gas a potential ally of renewable technologies because it can help address variability and intermittency challenges associated with renewables.[30] Natural gas also produces lower carbon emissions than electricity generated from coal and oil.[31]

Despite these advantages, investing in natural gas in Central America would mean a continued dependence on imported fossil fuels, which many countries in the region hope to move away from. Moreover, the extent of financial and infrastructure investment needed to generate power from natural gas can significantly displace efforts and investment that could otherwise go toward building a smart energy mix that is based on more-sustainable sources.

LNG shipping remains the most likely option for natural gas imports in Central America, although analysts have studied the possibility of building natural gas pipelines from Mexico and Colombia, which would lead to faster, more reliable, and—in the long term—cheaper access to gas for the region.

2.2 Renewable Energy: A Leader at the Crossroads

Renewable energy accounts for an estimated 62 percent of Central America's total electricity generation.[32] (See Figure 5.) The bulk of this comes from large hydropower, at 49 percent of generation in 2011.[33] Still, the remaining non-hydro renewable generation amounts to a noteworthy 13 percent, primarily from

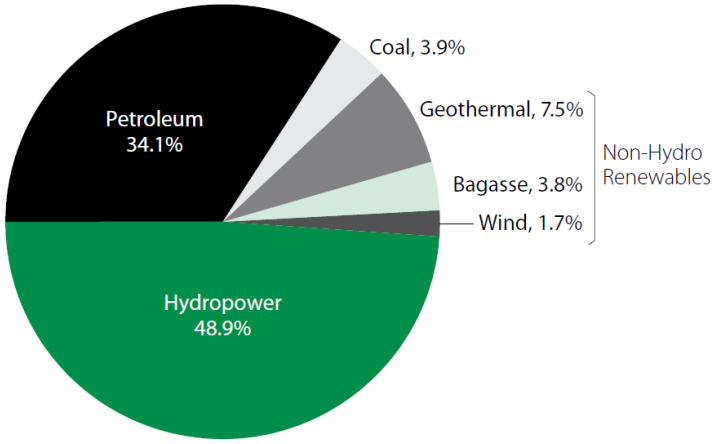

Figure 5.

Renewable Energy Share of Electricity Generation in Central America, 2011

Note: Data exclude Belize.
Source: UN-CEPAL

geothermal, agricultural biomass, and wind power.[34]

The year 2011 was especially good for renewables because the majority of newly built capacity in the region (660 MW) came from renewable sources, primarily hydropower (469 MW), wind (115 MW), and geothermal (35 MW).[35] On-grid renewable capacity additions included seven new hydropower plants in Panama (one with 222 MW capacity and the others between 5 MW and 57 MW); a 140 MW hydro and 12.8 MW wind farm in Costa Rica; a 1.5 MW hydro plant in Nicaragua; a 102 MW wind power plant in Honduras; and four hydro plants with capacities between 1.5 MW and 16 MW, as well as a combined 12 MW of sugarcane bagasse cogeneration, in Guatemala.[36] In El Salvador, new capacity included a 20 MW addition to a bagasse cogeneration facility and a small methane-based generation plant in a landfill in San Salvador.[37]

2.2.1 The Dominance of Hydropower in Electricity Generation

Hydropower is the world's largest renewable source of electricity, accounting for nearly one-fifth of total generation worldwide in 2011, or an estimated 3,400 terawatt-hours (TWh).[38] In Central America, hydro is the longest-standing form of power generation, with the first hydroelectric plants appearing in the late 1800s. Its dominance in the region's energy mix is decreasing gradually, however, as the region transitions to other renewable resources as well as to fossil fuels.

To date, Central America has installed just below 5,000 MW of hydropower, representing 42 percent of total installed electricity capacity.[39] The region generates an estimated 20,000 gigawatt-hours of hydropower annually, accounting for just under 49 percent of total electricity generation.[40] Of the region's 660 MW of new generation capacity in 2011, the majority came from three large hydro facilities—Panama's Changuinola and Bajo de Minas plants (222 MW and 57 MW, respectively) and Costa Rica's Pirris plant (140 MW)—but also from several smaller hydro plants.[41] The region has an estimated hydropower potential of 22,000 MW, meaning that some 17,000 MW remains to be exploited.[42]

Large hydropower is attractive because it can be one of the least expensive sources of electricity when considered over its entire life cycle.[43] After relatively high upfront costs (primarily for dam and reservoir construction), hydro has fewer recurring expenses, such as rising fuel costs, than fossil fuel-based energy.[44]

Because it has been (at least historically) a reliable source of baseload power that can be ramped up or down on demand, it can complement variable renewable energy sources such as wind and solar.[45]

Yet all energy sources represent tradeoffs between competing priorities, and large hydropower is no exception. Hydropower is "renewable" in the sense that the water resource is regenerated, but the large-scale damming of rivers can have significant social and environmental impacts including large-scale population displacement, loss of cultural landmarks, biodiversity loss through flooding of land ecosystems and disruption of aquatic ecosystems, as well as greenhouse gas emissions from land use change.[46] Experts suggest that in order to be viable, "new hydropower schemes would need to meet stringent environmental sustainability and human rights criteria, and minimize negative impacts on river flows and freshwater habitats."[47] Other commentators caution against viewing large hydropower as a sustainable energy source altogether.[48]

Not all forms of hydropower are as controversial as conventional large dams. Many countries, including in Central America, are shifting increasingly to smaller-scale hydro stations, typically in the kilowatt range of capacity.[49] (See Case Study 1.) These facilities often allow space for an uninterrupted branch of the river to bypass the dam in order to enable fish and other species to migrate. The impacts of dams can also be reduced by turning off turbines during fish migration, with the aim of mimicking seasonal flow variations that trigger fish spawning and support other natural processes, and by releasing the same silt

Case Study 1. Promoting Micro-Hydropower in Guatemala Through Community Participation

Guatemala's decades-long civil war, which ended in the mid-1990s, devastated the remote highland villages of Chel, Las Flores, and Xesai, leaving them without access to reliable electricity or clean water. Until recently, the only form of electricity available in these largely Mayan communities was from diesel generators. In 2007, however, a 165 kilowatt micro-hydroelectricity project was completed in Chel to provide power.

What was remarkable about this micro-hydro project is the degree of community participation it garnered. Each family provided 80 days of labor between 2003 and 2007 in exchange for a connection to the system. The village built an eight-kilometer dirt road for transporting equipment. With help from the Guatemalan nonprofit Fundación Solar, the community formed an association to operate and administer the small power plant.

The new source of electricity helped transform Chel into a local hub for business and aided in post-war rehabilitation. Through the project, 440 participating households gained access to reliable power, and the initiative increased the institutional and organizational capacity of local communities. Although the project was supported by Fundación Solar and various national and international organizations, the strong community involvement is what makes this project distinct.

Source: See Endnote 49 for this section.

and mineral composition as a healthy, flowing river. Depending on individual ecosystems, electricity needs, and the need for investment returns, however, these efforts can prove difficult.[50]

Governments across Central America have encountered serious domestic and international resistance to large hydropower projects, largely for environmental and social reasons, and are actively seeking alternatives for electricity generation. In many cases, community activism (often with legal backing) as well as international attention has led decision makers to abandon large hydro projects.

2.2.2 World Leaders in Geothermal Energy

Worldwide, more than 27 countries produce power from geothermal energy, and the global installed capacity of geothermal reached 10,700 MW in 2010.[51] In Central America, use of geothermal dates to at least the 1970s. Costa Rica, El Salvador, Guatemala, and Nicaragua all have geothermal power plants, with a combined capacity of 558.6 MW; in 2011, these countries generated 3,188 GWh of geothermal power, or 7.6 percent of the region's total electricity generation.[52] In El Salvador, geothermal accounts for nearly a quarter of electricity generation, ranking the country second in the world (after Iceland) in geothermal's share of overall electricity production.[53] Costa Rica and Nicaragua are sixth and eighth in the world, at 12.4 percent and 9 percent, respectively.[54]

Table 2. Geothermal Installed Capacity and Estimated Potential in Central America

	Installed Capacity	Estimated Potential	Number of Sites
	megawatts		
Costa Rica	217.5	750–2,900	10
El Salvador	204.4	362–2,210	4–13
Nicaragua	87.5	992–3,340	10
Guatemala	49.2	480–3,320	8–13
Honduras	0.0	100–990	6–7
Panama	0.0	42–450	5
Total	558.6	2,726–13,210	~50

Note: Capacity data represent recent years for which data were available. Data for Belize are not available.
Source: See Endnote 55 for this section.

Still, most of Central America's geothermal potential has yet to be tapped. Studies vary widely in their estimates of regional geothermal resources, ranging from 2,700 MW to 13,000 MW at some 50 different sites.[55] (See Table 2.) The discrepancies can be explained by different assessment methodologies and because actual test drilling has occurred at only a fraction of potential sites. The high upfront cost of resource assessments and test drilling is a key barrier to geothermal development in Central America.

Geothermal power offers environmental and social advantages over fossil fuels and many other renewable technologies. It can be the cleanest baseload source of renewable energy because of its very low greenhouse gas emissions, its relatively small footprint on the land base, and its low overall impact, provided that drilling and reinjection procedures and management of residual fluids are done responsibly. But as with any energy technology, the social and environmental impacts associated with geothermal projects must be studied and managed throughout the life of a project to reduce possible adverse effects, including on communities and ecosystems.

2.2.3 The Growth of Wind Power

In 2011, global wind power capacity increased roughly 20 percent, to 238 gigawatts (GW), and more wind power was put into operation than any other renewable energy technology.[56] A total of 68 countries reported more than 10 MW of wind capacity, and 22 countries had capacities exceeding 1 GW.[57]

In Central America, wind has been harnessed to produce utility-scale power since the 1990s. The region's total installed wind power capacity reached 298 MW in 2011, and just over 38 percent of wind capacity was installed as recently as 2010.[58] (See Figure 6.) In 2011, Central America produced 738 GWh of electricity from the wind, representing 1.7 percent of total generation in the region.[59]

These trends do not reflect the whole region, however. Only three Central American countries—Costa

Rica, Honduras, and Nicaragua—currently operate large wind farms. In Costa Rica, the largest wind project is La Gloria (49.5 MW of capacity), followed by the Pantas Eólicas Sociedad de Responsabilidad Limitada (PESRL) and Tilaran projects (23 MW each), Eolico Valle Central and Valle Central (15.3 MW each), Tejona (19.8 MW), and Coopesantos (13 MW).[60] (See Case Study 2.) Nicaragua's major installations are Amayo (63 MW), San Martin (39.6 MW), and Eolo (40 MW). The region's largest wind park is Honduras's 102 MW Cerro de Hula.

Regional interest in wind power is expanding rapidly. All three currently producing countries have new installations in the pipeline. Panama, an ambitious newcomer, has licensed more than 850 MW of wind capacity—equivalent to an astonishing 37 percent of the country's installed generation capacity in 2011—and a first wind park is under construction in the province of Coclé.[61] Guatemala's first wind project, San Antonio El Sitio, is also under construction and has an expected capacity of 48 MW.[62]

Figure 6.

Wind Power Installed Capacity in Central America, 2000–11

Source: UN-CEPAL

Case Study 2. Wind from Costa Rica's Mountains

Along the Pan-American highway south of San José, in the cloud-forested hills of Costa Rica's Cartago Province, stand 14 wind turbines, each 44 meters high, that together comprise the Los Santos wind farm. The 13 MW wind power project was developed as a community initiative by Coopesantos, one of Costa Rica's four energy cooperatives. In 2000, Coopesantos initiated a wind feasibility study by placing weather instruments in a windy area known as La Ventalera. An innovative group of cooperative members was able to carry out the feasibility study, conduct the environmental impact assessment, develop the project design, secure financing, and, in 2009, complete construction.

The cooperative was able to secure financing for the Los Santos project through the Banco Internacional de Costa Rica, a state-owned commercial bank, based on the value of projected costs that would be avoided as a result of local power production through the wind farm. The bank loaned Coopesantos 75 percent of the $36.5 million in project costs, and the cooperative, a for-profit entity with its own cash flow, was able to cover the remaining 25 percent. The loan will be paid off entirely in 12 years, and the wind farm will generate power for up to 30 years.

Coopesantos is now plotting out land and carrying out feasibility tests for an extension to the wind farm in the same location.

Source: See Endnote 60 for this section.

Existing data on Central America's wind resources (both the amount of wind and its speed) are largely generic and provide little detail about specific sites. One of the most widely cited sources for renewable energy potentials in the region is the *Solar and Wind Energy Resource Assessment* (SWERA), which provides resource maps for 13 locations, including Central America overall and country-wide assessments for El Salvador, Honduras, Guatemala, Nicaragua.[63] These data sets, as well as maps and analysis tools, are used by policymakers, developers, investors, educators, utility companies, and consumers.

According to SWERA, the mapped region of Central America (Belize, El Salvador, Guatemala, Honduras, and Nicaragua) contains some 12,969 square kilometers with good-to-excellent wind resource potential, representing 3.3 percent of the total land area.[64] Using a conservative assumption of 5 MW per square kilometer, these areas would support nearly 65,000 MW of potential installed wind power capacity.[65] Of this area, some 5,713 square kilometers, or 1.5 percent of the mapped region, is considered to have excellent wind resource potential that could support more than 28,500 MW of capacity.[66] Although these country-wide assessments offer a broad starting point, specific terrain features, land-use exclusions, and accessibility to the existing transmission grid are needed to determine the feasibility of developing wind power at individual sites.

In general, there is a need for more publicly available, comprehensive, and accurate wind resource assessments for Central America. Regional or country-scale maps can be useful in early stages of energy planning, but for final comprehensive decisions, it is important to conduct more-detailed zone-specific assessments that include data on seasonal and diurnal variability.[67] By having access to a roster of zones (one level up from individual sites, which can then be assessed by project developers) with optimal wind conditions in the region, policymakers would be equipped to design energy strategies that integrate wind profiles with data from other technologies, demand curves, and transmission opportunities and barriers. The full potential and challenges of the resource throughout the day and year would become visible, enabling the appropriate steps in policy and investment.

Apart from insufficient resource information, local challenges to developing wind power in Central America include inadequate roads to carry the large blades, towers, and generators to remote locations where wind is abundant; the need to build costly transmission lines to bring the power to consumers; and the lack of zoning laws and clear land rights, which often stalls wind projects at the local level.

2.2.4 Underutilized Solar

In 2011, global electricity capacity from solar photovoltaic (PV) technologies increased by an astounding 74 percent, to 70 GW.[68] Late that year, Germany connected its one-millionth PV system to the grid; in China, the market for solar PV nearly quadrupled following the introduction of a feed-in tariff; and in California, as a result of falling module prices, the cost for large-scale PV projects came in below the price of the same amount of generation from natural gas.[69]

Other solar markets are also maturing. The installed capacity of concentrating solar thermal power (CSP) reached 1,760 MW in 2011, up 35 percent from the previous year.[70] Smaller-scale solar thermal, used mainly for water heating, also is making a significant impact around the world, with an estimated global total of 232 gigawatts-thermal (GW_{th}).[71]

In Central America, solar power is in the early stages of market development. The region's first utility-

scale PV plants are Costa Rica's 1 MW Parque Solar Miravalles project, commissioned in November 2012, and Nicaragua's 1.2 MW La Trinidad plant, inaugurated in February 2013.[72] Each installation will produce enough energy to power more than 1,000 households.[73]

The Japanese International Cooperation Agency (JICA) helped finance both projects, with Costa Rica's totaling $11.5 million ($10 million from JICA and $1.5 million from ICE, the national utility) and Nicaragua's totaling some $12 million ($11.4 million from JICA and $530,000 invested by Enatrel, the national transmission company).[74] Critics have argued that these costs were exorbitant and that the plants could have been built for much less; however, international experience has shown that the early adoption of renewable technologies in new markets in less industrialized countries often results in project costs that are significantly above the global average.[75]

Elsewhere in the region, utility-scale PV projects are at varying stages of planning or development. El Salvador's leading power producer, CEL (Comisión Ejecutiva Hidroeléctrica del Río Lempa*)*, is developing a 14.2 MW PV facility adjacent to the company's "15 de Septiembre" hydroelectric dam.[76] CEL has designed the solar farm, acquired financing from the German Development Bank (KfW), and is seeking an installation contractor.[77] As was the case in Costa Rica and Nicaragua, the project would not have gone forward without international cooperation funds and is projected to be only marginally profitable over its lifetime. CEL has already installed a 24.5 kilowatt solar PV "investigation project" on the roof of its headquarters in San Salvador, assessing the costs versus power output for three types of PV technology: polycrystalline, monocrystalline, and amorphous thin-film.[78]

In the near future, Panama is expected be home to two large-scale PV plants (of 2.4 MW and approximately 2 MW in capacity), and Honduras has taken initial steps in agreement with foreign investors to develop 50–150 MW of PV power.[79]

In addition to the region's two operational utility-scale PV installations and a handful of commercial-scale installations, solar PV has been widely adopted in small, distributed applications. Thousands of low-income, mostly rural, households have small solar PV systems (in the Watt range) to supply power for lighting and electrical appliances. Meanwhile, middle- to upper-income households and businesses—which often face higher electricity tariff rates—are increasingly installing off-grid and grid-tied PV installations, motivated by a desire to reduce both costs and grid dependency, as well as, in some cases, by environmental aspirations.

Solar thermal (or passive solar) has a growing presence in Central America and is used primarily for water heating as well as for commercial applications such as drying fruit or wood products. But it is not yet as common in the region as it is in places like China, Europe, or parts of the Caribbean.

The SWERA initiative has compiled solar resource data for Central America from several different international organizations, including the United Nations Environment Programme, the U.S. National Renewable Energy Laboratory (NREL), the German Aerospace Center, and the Risø National Laboratory for Sustainable Energy, as well as local groups. In addition to providing solar insolation maps for each of the seven countries, it provides data on seasonal variation, including breakdowns for the dry season, the transition from the dry to rainy season, the rainy season, and the transition from the rainy to dry season.

The international version of NREL's online PV energy output tool, "Pvwatts," features five Central American countries: Belize, Guatemala, Honduras, Nicaragua, and El Salvador.[80] It offers site-specific data and makes it possible to calculate the anticipated output for PV systems, making it a highly useful resource. Overall, these solar resource assessments provide a good overview of the solar potentials of most of the region. What is lacking, however, are technical feasibility studies for individual geographic areas.

2.2.5 Continued Use of Agricultural Residues

Central American countries have burned biomass to generate electricity for more than two decades, primarily in the agricultural sector. Since the 1990s, private sugarcane mills in El Salvador, Guatemala, Costa Rica, and Nicaragua have used agricultural residues—mainly *bagasse*, or sugarcane stalks—to generate electricity, and in 2009, Belize completed construction of its acclaimed 31.5 MW Belcogen cogeneration power plant.[81] (See Case Study 3.) In total, cogeneration in sugar mills accounted for 3.8 percent of Central America's electricity generation in 2011.[82]

Case Study 3. A Project of National Importance: Belize's Bagasse Power Plant

In 2009, a subsidiary of Belize Sugar Industries Limited (BSI) completed construction on the 31.5 MW Belcogen cogeneration power plant (also known as a "combined heat and power," or CHP, plant). The facility burns bagasse, the fibrous material that remains after the juice is extracted from sugar cane, and the resulting heat is used to produce high-pressure steam that powers the facility's generating turbines.

A typical bagasse power plant emits both greenhouse gases and particulate matter; however the Belcogen facility, using a complete combustion process, electrostatic air cleaners, and high operating standards, emits relatively few pollutants. In addition to lowering emissions, the plant reduces Belize's reliance on fossil fuels, thereby providing the country with relief from international oil price fluctuations. The facility has also been a boon to the local economy, creating new jobs in construction and operations and providing a catalyst to the agricultural sector. Future expansion of the facility's generation capacity would only increase these benefits.

The Belcogen plant's ability to convert agricultural waste into sustainable, clean energy is only part of this success story. Perhaps more noteworthy was the ability of all stakeholders to cooperate effectively to make the project a success. BSI, a private company, provided $27.8 million as an initial investment for the project. In addition, the company secured international loans totaling $35.3 million from various sources, including the Caribbean Development Bank. At the time, the project represented the single largest private investment ever in Belize. The Belizean government also provided tax exemptions, and BEL, the national electricity distributor, provided an interconnection station and transmission lines with a combined value of $6 million.

Source: See Endnote 81 for this section.

Some coffee mills in Central America are using their biomass residues to produce heat and power, mainly for their own consumption, and several countries are studying the potential for burning wood products (new or modern biomass, in the form of brickets or pellets) in power generation. Additionally, a variety of regional and national projects are aimed at producing biogas from agricultural waste (including residues from pineapple and banana production), animal waste, and wastewater, which are proving to be very attractive for farmers and communities. Although aggregate statistics on potential and current use are lacking for some areas, including Costa Rica, it can be assumed from the available data that the region's potential for sustainable biomass power generation is many times higher than today's actual production.

Table 3. Reliance on Traditional Biomass in Central America, by Country, 2011

	Traditional Biomass Share of Total Energy Use	Share of Households Using Fuelwood for Cooking
	percent	
Guatemala	48	73
Honduras	47	69
Nicaragua	38	67
El Salvador	31	27
Costa Rica	16	9
Panama	13	16

Note: Data for Belize are not available.
Source: See Endnote 86 for this section.

2.2.6 High Consumption of Traditional Biomass

Outside of the electricity sector, biomass is the dominant renewable energy source in Central America. Traditional biomass, especially fuelwood for cooking, continues to account for more than a third of the region's energy consumption.[83] Several countries in the region are seeking to establish or expand production of biofuels for transportation.

Traditional biomass sources such as wood, charcoal, and agricultural residues account for 38 percent of total final energy use in Central America.[84] Traditional biomass is used primarily for cooking in the home; it represents a very high 82 percent of the region's residential primary energy consumption, compared with only 37 percent for Latin America as a whole.[85] In Guatemala, which has the highest share of traditional biomass use in the region, nearly three-quarters of households rely on fuelwood for cooking.[86] (See Table 3.)

Even countries with high levels of electricity access utilize wood to a significant degree. In Costa Rica, where the electrification rate is an estimated 99.2 percent and people have relatively easy access to liquefied propane gas (LPG), residents use traditional biomass for cooking in nearly one out of 10 households.[87]

Ways to reduce these high consumption levels of fuelwood—which contributes to deforestation and serious health risks associated with indoor air pollution—include adopting alternative cook stoves that burn wood more efficiently and create fewer emissions, as well as developing more-sustainable methods of cultivating, harvesting, and using traditional biomass. Among the energy alternatives for cooking are electricity and methane gas derived from biogas digesters.

In general, studies of energy use in Central America do not sufficiently address the topic of fuelwood use.[88] A central reason for this is that traditional biomass is part of the informal economy, which makes the collection of reliable data extremely difficult. Further research into the use of fuelwood and other unsustainable biomass uses is essential to enable a more detailed assessment of the current situation and to find and support alternatives.

2.2.7 Rising Biofuel Production

Globally, liquid biofuels (predominantly ethanol and biodiesel) provided about 3 percent of road transport fuels in 2011, up from 2 percent in 2009.[89] Within Latin America, Brazil, Argentina, and Colombia are the leading biofuel producers, with Brazil alone producing nearly 24 billion liters of ethanol annually—competing globally only with the United States, and dwarfing all other production in Central and South America.[90]

Central America was not on the global biofuels map until very recently. Still, production is not insignificant

on a national scale and is ramping up quickly. Ethanol dominates the region's biofuel industry because of the high amount of sugarcane production. El Salvador is the largest producer, followed by Guatemala. Interestingly, neither country uses ethanol domestically because the fuel's value on the international market exceeds what it is worth domestically.[91] The only regional ethanol consumer is Costa Rica, which still produces some 40 million liters more annually than it consumes.[92] Nicaragua also produces a small amount of ethanol, bringing the regional total to some 346 million liters annually.[93] (See Figure 7.)

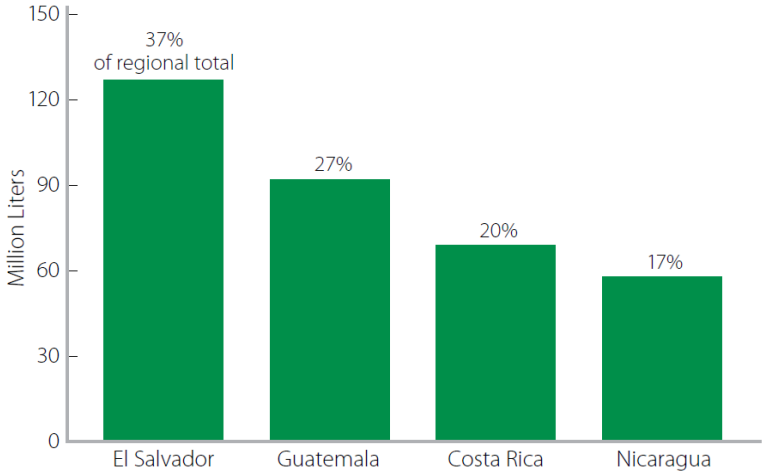

Figure 7.

Ethanol Production in Central America, by Country, 2011

Source: CIFOR

Production of biodiesel is very limited in Central America. Guatemala and Honduras each generate an estimated 1 million liters annually for domestic use.[94] African palm is grown extensively throughout the region, but palm oil is currently more valuable in food production, so its use as a biodiesel feedstock has been limited.[95]

Between 2006 and 2011, five Central American countries invested in biofuels of different types. Belize was the largest investor, at $135 million, followed by Guatemala ($119 million), Nicaragua ($66 million), El Salvador ($50 million), and Costa Rica ($12 million).[96] Much of this financial support comes from outside the region: Colombia, for example, has offered to finance a $400 million biodiesel plant in Guatemala.[97] Foreign support to the region's biofuels industry also comes in the form of capacity building. In 2005, Guatemala and Brazil signed a Protocol for Technical Cooperation that facilitated training and technology transfer in the sector, and Guatemala was subsequently included in Brazil's 2008 Biofuels Initiative with the United States.[98]

Overall, biofuel production in Central America falls far short of its potential. Costa Rica, Guatemala, and El Salvador each have an estimated potential to produce 265–285 billion tons of biofuel, whereas Nicaragua's potential is about a fifth of that.[99] Although the bulk of this capacity is for ethanol, about a third of Costa Rica's and a tenth of El Salvador's is for biodiesel.[100]

One significant challenge to biofuels expansion is the lack of feedstock. Energías Biodegradables, a biodiesel company in Costa Rica, operates at less than a tenth of its capacity for this reason.[101] Production is also limited because of inadequate transportation infrastructure and the lack of a domestic market for biofuels.

Another constraint is that biofuels have been wrought with controversy, especially over their role in raising food prices, increasing deforestation, and further establishing monoculture—the planting of a single crop across many hectares. Some concerns reflect those associated with large-scale agricultural production in general, such as water use and pesticide contamination; working conditions; biodiversity loss and destruction of valuable habitat; and human displacement and land rights.[102]

Because biofuels are associated with wider goals of climate change mitigation, the industry's greenhouse gas emissions are under particular scrutiny. Studies show that although biofuels release fewer tailpipe emissions of particulate matter, carbon monoxide, and hydrocarbons, the bulk of the industry's carbon dioxide emissions are released during feedstock production, long before the fuel reaches a vehicle.[103] One significant source of emissions is deforestation, or the clearing of land to grow feedstock crops. Researchers found that the full climate change benefits of biofuels can be achieved only if the feedstock is grown on land with low carbon content—for instance, on heavily grazed pasturelands instead of dense rainforest.[104]

The use of nitrogen-based fertilizers also contributes to emissions. Research shows that the potential for mitigating greenhouse gas emissions varies widely by feedstock and biofuel type: for example, growing sugarcane corn for ethanol has been found to result in much lower emissions than growing corn for ethanol, or palm oil for biodiesel.[105] In Central America's large forested areas, biofuel production is not a sustainable option.

2.3 The Problem of Electricity Loss and Dated Grids

The shift to local and distributed generation of renewable energy can play an important role in reducing electricity loss in Central America. This includes technical losses that occur during transmission and distribution from centralized power plants over large distances, as well as non-technical losses such as illegal connections.

In 2010, the average electricity loss rate across Central America was around 15 percent.[106] Nicaragua had the highest loss level at more than 25 percent, followed by Honduras at nearly 24 percent and the remaining five countries at less than 14 percent each.[107] (See Figure 8.) For these latter five countries, the loss levels are comparable to those of industrialized countries, but for Nicaragua and Honduras, losses are significant, representing roughly a quarter of all electricity produced.

The primary driver of technical electricity loss in Nicaragua and Honduras is the lack of investment in maintaining the existing transmission and distribution grid. One advantage of distributed, local energy generation is that countries can diminish both transmission and distribution losses by reducing the distance between the source of generation and the electricity end-user. Energy cooperative "mini grids," for example, have low losses because users are directly involved in administration of the grid and therefore have an interest in ensuring that it runs efficiently. Meanwhile, rooftop solar PV and distributed wind for residential, commercial, or industrial purposes can have virtually no losses because these systems bypass the need for electricity distribution.

To help reduce losses from large-scale renewable generation facilities that tie into the electricity grid these facilities should ideally be sited near easily accessible transmission and distribution networks.

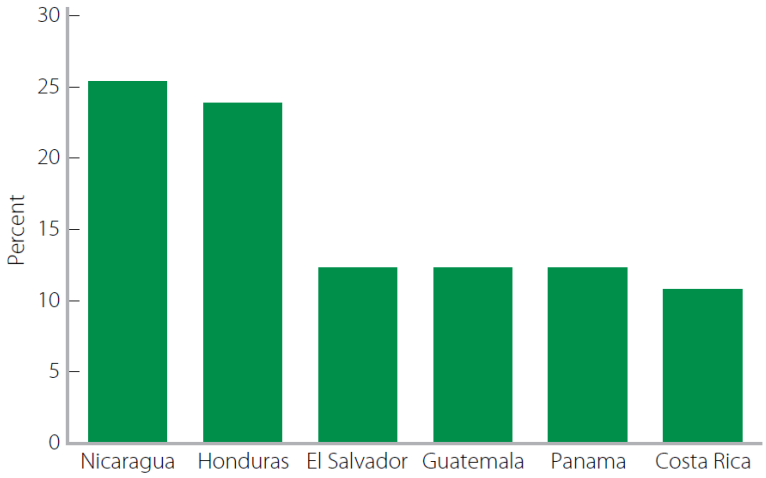

Figure 8.

Electricity Losses as Share of Total Generation, Selected Central American Countries, 2010

Note: Data for Belize are not available.
Source: UN-CEPAL

2.4 Assessment of Renewable Resource Potentials

For wind energy, the SWERA assessment covers a mapped region including Belize, El Salvador, Guatemala, Honduras, and Nicaragua. For solar, SWERA provides country-specific resource assessments for all Central American countries except Costa Rica and Panama. Another key source for estimates of renewable resource potentials in the region is the World Bank's analysis of "Remaining Effective Potential," which evaluates the long-term market potential of implementable projects and aims to give an idea of the resource potential that is likely developable.[108] (See Table 4.)

Existing and new resource assessments are important analyses upon which to build future research, energy planning, and renewable energy policymaking. Biomass, hydro, and geothermal technologies have been

Table 4. Remaining Effective Potential of Renewable Resources in Central America, as of 2009

	Hydropower	Geothermal	Wind	Bagasse	Geothermal, Wind, and Bagasse Total
			gigawatt-hours		
Belize	—	—	—	80	80
Costa Rica	20,386	1,621	1,127	293	3,041
El Salvador	6,544	2,605	2,798	273	5,676
Guatemala	15,010	3,630	2,124	1,075	6,830
Honduras	15,302	545	2,883	320	3,747
Nicaragua	7,187	5,377	6,014	147	11,538
Panama	9,329	206	2,139	128	2,474
Central America	73,758	13,984	17,085	2,316	33,386

Note: "Effective potential" refers to the long-term market potential of implementable renewable energy projects. Where data are missing, it is because the source did not provide them.
Source: See Endnote 108 for this section.

tried and tested in Central America for decades now. Studies of these technologies should concentrate on their local impact on communities, ecosystems, and climate change. Regarding small-scale solar PV and solar water heating, studies can focus on where and how these technologies can be extended and commercialized.

There is less experience with utility-scale solar PV and small and large wind generation. It will be important to study and document the experiences with recently installed technologies in order to improve practices in the future. New feasibility studies would be particularly helpful for small-scale wind, different types of biomass, as well as ocean (wave and tidal) technologies.

Most importantly, there is a lack of comprehensive system analysis. Renewable energy potentials need to be overlaid with load profiles in a given region to enable integrated planning. They also need to be integrated with other electricity sources—existing and planned, renewable and conventional—as well as with efficiency measures and available on- and off-grid solutions. Comprehensive data illustrating how the variability of different renewable resources aligns with daily and seasonal electricity demand patterns can help energy planners harness these energy sources efficiently. Integrating a variety of renewable energy resources across a wide geographic area on the same electricity grid can also help to reduce the effects of localized intermittency.

2.5 High-Impact Areas for Renewable Energy Deployment

Much research attention has been paid to renewables in the electricity sector in Central America; however, there has been limited research and communication to address important additional needs such as access to energy in remote geographic areas, household fuelwood use, and petroleum use in the transportation sector. Among the high-impact areas where more research and coordinated action are needed with regard to resource potentials and renewable energy technologies in the region are:

1. Expand access to sustainable energy in underserved communities through distributed renewable energy;
2. Prevent large-scale fossil fuel-powered generation by integrating renewable energy sources, energy efficiency, and smart grid solutions;
3. Make the use of fuelwood more sustainable through a change in practices and the use of alternatives to traditional biomass; and
4. Create sustainable mobility options with smart solutions in the transportation sector.

Central America has vast potential for a variety of renewable energy technologies. Countries in the region are increasing their efforts to harness these resources, but most of these sustainable energy solutions remain untapped.

3 | Socioeconomic Opportunities Through Renewables

Proceeding with "business-as-usual" energy development in Central America will mean the continued unsustainable use of fuelwood and petroleum-based energy sources. The region will also face the rising social and economic consequences of this path. If electricity prices in Central America were to reflect the costs of burning fossil fuels to both human health and the climate, fossil-based generation would cost an estimated 8–10 percent more through 2020. Although the socioeconomic advantages of a regional transition to renewables have been documented sporadically, what is needed now are LCOE+ (Levelized Cost of Energy, plus) assessments for the region and its countries, internalizing the full costs of both direct subsidies and indirect costs to societies such as impacts on health, the environment, and the climate. Such an analysis would further strengthen the case for limiting fossil fuel use and investing in sustainable energy technologies.

Energy is key to human development. Rather than being an end in itself, it is the means by which communities have access to clean water, cooking, lighting, and temperature control. Gaining access to modern forms of energy can expand important social and economic opportunities such as health care, education, and income generation.

Across Central America, social and economic conditions have improved markedly over the past decade; however, outcomes vary widely both among and within countries. According to the United Nations Human Development Index, which evaluates nations along the three dimensions of health, education, and standard of living, Costa Rica and Panama occupy the upper-middle category of human development, whereas their neighbors to the north—Belize, El Salvador, Guatemala, Honduras, and Nicaragua—rank in the lower-middle range.[1] (See Table 5.)

On average, people in Central America consume roughly one-quarter of the primary energy used by people in the United States.[2] But population growth and rapid economic development are contributing to rising regional energy demand, which increased 4.2 percent in 2011 alone.[3] According to the *Central American Sustainable Energy Strategy 2020*, the region will require an additional 6.3–7.3 GW of installed electricity capacity by 2020 to keep up with projected growth.[4] Faced with this challenge, governments must choose between continuing to import massive amounts of expensive fossil fuels and building unsustainable large dams, or developing the region's enormous sustainable energy potential and investing in greater energy efficiency.[5]

As elsewhere, rapid economic development and industrialization have had an immense impact on both people and the environment in Central America. The burning of oil and other fossil fuels is responsible for local air, ground, and water pollution; has adverse impacts on ecosystems and human health; and is a major contributor to global climate change.[6] Across the region, water contamination due to particulate

Table 5. Human Development Index (HDI) Rankings for Central America, 2012

	HDI Ranking	Life Expectancy at Birth	Mean Years of Schooling	Expected Years of Schooling	Gross National Income per Capita
			years		constant 2005 PPP$
Panama	59	76.3	9.4	13.2	13,519
Costa Rica	62	79.4	8.3	11.7	10,863
Belize	96	76.3	8.0	12.4	5,327
El Salvador	107	72.4	7.5	12.1	5,915
Honduras	120	73.4	6.5	11.4	3,426
Guatemala	133	71.4	4.1	11.5	4,235
Nicaragua	129	74.3	5.8	10.8	2,551

Note: Ranking is out of 132 countries evaluated, where a ranking closer to 1 indicates a higher level of human development.
Source: See Endnote 1 for this section.

matter emissions from oil-based power plants and transportation compounds pollution from solid waste and agricultural chemicals.[7] In addition, rapid urban growth has led to an increase in local air pollution, particularly in urban centers like San Salvador, San José, and Tegucigalpa.[8]

As renewable energy becomes more affordable and readily deployable, Central America has an unprecedented opportunity to bypass the carbon-intensive practices that drove an unsustainable course of development in industrialized countries, and to instead pursue a low-carbon growth path. Whether through distributed power from a single rooftop solar panel or by tapping into utility-scale wind power from the grid, communities can purse greater socioeconomic opportunities with relatively less environmental and human impact.

3.1 The Burden of Oil Dependency and Oil Price Volatility

Like many regions, Central America is extremely vulnerable to high and unpredictable oil prices. In 2008, during the worldwide oil crisis, the global price of oil reached an all-time high of $145 per barrel.[9] That same year, Central America spent $11.2 billion on oil imports, up nearly 50 percent from 2006.[10] As energy-intensive industries across the region faced rising costs, the competitiveness of many of them diminished in international markets.

Preliminary estimates suggest that in 2012, Central America spent $13.4 billion on oil imports, up slightly from the previous year.[11] (See Table 6.) Increased spending on oil imports can negatively affect the trade deficit of countries. High oil expenditures in the power sector and the resulting rising costs for electricity generation can create a ripple effect in the economy that causes governments to implement market interventions—subsidies, for example—to alleviate high electricity prices. Although many governments choose to intervene in the market to protect citizens from rising energy costs and household spending, such intervention also creates investment uncertainty. As oil prices continue their upward rise, this dependency will likely only worsen as long as oil is needed to supply the growing demand for energy.

Table 6. Oil Import Expenditures and Share of GDP in Central America, Total and by Country, 2007–11

	2007		2008		2009		2010		2011	
	million $	% GDP	million $	% GDP	million $	% GDP	million $	% GDP	million $	% GDP
Nicaragua	809	14.3	951	14.9	649	10.4	741	11.3	1,216	16.7
Honduras	1,392	11.3	1,937	14.0	1,215	8.6	1,684	10.9	2,267	13.4
Panama	1,230	6.2	1,927	8.4	1,235	5.4	1,713	6.5	2,863	9.2
El Salvador	1,288	6.4	1,647	7.7	1,038	5.0	1,350	6.3	1,819	7.9
Guatemala	2,422	7.1	2,690	6.9	2,014	5.4	2,227	5.4	2,951	6.3
Costa Rica	1,440	5.5	2,089	7.0	1,232	4.2	1,604	4.4	2,150	5.2
Total	8,580	7.3	11,243	8.4	7,383	5.7	9,320	6.3	13,265	8.0

Note: Data for Belize are not available.
Source: See Endnote 11 for this section.

Across Central America, governments have used energy subsidies to shield their economies from high oil prices, improve people's access to energy, and promote economic growth. These subsidies have increased dramatically in recent years.[12] In 2008, El Salvador alone provided $420 million annually in energy subsidies for electricity, gasoline, propane, and public transportation—nearly double the amount of Honduras and representing nearly 14 percent of the fiscal revenue.[13] (See Table 7.)

When energy subsidies are administered effectively, they can facilitate energy access for low-income consumers by making energy more affordable. But reducing the price of electricity to the consumer through subsidies can have adverse effects as well. With electricity prices low, consumption often increases, which deters consumers from using electricity in a more efficient manner. Subsidies can also have the effect of privileging already established conventional electricity generation. In Central America, subsidization gives petroleum-fueled thermal power plants an advantage, undermining the market opportunity for renewable energy.

Table 7. Energy Subsidies in Central America, Selected Countries, 2008

	Electricity	Gasoline	Propane	Public Transportation	Share of GDP	Share of Revenue
	million U.S. dollars				percent	
El Salvador	223.0	—	140.0	57.1	1.5	13.5
Honduras	42.1	156.6	—	19.9	1.6	9.5
Nicaragua	27.9	—	—	40.0	1.2	6.3
Panama	82.0	—	64.0	19.0	0.7	3.5
Guatemala	37.8	—	—	48.4	0.2	2.2

Note: More recent aggregate data for energy subsidies are not available. Where data are missing, it is because the source did not provide them. There are no direct subsidies in Costa Rica, and no known data are available for Belize.
Source: See Endnote 13 for this section.

Through their energy subsidy policies, governments in the region are sending mixed signals to renewable energy developers. On the one hand, governments are outspoken in support of renewables, yet at the same time they continue to subsidize fossil fuel use and fossil fuel-based electricity generation, impeding the accelerated uptake of renewables in the region. Overall, the market distortion that subsidies creates in favor of fossil fuels (and thus imported oil) ends up hindering renewable energy development, restricting access to energy, and detracting from energy efficiency.

3.2 Social and Economic Benefits of Renewable Energy and Energy Efficiency

3.2.1 Cost Competitiveness of Renewables

Making the switch to renewable energy can have significant cost advantages over fossil fuels. In general, cost comparisons among various types of energy generation can be challenging because diverse factors influence the retail price of electricity, including the costs of production, transmission, and distribution, subsidies, taxes, and regulations. One approach, however, the Levelized Cost of Energy (LCOE), allows for comparison between different technologies by providing the per-kWh cost of energy over the life cycle of a power plant. The standard LCOE takes into account factors related directly to energy production such as the cost of equipment, fuel, and labor, as well as estimates of plant efficiencies.

A recent LCOE study of Central America by the World Bank compared geothermal, hydropower, and fossil fuel technologies and concluded that renewables are more cost competitive than fossil fuel energy sources.[14] The report estimates the cost of geothermal power at 5–8.9 U.S. cents per kWh and the cost of hydropower at 7–8 cents per kWh.[15] In contrast, for plants powered by heavy fuel oil, generation can be as high as 12–15 cents per kWh; costs of coal-powered generation are 10–11 cents per kWh.[16]

By making a levelized cost comparison of energy sources, it is possible to estimate the cost benefits of renewables over fossil fuels. However, standard LCOE estimates still fail to include the true cost of energy due to externalities associated with power generation, as well as the market distortions caused by the heavy use of subsidies. In Central America, both fossil fuels and renewables currently receive subsidies, but the balance leans disproportionally in favor of fossil fuels despite their detrimental external costs.

Extending the standard LCOE analysis to account for these externalities—through an approach known as LCOE+—can help address these missing factors. The LCOE+ is an important tool for analyzing the real societal costs of fossil fuel energy and to demonstrate the actual cost gap between renewable and non-renewable electricity production.

3.2.2 The Hidden Costs of Fossil Fuels

Most estimates of the cost of oil and other fossil fuels fail to account for the social and environmental impacts associated with these fuels, including the climate impacts related to greenhouse gas emissions. When these various external costs are added to the nominal price of energy, it becomes clear that fossil-based energy in Central America is socially and environmentally more expensive than many renewable energy alternatives.

In 2009, the Economic Commission for Latin America and the Caribbean (ECLAC, or CEPAL in Spanish) estimated the externalities of fossil fuel-based electricity generation in Central America under several

scenarios.[17] It found that the *health costs alone* from local pollution would raise the cost of electricity anywhere from 1.8 percent to 5.4 percent, or by an average of 0.14 cents per kWh. When the climate impacts of CO_2 emissions were considered, the "true cost" of electricity increased by another 0.87 cents to 2.3 cents per kWh, using the conservative baseline of $20 per ton of CO_2 emitted.[18] Internalization of both types of externalities raised electricity costs by an average of 1.57 cents per kWh.[19]

ECLAC also analyzed externalities for energy in Central America and the Caribbean over the period 2010–23.[20] It found that average annual climate-related costs equate to $307 million and average annual health-related costs are $44 million.[21] Applying these results to energy expansion scenarios used in the *Central America Sustainable Energy Strategy 2020*, the study found that externalities related to health and climate change would increase the real cost of fossil fuel generation plants by between 8 percent and 10.6 percent through 2020.[22]

When compared to other LCOE+ analysis for countries in Latin American and the Caribbean, the estimations given by ECLAC are conservatively low. For example, Worldwatch Institute calculations for Jamaica estimate that adding in the health impacts associated with oil-fueled generation plants (built after 1990) equate to an average increase in the cost of electricity of 44.6 percent, as opposed to the 1.8 to 5.4 percent increase given by ECLAC.[23]

For climate impacts, as opposed to the $20 per ton of CO_2 used in ECLAC's study, $100 per ton of CO_2 is considered a reasonable median value given that varying studies use values ranging from $20 to as high as $400 per ton.[24] Moreover, $100 per ton of CO_2 is a *global average*, while the impact of climate change will be considerably higher for countries in Central America, which rank among the most vulnerable to more extreme weather including more frequent storms and changes in seasonal rainfall.

Identifying the hidden costs of fossil fuel-based electricity provides an opportunity to take action to reduce them. Policymakers and energy planners in the region should seek to internalize these externalities with the aim of reducing the detrimental effects through increased implementation of renewable energy.

3.2.3 Climate Change and Human Health Benefits

One of the driving forces behind renewable energy deployment is climate change mitigation through the reduction of greenhouse gas emissions. But renewables can contribute to other aspects of sustainable development as well, such as reducing the negative effects of dirty fossil fuels on air pollution and the environment, increasing access to modern forms of energy, and boosting energy security.

Despite low per capita petroleum use in Central America and the region's comparatively minor contribution to global greenhouse gas emissions, there is rising concern about the adverse effects of climate change and the importance of mitigating emissions. In 2008, Central America accounted for an estimated 0.16 percent of global emissions, with more than half of the regional total coming from transportation.[25] (See Figure 9.) Guatemala is the region's highest emitter of greenhouse gases because of the size of its population.[26] (See Figure 10.)

Although its emissions contribution is low compared to many other regions, Central America is disproportionally vulnerable to the effects of climate change due to its geographic location and the

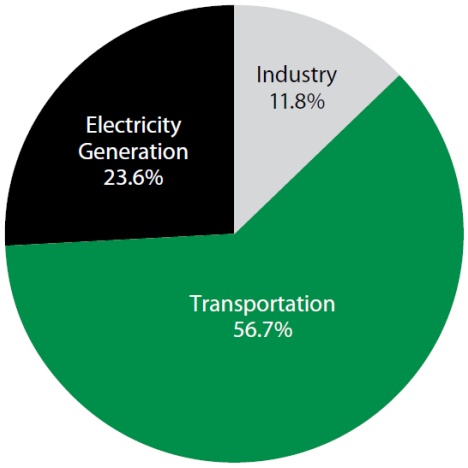

Figure 9.

Share of Carbon Dioxide Emissions in Central America, by Sector, 2008

Note: Data exclude Belize.
Source: UN-CEPAL

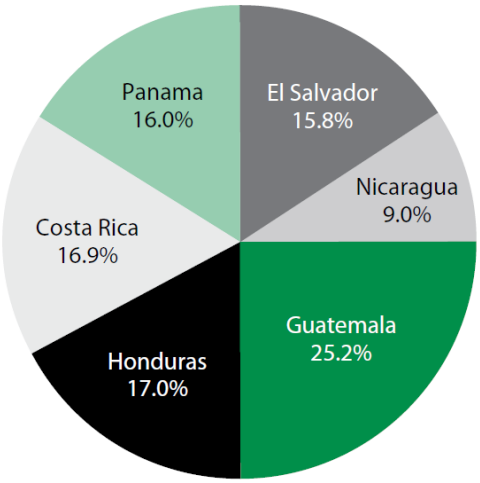

Figure 10.

Share of Carbon Dioxide Emissions in Central America, by Country, 2008

Note: Calculations of regional emissions do not include data from Belize.
Source: UN-CEPAL

inability of low-income communities to respond to the impact of climatic variations and severe weather events. Through the *Central American Sustainable Energy Strategy 2020*, the region has committed to reducing total greenhouse gas emissions 20 percent by 2020 (from 2007 levels).[27] Renewable energy plays a key role in achieving this target, along with energy efficiency and energy savings. The strategy aims to increase renewables and to lower the share of fossil fuel-based power generation.

In addition to reducing climate-altering emissions, renewables offer benefits in the areas of health, air pollution, and the environment. Non-combustion renewables have the potential to significantly reduce local air pollution, lowering health impacts associated with fossil fuel power generation. The widespread burning of fuelwood and other traditional biomass sources results in health impacts from particulate matter, carbon monoxide, and other pollutants.[28] In children, long-term exposure to these pollutants can increase the risk of developing acute respiratory infections, and is a major cause of mortality.[29]

3.2.4 Domestic Job Creation

The labor required to implement energy efficiency measures, add significant renewable energy capacity,

and improve the electrical grid will create new job opportunities in Central America. Job creation includes direct jobs in the renewable energy sector's core activities, indirect jobs in sectors that supply the renewable energy industry, and induced jobs created when wealth generated by the renewable energy industry is spent in other sectors of the economy.[30]

Direct renewable energy jobs are generally divided into two categories: construction, installation, and manufacturing (CIM) jobs, and operation and maintenance (O&M) jobs.[31] (See Figure 11.) CIM jobs are typically concentrated in the first few years of setting up a renewable energy facility, whereas most O&M jobs exist for the lifespan of the installation. In general, renewable power plants are more labor intensive than petroleum-fired power plants, and this is positive in terms of job creation. Spending resources on labor rather than fossil fuel imports from other countries generates domestic benefits from energy investment.

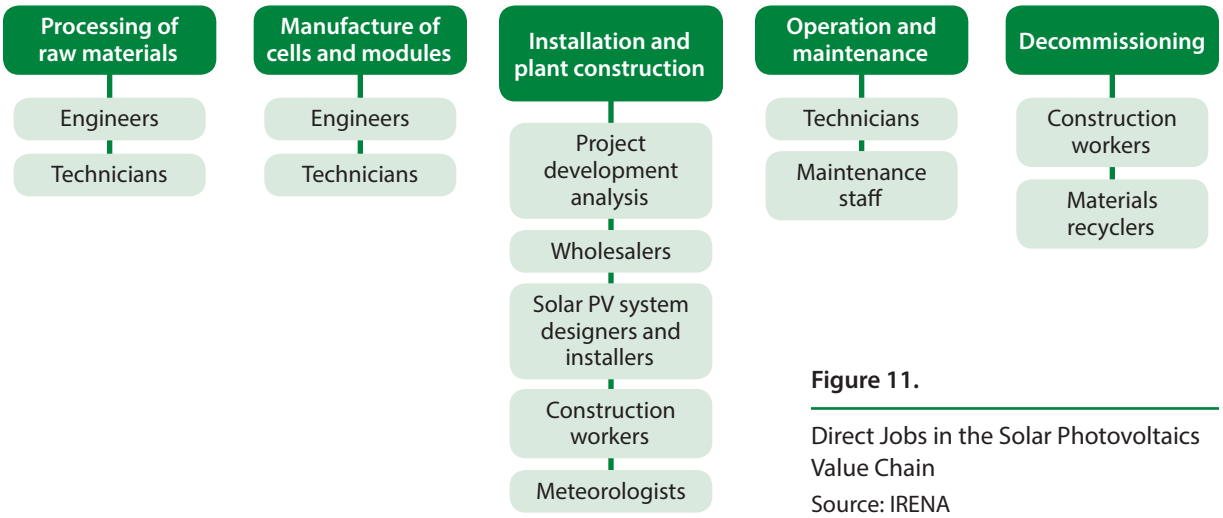

Figure 11.

Direct Jobs in the Solar Photovoltaics Value Chain

Source: IRENA

A study of job-creation potential in the global solar industry found that, in the short term, each new MW of PV capacity will create 20 manufacturing jobs, 30 installation jobs, and one maintenance job.[32] Assuming a 25-year lifespan for PV installations, this would result in 0.8 manufacturing jobs and 1.2 installation jobs annually per MW of installed capacity.

A similar study of the wind industry estimates that each new MW of wind capacity will create 16 jobs in manufacturing and the supply of components*; five jobs in wind farm development, installation, and indirect employment; and 0.33 jobs in O&M.[33] Assuming a 25-year lifetime for wind installations, this results in 0.64 manufacturing jobs and 0.2 installation jobs annually per MW generated. These job-creation estimates—especially for solar power—are significantly higher than what could be expected from continued reliance on fossil fuel generation.[34]

Although some foreign companies installing renewable energy in Central America will come with their

* Even though these jobs are currently held overseas, as a full supply chain develops in the region, local labor economies will eventually benefit.

own work force, many of the initial jobs from renewables will occur in installation and O&M since these positions are located in-country. Until there is a full value chain for various technologies in the region, most manufacturing and indirect jobs will be concentrated in the countries that manufacture the renewable energy equipment and materials. Therefore, continuing to build regional capacity in all areas of renewable energy is critical.[35] (See Case Study 4.)

3.2.5 Access to Energy

Although electrification has expanded significantly in Central America over the past two decades, an estimated 7 million people in the region still have limited access to this critical component of socioeconomic empowerment.[36] (See Table 8.) Policies oriented solely at centralized production and distribution of electricity are inadequate to meet the needs of marginalized people and communities; as a consequence, every country in Central America has implemented an energy access program of some kind, with varying degrees of success and incorporation of renewable energy.

For many communities in remote areas, grid connection is unlikely to happen due to geographic inaccessibility and unfavorable cost-to-return ratios. Distributed (or decentralized) power therefore is not simply an alternative, but may be the only option for these communities. To achieve electrification,

Case Study 4. Developing Markets for Renewable Energy in Rural Honduras

Founded 70 years ago as an agricultural school, Zamorano in Honduras is now one of Latin America's most prestigious academic institutions in the field of rural development, enrolling more than 1,200 students from across the region. In 2009, a project of the Zamorano Environment and Development Department, titled "Development of Local Markets for Renewable Energy," was selected from a pool of more than 1,000 applicants as one of 26 winners of the Global Village Energy Partnership's IDEAS contest.

The objective of the project was to narrow the gap between supply and demand for renewable energy services in rural communities, especially in the Yeguare Valley where Zamorano is located. The project granted scholarships to 25 residents of different communities for a renewable energy business training program and encouraged them to establish formal microenterprises to sell, install, and maintain solar PV panels, improved woodstoves, and other technologies. In addition, the project worked with microfinance institutions to create credit lines to help local families and businesses purchase renewable energy technologies; promoted contacts with equipment suppliers; and developed awareness campaigns in the communities about the benefits of renewable energy.

As of October 2011, the energy micro-entrepreneurs trained by Zamorano reported sales of 400 renewable energy systems, including 246 solar PV panels in local homes and 160 improved wood stoves. As part of the demonstration activities, Zamorano also installed five 200-watt PV systems in rural schools and provided them with multimedia equipment. They trained teachers and parents to maintain the solar systems and to collect funds to ensure long-term sustainability. Zamorano has received international recognition for the project's achievements, and the methodology is being replicated by other organizations in Honduras.

Through the Zamorano Renewable Energy Center (CZER), created in 2007 to find solutions to problems such as climate change, the school continues to create capacities to use renewable energy in rural development. Among other activities, CZER has participated in and developed research projects and studies, experimented with biofuels, and promoted the use of renewables in different sectors. The German government, through its international cooperation arm, GIZ, financed a project on "Training, Research, and Promotion of Renewable Energy in the Agricultural and Forestry Sector in Central America," which seeks to train Zamorano students, farmers, and micro-entrepreneurs on different renewable energy applications in the region.

Source: See Endnote 35 for this section.

Table 8. Electricity Access in Central America, 2012

	Population Without Electricity	Overall Electrification Rate	Urban Electrification Rate	Rural Electrification Rate
	millions		percent	
Costa Rica	0.0	99	100	98
El Salvador	0.5	92	97	82
Panama	0.4	88	94	71
Belize	0.05	85	—	—
Guatemala	3.0	80	91	70
Honduras	1.5	80	99	60
Nicaragua	1.6	72	95	41
Central America	7.1	85	96	70

Note: Where data are missing, it is because the source did not provide them. Urban and rural electrification rates for Central America overall exclude Belize.
Source: See Endnote 36 for this section.

the choice is between diesel generators—which will only become more expensive as fuel costs continue to rise—or clean, distributed energy.

The *Central America Sustainable Energy Strategy 2020*, approved by regional energy ministers in 2007, has the stated goals of reducing fuelwood consumption by 10 percent through the deployment of fuel-efficient stoves in 1 million Central American homes, and of achieving 90 percent electrification in the region by 2020.[37] At a more recent meeting of member countries of the Central American Integration System (SICA) in 2012, energy directors emphasized expanding access to electricity as a major priority, reiterating the 2020 target.[38]

In Guatemala, the Ministry of Energy and Mines has worked closely with the National Electrification Institute (INDE) for more than 10 years to administer the Rural Electrification Plan (PER), which requires electricity distributors to develop grid extension for rural electrification in their respective jurisdictions. PER is just starting to move into the implementation of renewable energy in off-grid rural applications.

Nicaragua's off-grid rural electrification project, PERZA (Programa de Eletrificación Rural en Zonas Aisladas), ended in 2011 after providing electricity to more than 6,000 rural households in the country through small residential solar energy and the construction of seven solar PV charging stations and four mini-hydro systems. More importantly, the program provided a framework for the long-term financial well-being of the communities and business that were involved. More than 3,000 people participated in workshops and meetings through PERZA, 43 business plans were developed, and 10 microfinance institutions now offer loans for rural electrification.[39]

Distributed renewable energy offers a development path that is locally based, allowing individuals and communities to be closely involved and to have control over their own energy supply.[40] Small-scale

distributed renewable energy technologies constitute an important, community-driven alternative to large centralized projects that can be removed from community participation and interests.

3.2.6 Women's Empowerment Through Clean Energy

Gender dynamics are at play in nearly all aspects of social and economic life, including how energy is produced and used. For many years, the discussion on gender and energy has focused largely on "household energy," particularly the burning of traditional biomass for cooking and its impacts on women's health.[41] In Central America, this topic remains timely because of the role that women throughout the region continue to play in this sphere.

Nevertheless, in Central America, as elsewhere, women are increasingly seeking to empower themselves and their communities through the deployment and use of renewable energy. Renewables have the potential to reduce hours spent collecting fuel wood and other energy sources for use in the home and allow time for other social activities such as education, participation in decision making, business, and income generation.[42] Women are also increasingly involved in technical renewable energy projects and are taking on roles traditionally held by men, such as electrifying their communities, businesses, and homes.[43] (See Case Study 5.)

3.3 The Need to Develop Full Socioeconomic Assessments of Energy Pathways

Although specific studies have demonstrated the cost, health, environmental, employment, development, and gender equity advantages of renewable energy, there is still a need for comprehensive assessments

Case Study 5. The Solar Women of Totogalpa, Nicaragua

The Solar Women of Totogalpa (Mujeres Solares) is a unique cooperative of 19 women and two men who work together in Nicaragua to develop their communities through the production and use of renewable energy technologies. The group has so far developed solar projects in two rural communities in the country's northeast.

The cooperative was formed in 1999 as an outgrowth of the Program of Alternative Energy Sources of the National Engineering University of Nicaragua. The project's initial objective was to train landmine victims in the production and installation of solar PV panels. Through exposure to the project, the women of Totogalpa realized that solar energy could also be used for cooking as a substitute for fuelwood. They began organizing in 2003 and obtained legal status as a cooperative in 2010.

The Solar Women are not only users of the technology, but they are actively involved in the research and development of new products and applications. In addition to designing, building, and selling solar stoves and solar thermal systems (used for drying), they design and assemble various types of PV panels using recycled PV cells. They produce a variety of goods processed using renewable energy, such as cookies, fruit preserves, and coffee, and have recently opened their own "solar restaurant." The sale of these goods creates sustained financing, and the women are constantly exploring new opportunities such as working with improved wood stoves, biogas, and solar water pumps.

The group is also helping to build awareness and capacity in other communities and organizations through training events for local and international participants. Several of the women have served as speakers and instructors in other parts of the world. The cooperative has received the National Renewable Energy award several times and was honored with the United Nations' SEED award in 2008.

For more information, see www.mujeressolares.org.

Source: See Endnote 43 for this section.

that quantify these benefits in the Central American context. A full LCOE+ assessment for the region that includes health, environmental, and climate change costs would strengthen the case for limiting fossil fuel generation and help energy planners determine the best mix of renewable energy sources for the region. Assessments of the economic structures and labor markets of Central American countries as they relate to renewable energy are also essential to determine the full supply chain and employment opportunities for renewable technology development in the region, as well as priority sectors for capacity-building efforts.

4 Renewable Energy Investments and Future Finance Needs

To meet its rising energy demand, Central America will require tens of billions of dollars in investment in new electricity capacity over the coming decades, and renewable energy is best positioned to receive the bulk of it. When assessed over their entire life cycle, many renewable energy technologies, including solar, wind, biomass, and small hydro, are more cost effective in most parts of the region than fossil fuels for power generation. But investment in renewables is influenced heavily by a country's overall investment climate, and many Central American countries rank comparatively poorly on global competitiveness indexes. Nicaragua is an example of a country that has overcome its low overall investment ranking by putting in place specific support measures for renewable investments. Key barriers in the financial sector across the region include the lack of capacity of banks to understand the value proposition of renewable technologies, and the lack of understanding among many renewable energy developers of what banks require to approve a loan.

In 2012, global investment in new renewable energy capacity dropped slightly, to $269 billion, from its peak of $302 billion in 2011; however, overall growth over the last decade has been unprecedented.*[1] Between 2004 and 2011, the installed capacity of renewables grew at an average annual rate of 31 percent.[2] Importantly, investment growth has been increasing in developing countries (i.e., countries that are not members of the Organisation for Economic Co-operation and Development, or OECD), accounting for 35 percent of total investments in 2011.[3]

Fulfilling the aspirations of Central American governments for a more sustainable energy sector will require scaling up finance efforts to achieve this transition and to lock-in clean technologies for climate-compatible development. The *Central American Sustainable Energy Strategy 2020* estimates that the region needs to install between 6,300 and 7,300 MW of new capacity before the end of 2020, requiring investments of $12–18 billion.[4] One of the primary goals of the strategy is to increase the share of renewables in regional electricity generation 11 percent by 2020 (over 2007 levels).[5]

4.1 Investment Climate

Investment in renewable energy varies significantly across Central America. In half of the countries, non-renewable generation capacity grew more than renewable capacity during 2007–11, the last five-year period for which official data have been published for all countries.[6] (See Figure 12.) This balance is expected to change dramatically in the coming years, however, with completion of the numerous wind, geothermal, and hydro power projects under construction in Nicaragua and Panama.

* Global investment in new renewable energy capacity excludes large hydropower and includes utility-scale wind, solar, geothermal, biofuels, small-scale solar, and solar heating.

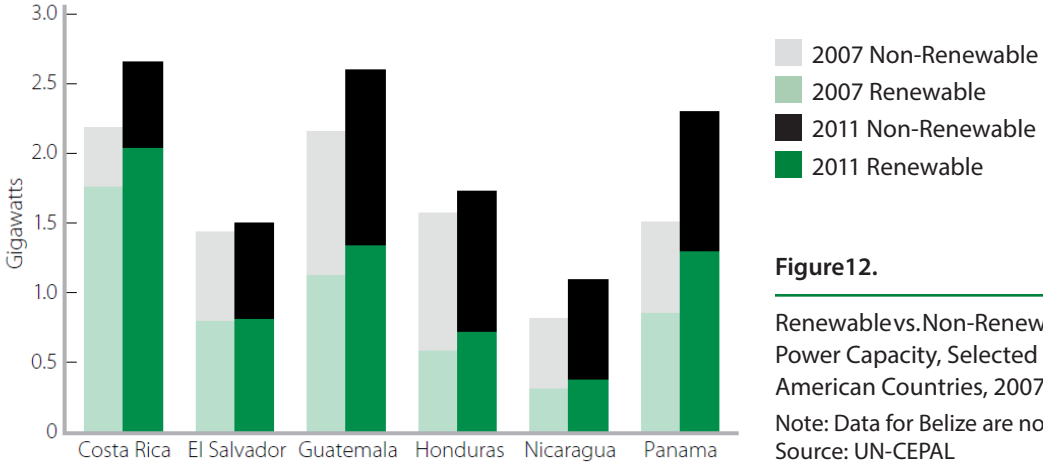

Figure12.

Renewable vs. Non-Renewable Installed Power Capacity, Selected Central American Countries, 2007 and 2011

Note: Data for Belize are not available.
Source: UN-CEPAL

Some countries have been more successful in attracting the necessary investments than others. El Salvador's total installed capacity grew only 5 percent during 2007–11, with only one-sixth of that being renewable, while Nicaragua's growth was 33 percent (one-fifth renewable) and Panama's was 52 percent (more than half considered renewable, although it was all hydropower).[7]

The investment climate for renewables is influenced heavily by a country's overall investment climate. Across Central America, the capacity of countries to finance new projects with local and international funds varies widely. Panama, for example, has both a very healthy internal savings rate and a high level of foreign direct investment (FDI), whereas El Salvador has the weakest performance in both areas.[8] (See Figures 13 and 14.) This is consistent with the performance of investments in the power sectors of these countries. Nicaragua has negative internal savings, but a very high rate of FDI, while Guatemala and Honduras have modest but positive rates in both areas.

Indicators of the investment climate in the region confirm that some Central American countries have macroeconomic and legal frameworks that are more favorable to attracting private investment. For example, according to the most recent World Economic Forum's Global Competitiveness Index (GCI), which measures the macro and microeconomic foundations of national competitiveness, Panama and Costa Rica rank highest across the region.[9] (See Table 9.)

A country's business environment determines not only the level of investment attracted, but also ultimately the cost of the capital, goods, and services. Lengthy and costly bureaucratic procedures are consistently mentioned as one of the main obstacles to the development of renewable energy in Central America. Obtaining environmental and construction permits can take several years in many countries, and the effective implementation of policies and regulations has proven to be lengthy and difficult to materialize due to lack of capacity and training across the many agencies involved in these processes. For example, securing reimbursements for tax exemptions provided by renewable energy promotion laws can be difficult or impossible in some countries.

The region's heavy bureaucratic burden and the risks to investors are evidenced by the International

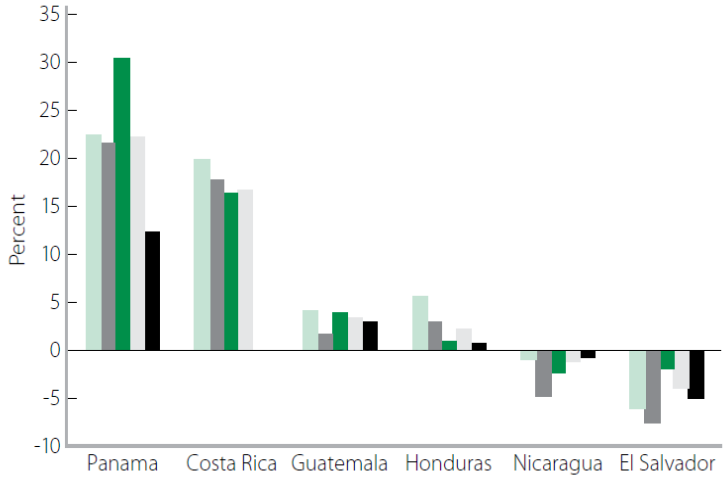

Figure 13.

Gross Internal Savings as a Share of GDP, Selected Central American Countries, 2007–11

Note: Data for Belize and 2011 data for Costa Rica are not available.
Source: World Bank

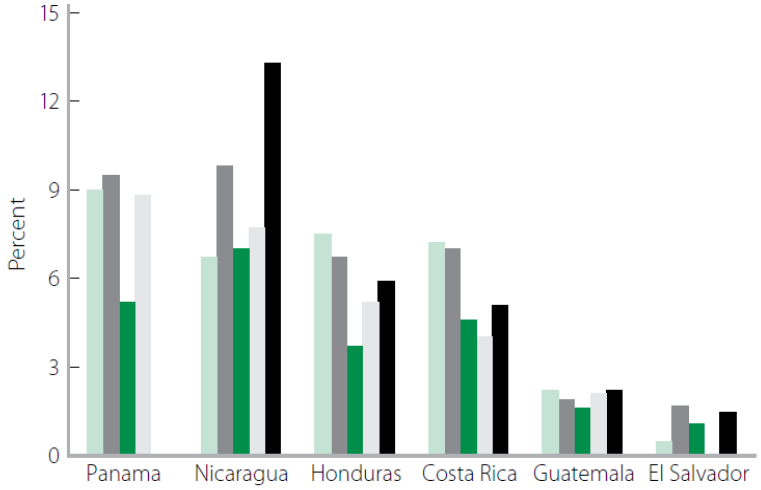

Figure 14.

Foreign Direct Investment as a Share of GDP, Selected Central American Countries, 2007–11

Note: Data for Belize and 2011 data for Panama are not available.
Source: World Bank

Finance Corporation's 2012 *Doing Business* report, which ranks Central American countries in the lower third in at least one of the four categories measured.[10] (See Table 10.) The region underperforms in the areas of starting a business, complicated permitting processes, the burden of taxes, and enforcing contracts. In practice, these barriers translate into long delays and overly complex bureaucratic processes that increase investment costs and diminish returns on investment, thereby deterring investors from participating in the region's energy sector.

There are examples, however, where the investment climate in the green sector differs significantly from that of overall investments. Nicaragua, despite receiving the lowest ranking in the region in the GCI and second-to-last overall in *Doing Business*, has received recognition for being able to attract new investments in the electricity sector, according to *Climate Scope 2012: Assessing the Climate for Climate Investing in Latin America and the Caribbean*.[11]

Nicaragua's second-place *Climate Scope* ranking among 26 Latin American and Caribbean countries is attributed mainly to its high use of renewable energy relative to the size of its economy, with 40 percent

of total installed power capacity derived from renewables.[12] Nicaragua also received recognition in the study because it is home to 10 organizations that have provided 3,511 low-income borrowers "with some kind of green financial product."[13]

Although its rankings in the two indexes are low overall, Nicaragua scores considerably higher than most of its neighbors in contract enforcement and investor protection, two extremely important signals for potential energy investors. Additionally, the Nicaraguan government has used Build-Operate-Transfer (BOT) contracts to provide security and predictability to private investors, which can offset some concerns about the overall investment climate.

Table 9. Global Competitiveness Index (GCI) Rankings for Central America, 2012–13

	Overall GCI Ranking	Macroeconomic Environment Ranking	Financial Market Development Ranking
Panama	40	53	23
Costa Rica	57	65	101
Guatemala	83	77	41
Honduras	90	80	51
El Salvador	101	103	81
Nicaragua	108	101	116

Note: Ranking is out of 144 countries, where a ranking closer to 1 indicates a more competitive economic environment. The GCI does not contain data for Belize.
Source: See Endnote 9 for this section.

Table 10. "Doing Business" Rankings for Central America, 2013

	Overall Ease of Doing Business	Starting a Business	Dealing with Construction Permits	Protecting Investors	Enforcing Contracts
Panama	61	23	73	82	125
Guatemala	93	172	94	158	96
Belize	105	158	21	128	169
Costa Rica	110	128	128	169	128
El Salvador	113	139	146	169	71
Nicaragua	119	131	154	100	55
Honduras	125	155	65	169	179

Note: Ranking is out of 185 countries, where a ranking closer to 1 means that the regulatory environment is more conducive to the starting and operation of a local firm.
Source: See Endnote 10 for this section.

4.2 Sources of Finance

A wide range of institutions finance renewable energy projects, and both the number of institutions and the range of modalities that are being used—from standard investing and lending to public, climate, and development finance—continue to grow.

Until the early 1990s, electricity generation in Central America was financed almost exclusively by international financial institutions, in particular the World Bank, the Inter-American Development Bank (IDB), and the Central American Bank for Economic Integration (CABEI). Beginning in the late 1990s,

however, the privatization and opening of electricity markets in the region brought a wave of FDI from private financial institutions in the United States, Europe, and South America, mainly to develop fossil fuel-based generation capacities. More recently, local investors have helped to finance small and medium-sized renewable energy projects, creating new opportunities for local financial institutions.

The experience of local banks in financing renewable projects varies among countries, as evidenced by a study by CABEI's Accelerating Renewable Energy in Central America (ARECA) program, which interviewed representatives of the largest banks in each country. In Panama, Costa Rica, and Honduras, every bank interviewed (five, five, and four, respectively) reported having participated in the financing of small renewable energy projects, whereas in Guatemala, four out of six banks interviewed said that they had done so.[14] Between El Salvador and Nicaragua, meanwhile, only one local bank had experience in financing a renewable energy project.[15]

An important barrier to renewable energy lending in Central America is the lack of information and knowledge. First, capacity shortfalls prevent small project developers from being able to present "bankable" proposals to financial institutions; second, a lack of understanding on behalf of bank officials of the value proposition offered by renewable energy projects keeps them from assessing proposals properly. Some regional cooperation programs, such as ARECA and the German Agency for International Cooperation's (GIZ's) 4E program, are attempting to fill this gap, but more and better coordinated efforts are needed at the national level in every country.[16]

4.2.1 Private Investment Funds

Several private investment funds dedicated to renewable energy operate in Central America. Globeleq Mesoamerica Energy, a venture capital vehicle for regional investors, specializes in the development of wind power projects.[17] The fund operated successfully as Mesoamerica Energy for several years with investments from large regional companies, and, in 2010, it changed its name when a majority of shares was acquired by the international corporation Globeleq.[18]

Another fund, supported by multilateral and bilateral development banks, is the Central American Renewable Energy and Cleaner Production Facility (CAREC), developed by E+Co Capital with support from the IDB's Multilateral Investment Fund (MIF), CABEI, the Belgian Investment Company for Developing Countries (BIO), the Finnish Development Finance Company (Finnfund), and the Netherlands' Triodos Bank. CAREC used mezzanine financing mechanisms such as subordinated debt, convertible debt, preferred shares, and other non-traditional financing instruments to fund energy projects. Between 2006 and 2011, CAREC invested close to $10 million in eight projects, including three small hydro plants in Honduras and a biogas production facility in Guatemala.[19] As of 2012, the fund allocation stage for CAREC has been finalized, and the facility is now managing only existing investments.

In addition to initiatives focused specifically on the energy sector, many non-specialized funds are open to investments in renewables. The Central American Small Enterprise Investment Fund II (CASEIF II), for example, is a $35 million risk capital fund administered by the regional banking group Latin American Financial Services (Grupo LAFISE).[20] Investors include the IDB's MIF, the Norwegian Investment Fund for Development (Norfund), the Swiss Investment Fund for Emerging Markets (SIFEM), Finnfund, the Andean Investment Corporation (CAF), and BIO.

CASEIF II was created to invest in small and medium enterprises in the growth stage in Central America and the Dominican Republic. It invests in shares and other capital or quasi-capital instruments and remains a shareholder for a 4–7 year period. In 2009, the fund acquired a 20 percent participation in Tecnosol, a Nicaraguan company specialized in providing off-grid renewable energy solutions to rural families and to support renewable energy expansion to other countries in the region.[21]

The experience of these funds has shown the importance of having "patient capital" and flexible financing and equity instruments to complement the commercial options available in the region, especially for small and medium private developers. Some of them have also invested technical and financial resources to assist project developers in preparing business plans, finding other sources of financing, and going through the permitting processes. This confirms that the development of more renewable energy projects requires not only more funds but also strengthened capacities on the part of both financiers and developers.

4.2.2 International Cooperation

International development and cooperation programs have provided financial support for renewable energy projects (especially small-scale projects) in the form of grants and technical assistance for studies and project implementation. The regionally based Energy and Environment Partnership with Central America (EEP), for example, uses funds from the Finnish and Austrian governments as well as the European Union to support sustainable energy initiatives. Since its creation in 2002, EEP has invested nearly €14 million ($18 million) in 284 projects, most of them small-scale and developed by community organizations in Central America.[22]

ARECA, mentioned earlier, is a joint program funded through CABEI, the United Nations Development Programme (UNDP), and the Global Environment Facility (GEF) that supports renewable energy investment through a series of market studies, guidelines, and other tools. ARECA has established a Program of Partial Loan Guarantees for projects under 10 MW, which reinforces guarantee coverage from CABEI's intermediary financial institutions, the local banks that disburse the loans to project developers. As of early 2013, the program had supported the development of 10 projects, totaling 38.7 MW, and identified 30 potential projects to be included in its partial guarantee program for 2013–14.[23] Further efforts are needed to communicate how many loan guarantees have been made through this program, at what amounts, and their success rates.

4.2.3 International Finance for Low-Carbon Development and Climate Change Mitigation

Several international financial players are involved in low-carbon development and climate change mitigation in Central America. These include the GEF, the Carbon Finance Unit of the World Bank (through its different funds), the IDB, and numerous international cooperation agencies including GIZ, the U.S. Agency for International Development (USAID), and the Japan International Cooperation Agency (JICA).[24]

The IDB and JICA joined efforts in early 2012 and pledged $600 million in financing for renewable energy and energy efficiency projects in Central America and the Caribbean.[25] The initiative is considering projects in the areas of hydro plant rehabilitation, PV and geothermal power generation, as well as installation of energy-saving facilities and equipment.[26]

Among GEF-financed efforts in the region is the project "Accelerating Renewable Energy Investments through the Central American Bank for Economic Integration in Central America," approved in 2007.

The regional initiative, involving all seven Central American countries, is aimed at reducing greenhouse gas emissions by promoting the use of renewable energy systems for electricity generation in grid-connected applications.[27]

The GEF also serves as a financial mechanism for the United Nations Framework Convention on Climate Change (UNFCCC), supporting initiatives such as the Clean Development Mechanism (CDM) and the United Nations Collaborative Program on Reducing Emissions through Deforestation and Forest Degradation (UN-REDD).[28] In the early stages of the Kyoto Protocol climate agreement, Central America was active in harnessing climate finance, and countries such as Honduras have been successful in the development of CDM projects. As of December 2012, the region was home to some 8 percent of the CDM projects in Latin America, which itself accounts for 13.6 percent of CDM projects worldwide.[29]

Although Central American governments and investors were very enthusiastic about the opportunities presented by the CDM, and have received support for a total of 71 registered projects (with 132 additional projects in the pipeline; see Figure 15), the general sentiment among project developers is that the CDM has not met the region's expectations in providing significant enough funding.[30] For that reason, and because renewable energy promotion in the region generally is driven more by socioeconomic goals than by climate policies, not all governments are effectively linking their sustainable energy advances to opportunities for climate finance.

Future financing through UNFCCC channels is likely to shift away from CDM funding toward support for Nationally Appropriate Mitigation Actions (NAMAs), policies and actions that countries undertake as part of their international commitment to reduce greenhouse gas emissions.[31] Disbursement of climate finance through NAMA funding has yet to begin, and a concrete definition of what qualifies as a NAMA does not exist, but many countries are hoping to access funding for national energy plans, policy measures, and specific sustainable energy projects through this mechanism. So far, Costa Rica is the only country in Central America to express interest in NAMA funding for its non-traditional renewable energy development plan. Other countries could benefit from exploring the increasing finance opportunities in the form of support for NAMAs and Low Emission Development Strategies through international cooperation agencies.

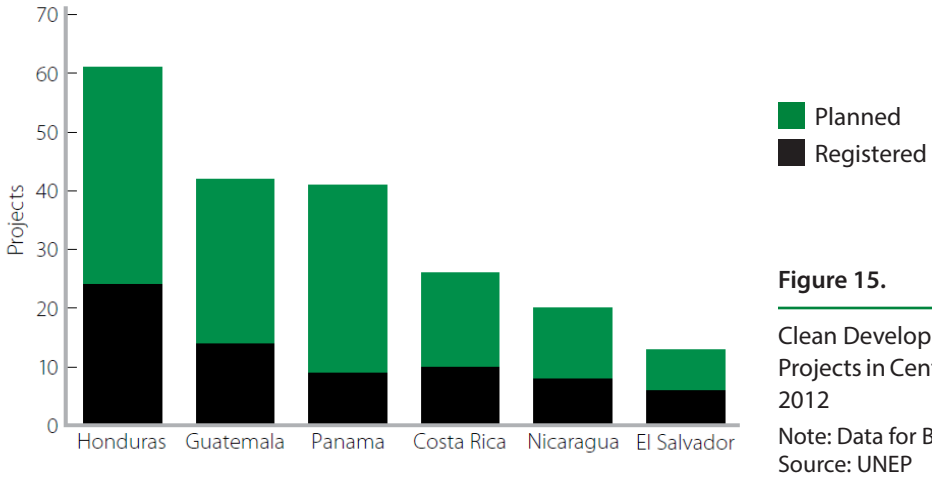

Figure 15.

Clean Development Mechanism Projects in Central America, by Country, 2012

Note: Data for Belize are not available.
Source: UNEP

4.2.4 Microfinance

Increasingly, microfinance institutions are playing an important role in supporting distributed renewable energy in communities that do not otherwise have access to credit, and in helping small businesses make their operations more sustainable. At the global level, families in low-income countries spend an average of $10 per month on energy, or 20–25 percent of their household income, suggesting that there is significant market potential to transition to modern, cheaper, and renewable forms of energy.[32] Microfinance can provide loans that have repayment levels within the household energy budget while providing cleaner and more reliable sources of energy services.[33]

The number of institutions offering green microfinance in Central America is growing. Nicaragua represents the most active microfinance market for sustainability initiatives in Latin America, with nearly one-third of its microfinance institutions providing some kind of green product and more than 3,500 low-income borrowers being served.[34] (See Table 11.) Microlending can be distinguished between a for-profit business model and one in which social and environmental benefits are central. Financial costs on microloans range from 1.5 percent to 28 percent, depending on the institution and product.[35]

Table 11. Overview of Microfinance and Green Microloans, Selected Central American Countries, 2012

	Number of Microfinance Institutions	Microfinance Institutions Offering Green Microloans	Average Interest Rate of Green Microloan	Total Amount of Green Microloans Disbursed	Number of Green Micro Borrowers
Costa Rica	20	3	—	0	0
El Salvador	19	3	11 %	$250,000	500
Guatemala	23	3	—	0	0
Honduras	24	6	—	0	0
Nicaragua	31	10	13.2 %	$2,934,307	3,511
Panama	0	0	—	0	0

Note: Where data are missing, it is because the source did not provide them. Data for Belize are not available.
Source: See Endnote 34 for this section.

Private renewable energy companies are establishing partnerships with microfinance institutions to offer loans to low-income families for the purchase of solar PV systems for their homes. Several companies, such as Quetsol in Guatemala and Tecnosol in Nicaragua, report having established these connections in order to develop local markets for renewable energy.[36]

4.3 Addressing Investment Barriers

Central America has come a long way in the past decade in developing policies and regulatory frameworks to promote renewable energy, despite challenges in some countries relating to the overall investment climate. Growing awareness among residents of the need to develop local renewable energy resources is creating opportunities for companies of all sizes—old and new, local and international—and on both the

supply and demand sides of the financial market (i.e., banks and project developers). There is a growing understanding and interest from investors and lending institutions to provide loans and capital to renewable energy project developers. The main challenge is to foster an environment that allows investors to assess and manage the risk involved in order to convert the tremendous opportunities for sustainable energy development in Central America into successful ventures.

5 | Assessing Existing Renewable Energy Support Mechanisms

All Central American countries have targets related to renewable energy, and some, particularly Costa Rica and Nicaragua, rank high in their ambition to transition to renewables. Most countries also have in place concrete policy mechanisms for advancing renewable energy; these include tax incentives, tendering schemes, biofuel mandates, net metering, and public financing mechanisms. However, many of the targets lack clarity and are voluntary rather than mandatory, and many existing policies and measures are not cost efficient or robust enough to move the region to its full renewable energy potential. No Central American country yet has in place a comprehensive, streamlined policy mix to support the transition to a sustainable energy system that makes full use of the available resources and technologies, considers alternative socioeconomic scenarios, and aims at creating an attractive investment climate based on the effective use of market forces. Administrative inefficiency and a lack of transparency often increase the risk for investors unnecessarily.

International experience suggests that countries that have successfully promoted renewable energy development and deployment have in place three essential policy building blocks: a long-term energy vision that includes goals and targets; concrete policies and measures toward achieving this vision; and effective administrative structures and processes for implementing and revising these policies and measures.

Central American governments have announced ambitious plans for their countries. At times, however, these plans lack clarity about specific goals: either the supporting analysis of pathways to achieve these goals is missing, and/or concrete policies and measures are inadequate or not fully implemented. Administrative inefficiencies, such as long permitting processes for new renewable energy projects, further complicate the attractiveness of renewable energy investments.[1] Still, there are important regulatory successes that can serve as a basis for the further development of robust policy frameworks and institutional reform within each country.

For policies to be effective in accelerating renewable energy, they need to be "long, loud, and legal."[2] "Long" refers to the need for a long-term vision that guides political action well into the future, and that will outlast any changes in political leadership. It creates a stable environment for a renewable energy transformation, while still being flexible enough to respond to changes in technologies, country needs, and resource availability. "Loud" highlights the importance of renewable energy targets and policies that are both ambitious and specific, committing all stakeholders toward advancing the same goal. "Legal" indicates the necessity of putting a comprehensive energy vision, including overall goals and targets, in writing to be accessible for any interested party and to ensure that renewable energy laws and targets are binding and enforceable. Long, loud, and legal policies commit all government branches, as well as key non-governmental stakeholders, to a common energy development agenda.

5.1 Visions, Goals, and Targets

Central American countries, to varying degrees, have ambitious targets related to renewable energy. Each country has expressed some form of "loud" and "long" vision for sustainable development based on the diversification of energy sources and scaling up of domestic renewable resources.[3] (See Table 12.)

A common goal of national energy plans in Central America is to strengthen energy security by reducing fossil fuel dependency and to assure the reliability and long-term sustainability of the energy supply. Since the oil crisis of 2008, which caused energy shortages and blackouts across the region, governments have emphasized diversification of energy sources. Each country's energy plan promotes the expansion of locally generated renewable energy, although clarity on targets and envisioned pathways differs.

Most countries are ambitious in their goals of bringing renewables to the forefront of their power sectors, but not all countries are explicit about what concrete targets they set for individual renewable technologies.[4] (See Case Study 6, page 58.) In addition, policies and measures are not yet sufficient for reaching overall goals and concrete targets in cases where these do exist.

5.2 Concrete Policies and Measures

In recent years, governments in Central America have established new policies and measures to encourage the adoption of sustainable energy. In general, three categories of policy mechanisms can be applied to promote renewable energy: regulatory measures, fiscal incentives, and public financing. These existing mechanisms need to be assessed at the country level for their efficiency, and, where necessary, new policies need to be designed. This study represents only a first step in a more detailed country-by-country assessment.

All countries in the region have begun to adopt measures to encourage a favorable investment climate for sustainable energy. Although many have established renewable energy fiscal incentives, regulatory measures and public financing are less common. Countries differ in their ambition and success in implementing renewable energy measures: Costa Rica, for example, has been a pioneer in policymaking for a relatively long time, while others have discovered only recently the importance of renewables and the necessity to support their deployment through targeted policies.

There is no single formula for determining which policies should be used in a given country to facilitate an energy transition. The "right" policy mix to maximize renewable energy development will depend on a country's unique set of institutions, electricity market structures, resources, and energy demand.

5.2.1 Regulatory Measures

In Central America, a variety of regulatory measures are in place to ensure that renewable energy continues to grow. For example, six of the seven countries have established tendering procedures, and three have adopted net metering policies.[5] (See Table 13, page 59.) Three countries have also passed biofuel blending mandates, and Guatemala and Nicaragua have started to experiment with feed-in tariffs. The experiences with these different policy mechanisms and their efficiency differ greatly, as discussed below.

Table 12. Renewables in National Energy Plans of Central American Countries

Country (Renewable Share of Electricity Use, 2011)	Energy Plan (Issuing/Overseeing Agency)	Goals and Targets
Belize (60%)	Strategic Plan 2012–2017 (Ministry of Energy, Science & Technology and Public Utilities)	• Improve energy efficiency and conservation 30 percent by 2033 (baseline year 2011) • Reduce the country's dependence on fossil fuel consumption 50 percent by 2020 • Generate a minimum of 50 percent of electric power from renewable sources • Reduce conventional transportation fuel use 20–30 percent by 2033 (SIDS DOCK commitment)
Costa Rica (91.2%)	VI Plan Nacional de Energía 2012–2030 (Ministry of the Environment and Energy)	• Become carbon-neutral by 2021 (re-emphasizing commitment in Second Communication to the UNFCCC, 2009) • Reduce residential energy consumption 7.8 percent between 2012 and 2030 • Equip 10 percent of households with distributed solar generation by 2020 • Provide 100 percent of population with access to energy by 2030 • Reduce electricity consumption in industry 8.5 percent by 2020 • Transform the vehicular fleet to be 39 percent high efficiency, 9 percent electric and hybrid plug-in, and 2 percent natural gas by 2030
El Salvador (63.3%)	Política Energética Nacional 2010–2024 (National Energy Council)	• Provide affordable and continuous power supply • Build institutional capacity • Reduce oil dependence • Minimize detrimental environmental and social impacts of energy, considering climate change
Guatemala (64.2%)	Politica Energética 2013-2027 (Ministry of Energy and Mines)	• Cover current and future energy demand • Strengthen electric power transmission • Diversify the energy mix and reduce oil dependence • Generate 80 percent of electricity from renewable sources by 2027
Honduras (43.5%)	Visión del País 2010–2038 Plan de Nación 2010–2022 (Technical Secretariat for Planning and External Cooperation)	• Reduce reliance on hydrocarbons • Mitigate and adapt to climate change • Expand country-wide electricity coverage to 85 percent by 2015 and 90 percent by 2020 • Generate 60 percent of electricity from renewable sources by 2022 and 80 percent by 2038 • Invest $1.5 billion in renewable and hydroelectric sources by 2022
Nicaragua (33.1%)	Plan Estratégico del Sector Energético 2007–2017 (Ministry of Energy and Mines) Plan Nacional de Desarrollo Humano 2009–2011	• Diversify the energy mix • Promote renewables • Maximize energy efficiency • Promote competitive markets and policies to ensure coverage and access to energy • Provide a regulatory framework • Identify 4,500 MW of renewable energy capacity, including hydro, geothermal, wind, solar, and biomass • Supply between 95.2 and 98.1 percent of the estimated electricity demand with renewable sources by 2017
Panama (52.9%)	Plan Nacional de Energia 2009–2023 (National Secretary of Energy)	• Ensure domestic energy supply through renewable energy and energy efficiency • Maximize the energy sector's contribution to sustainable development • Increase energy access • Promote capacity building • Develop biofuels in the transportation sector, and wind and hydropower in the electricity sector

Source: See Endnote 3 for this section.

Case Study 6. Energy Diversification in Panama

Among the goals of Panama's National Energy Secretariat, the state entity in charge of energy policy, are diversifying the national energy mix toward clean sources, optimizing energy efficiency, and promoting policies that guarantee access to energy. In 1997, following decentralization of the state electric company (IRHE), Panama created new regulations making it mandatory for energy distribution companies to buy power produced by private generators using a range of different technologies. Until then, hydropower was the only non-fossil fuel source in use.

Facing high petroleum prices and various environmental concerns, the National Energy Secretariat developed a new policy based on energy source diversification. It created laws to encourage wind and solar power production within a self-regulated, competitive market. Incentives were developed to attract investment in renewable energy without undermining competitiveness in the power generation sector.

Among these incentives and new regulations, Panama has created long-term, 15-year procurement plans for renewable electricity capacity (Law 45, August 2004), the Wind Power Law (Law 44, April 2011), and resolutions to incorporate renewable projects into the power distribution grids (Resolution AN No. 5399-Elec). In April 2011, Panama adopted legislation (Law 42) promoting national biofuel production.

On the demand side, Panama has created resolutions for the development of distributed generation to encourage the small-scale use of renewable energy resources. The country also recently approved the Rational and Efficient Energy Use Law, aimed at efficient energy management.

Panama's economic boom, reflected in rising electricity consumption of 6 percent annually, as well as its strategic position and the prospects of future regional grid interconnections via the Central American Electrical Interconnection System (SIEPAC) and the Colombia-Panama Interconnection, is another incentive driving forward investment opportunities to meet local as well as regional power market demand. In the coming years, Panama plans to obtain more than 1,000 MW of power from renewable energy sources, equal to more than $1.6 billion in private investment.

For more information, see www.energia.gob.pa.

Source: See Endnote 4 for this section.

Tendering: Traditionally, new power capacity in Central America is procured through bilateral contracting between a generator and a purchaser (typically a major utility company). Increasingly, however, competitive solicitation for renewable energy projects through public tendering is becoming more common. Through the tendering process, the most favorable contracts are selected to supply electricity to the grid through a competitive application process for capacity addition contracts. Tendering can be managed by the government, but it is most commonly carried out by a regulatory agency (for example, the Empresa de Transmisión Eléctrica, S.A (ETESA) in Panama) and is typically associated with long-term power purchase agreements.

Although tendering has been employed for renewable and non-renewable energy in six of the seven countries, it is currently being used for contracting on wind projects in Guatemala, Panama, and Nicaragua. In these three countries, government mandates are in place requiring electricity distributors to tender power purchase agreements for up to 10 years.[6] Tendering schemes represent a good mechanism to drive down project costs and increase competitiveness; however, there is a need to introduce international best practices to avoid underbidding and non-fulfillment of contracts as well as to support the participation of local players to assure sustainable growth of the regional market.[7]

Net Metering: Net metering is a low-cost, low-risk policy tool that has been successfully implemented in many countries. Geared toward compensating independent power producers at the residential and

Table 13. Regulatory Policies for Renewable Energy in Central America

	Feed-in Tariff	Net Metering	Quota Obligations	Tendering	Biofuels Mandate
Costa Rica		✓		✓	✓
El Salvador				✓	
Guatemala	✓	✓		✓	✓
Honduras				✓	
Nicaragua	✓			✓	
Panama		✓		✓	✓

Note: As of early 2013, no Central American countries were using quota obligations for renewables. Data for Belize are not available.
Source: See Endnote 5 for this section.

commercial levels for electricity that they feed to the grid, it is gaining prominence in Central America. Costa Rica, Guatemala, and Panama all have developed net metering schemes, and El Salvador's Consejo Nacional de Energía (CNE) in is in the process of developing a net metering policy. In Panama, the net metering scheme promotes and creates incentives for the installation and grid connection of solar and wind systems smaller than 10 kilowatts. Guatemala's net metering program was established through the Normativa Técnica para la Generación Distribuida Renovable (NTGDR), and Costa Rica's through the Plan Piloto de Generación Distribuida para Autoconsumo.

These net metering regulations represent a good start toward assuring that independent power producers can tie to the grid and be metered for what they produce; however, private sector involvement and public awareness of these programs needs to be increased. Pilot programs, such as Costa Rica's new net metering initiative, should be adopted as full-fledged and long-term programs.[8] (See Case Study 7.) Costa Rica's program applies to areas of the national grid operated by the national Institute of Electricity (ICE), which covers roughly 80 percent of the national grid, and stands as a model for smaller domestic utility companies that do not have their own net metering programs in place.

Costa Rica's success can also serve as a model for Panama's net metering policy, launched in June 2012, as well as Guatemala's net metering program for self producers, first established in 2008.[9] Both programs have had limited success in spurring on-site self-production at the point of grid connection, although further research is needed on these efforts.

Feed-in Tariffs: Net metering is often a precursor to other policies such as feed-in tariffs. A feed-in tariff provides a guarantee to independent power producers (IPPs) that they can tie into the grid and that they will receive a given price for the energy they generate. An effective feed-in tariff system provides one standard application that is easily accessible for IPPs to use and can assure them that they are able to connect to the grid.

Effective feed-in tariffs require a commitment of financial resources, which often means an increase in the per-unit price of electricity paid by consumers to allow power distributors to pay IPPs for renewable electricity fed into the grid. Seeking public approval of such tariff increases is difficult, especially when the price per kilowatt is low due to government-provided electricity consumption subsidies for low-

Case Study 7. Costa Rica's Net Metering Pilot Program

In October 2010, the Instituto Costarricense de Electricidad (ICE), a state-owned electricity distributor in Costa Rica, launched a net metering pilot program called the "Plan Piloto Generación Distribuída para Autoconsumo." ICE's pilot program in Costa Rica has two main goals: to promote small-scale, distributed renewable energy, and to gather data on the impacts of small-scale renewables projects on the national grid in order to improve future energy planning.

Under ICE's pilot program, small-scale renewable energy generators are allowed to connect directly to the grid, and ICE installs a bi-directional meter for the consumer/generator. If small-scale generators produce more electricity than they use, they receive a credit that can be carried over into the next billing cycle. Currently, credits can only be used to offset consumption.

ICE capped the total capacity for the net metering pilot program at 5 MW, with a limit of 1 MW total in residential installations. The program is applicable for solar, wind, biomass, hydropower, and cogeneration systems. As of May 2012, the project had incorporated 48 separate grid-tied distributed systems, 43 of which were solar PV systems, for a total of 225 kilowatts of electricity. The program was originally set to expire in October 2012, but the positive response has led ICE to consider extending the duration.

If Costa Rica's pilot program were to lead to a long-term national net metering scheme, it would bring tangible benefits for consumers, the government, electricity distributors (including ICE), and the country as a whole. Consumers would have incentives to generate their own electricity and lower their power bills, particularly as national electricity prices continue to rise. Electricity distributors would benefit from the additional power, which would free up electricity elsewhere and increase grid capacity in a country that already faces significant power shortages.

Through the pilot program, the Costa Rican government has gained valuable insight into how to regulate net metering for all consumers. In addition, net metering helps reduce the country's total carbon emissions, creates a more equitable international balance of trade, creates demand for new technology jobs, and provides additional economic security. A change in legislation to allow for more distributed capacity to be added is needed, however, in order for Costa Rica to benefit from the full impact of a nationwide program.

Source: See Endnote 8 for this section.

income consumers. Feed-in tariffs also require significant administrative capacity to make the necessary regulatory adjustments throughout the program, including changing feed-in tariff rates to reflect declining renewable energy technology costs.

Although this type of feed-in tariff scheme is currently nonexistent in Central America, the net metering laws reviewed earlier, in particular Guatemala's law for self-producers, can be seen as precursors for future production or feed-in laws.[10] Feed-in tariffs can also be implemented for utility-scale renewable energy generation.

Quota Obligations: Central America currently has no legally binding quota obligations (also known as renewable portfolio standards, or RPSs) in place. These measures require distributors to purchase a minimum amount of electricity generation from renewables or require that a utility purchase or generate a certain amount of its electricity from renewables by a given date. Further study is needed to assess the potential for creating and implementing quotas in the region.

Biofuel Blend Mandates: Demand for biofuels is driven largely by policy measures, the most common being a mandate that requires a blend percentage of biodiesel, ethanol, or both in a country's fuel mix. Three Central American countries have passed biofuel blend mandates—Guatemala, Costa Rica, and

Panama—and El Salvador currently has one under review.[11] (See Table 14.)

Mandates are often accompanied by other biofuel-promoting policies (such as direct subsidies to feedstock growers and refiners) or fiscal incentives (such as tax exemptions) to biofuel producers and consumers. Currently, there are no official reports on the outcome of these biofuel mandates. Further research is needed to assess the effectiveness and degree of success of those mandates in place.

Despite the recent emergence of renewable energy regulatory measures in Central America, many of these remain limited in scope and are at times not fully implemented, hindering their potential to encourage investment in renewables.

5.2.2 Fiscal Incentives

In addition to regulatory policies, governments can use fiscal incentives to reduce costs, spur investment, and improve the competitive advantage of renewables. At least six countries in Central America offer fiscal incentives (data for Belize are not available). The most common are tax exemptions such as import, income, and property tax concessions.[12] (See Table 15.) In many cases, however, such tax incentives are not providing prompt monetary benefits to renewable energy investors and developers.

Table 14. Overview of Biofuel Support Policies in Central America

	Blend Mandates	Legal Framework	Public Policy
Belize	None	None	None
Costa Rica	B10 by 2012	Fuel blend mandate	2008–2021 National Energy Plan refers to biofuels as a strategic objective; government aims to make Costa Rica "carbon neutral" by 2021
El Salvador	E10 (under review)	E10 mandate and tax exemptions under review	2007 Energy Policy calls for biofuels to diversify the energy mix
Guatemala	E5	Fuel blend mandate	2008–2015 Energy and Mining Policy mentions biofuels as beneficial for energy security
Honduras	B5 now, E10 by 2014 (suggested)	Companies that use at least 51 percent Honduran feedstock are eligible for 12-year tax exemptions for biofuel plants; biofuel companies also receive a 15-year tax exemption from Honduras's social programs tax	2009 Biofuels Production and Consumption law declares biofuels in the national interest; Secretary of Industry and Trade is promoting an immediate (non-binding) B5 blend followed by an E10 blend to be initiated in 2014
Nicaragua	None	Decree 42-2006 under the Bolaños administration set aside 200,000 hectares for palm production; however, this legal framework was later thrown out under Ortega	National Biofuels and Agro-Energy Policy, drafted in 2007, seeks to promote ethanol and biodiesel development while protecting food security; the group established a Supporting Fund for Biofuel Production to be financed by a gas tax and international organizations
Panama	E2 by 2013; E5 by 2014; E7 by 2015; E10 by 2016	Fuel blend mandate (successional approach—ethanol blend subject to increase beyond E10 after 2016 depending on technology advances)	National Secretary of Energy promotes sustainable biofuel development to mitigate climate change and spur rural development and job creation

Source: See Endnote 11 for this section.

Table 15. Fiscal Incentives for Renewable Energy in Central America

	Capital Subsidy, Grant, or Rebate	Investment or Production Tax Credits	Reductions in Sales, VAT, Income, Customs or Other Taxes	Energy Production Payment
Costa Rica			✓	
El Salvador		✓	✓	✓
Guatemala		✓	✓	
Honduras		✓	✓	
Nicaragua			✓	
Panama		✓	✓	✓

Note: As of early 2013, no Central American countries were using capital subsidies, grants, or rebates for renewables. Data for Belize are not available.
Source: See Endnote 12 for this section.

Project developers interviewed for this study (e.g., utility-scale wind developers and solar installation companies) reported that governments are not fulfilling their obligation to reimburse import taxes, that delays are significant, and that there is a lack of coordination with customs and other tax authorities for the effective and timely execution of tax rebates. Income tax exemptions for renewables exist in some countries, but in certain cases the timescales are insufficient and should be extended. Tax exemptions in El Salvador, for example, apply only for the first 10 years of a project, although income from wind development in the region is rarely generated within that timeframe.

Coordination needs to be improved between government energy institutions (an energy ministry or national energy commission) and those who actually implement a tax rebate (the tax authority, usually a ministry of economy or secretary of finance). This coordination can be carried out through the office specifically responsible for renewables within the energy agency. For an import tax exemption on imported renewable energy equipment to be properly executed, for example, renewable energy units can facilitate the process between the customs authority that processes the shipment and the tax authority responsible for the rebate.

Further research on tax incentives in the region needs to investigate the design of existing tax incentive laws, the familiarity of implementing agencies with these measures, and the track record of the different agencies involved in processing and honoring these incentives.

5.2.3 Public Financing

In some Central American countries, the risks and costs associated with energy and other investments deter private investors. Public financing in the form of grants, loans, and rebates can be critical for overcoming these barriers.

Publicly funded rural electrification programs that incorporate renewables have had some success in the region, as discussed previously. Government banks, such as the Banco Nacional in Costa Rica and the Banco de Costa Rica, can also provide loans for renewable energy projects. The extent to which government banks are willing and able to back renewable energy projects needs to be assessed.

To date, there have been no known government grants made directly to renewable energy projects in the region. Further research is needed on the potential for government grants, with or without international finance, to sponsor renewable energy projects.

5.3 Governance and Administrative Efficiency

The structure of Central American energy institutions has changed dramatically since reforms in the 1990s created new independent regulatory agencies, unbundled and privatized large state-owned utilities, and established competitive electricity markets in most countries (with the exception of Costa Rica and Honduras). Although new agencies initially faced a lack of maturity and other obstacles to achieving national energy goals, countries have developed stronger, more independent institutions over the years.

Within government agencies, the establishment of offices with mandates specific to renewable energy (aside from hydropower) occurred as recently as the last five years.[13] (See Table 16.) For example, El Salvador created the Unidad de Recursos Renovables, the renewable energy arm of the Consejo Nacional

Table 16. Key Institutions and Features of the Energy Sector in Central American Countries

		Fossil Fuel Sector		Electricity Sector		
	Energy Policymaking Body	Regulator	Price Regulation	Regulator	Generation	Wholesale Market Administrator
Belize	Ministry of Energy, Science and Technology and Public Utilities (MESTPU)	Public Utilities Commission (PUC)	No	Public Utilities Commission (PUC)	Open	Belize Electricity Limited (BEL)
Costa Rica	Ministerio de Ambiente, Energía y Telecomunicaciones (MINAET)	Autoridad Reguladora de los Servicios Públicos (ARESEP)	Yes	Autoridad Reguladora de los Servicios Públicos (ARESEP)	Single buyer	None
El Salvador	Consejo Nacional de Energía (CNE)	Dirección de Hidrocarburos y Minas (Ministerio de Economía)	No (Non-mandatory reference prices)	Superintendencia General de Electricidad y Telecomunicaciones (SIGET)	Open	Unidad de Transacciones (UT)
Guatemala	Ministerio de Energía y Minas (MEM)	Dirección de Hidrocarburos (Ministerio de Energía y Minas)	No	Comisión Nacional de Energía Eléctrica (CNEE)	Open	Administrador del Mercado Mayorista (AMM)
Honduras	Secretaria de Energía, Recursos Naturales y Ambiente (SERNA)	Unidad Técnica del Petróleo, (Secretaria de Industria y Comercio)	Yes	Comisión Nacional de Energía (CNE)	Single buyer	None
Nicaragua	Ministerio de Energía y Minas (MEM)	Dirección General de Hidrocarburos, Instituto Nicaragüense de Energía (INE)	No	Instituto Nacional de Energía (INE)	Open	Empresa Nacional de Transmisión Eléctrica (ENATREL)
Panama	Secretaria de Energía	Dirección General de Hidrocarburos (Ministerio de Comercio e Industria)	No	Autoridad Reguladora de los Servicios Públicos (ASEP)	Open	Empresa de Transmisión Eléctrica S.A. (ETESA)

Source: See Endnote 13 for this section.

de Energía (CNE), in 2007.[14] This emergence of renewable energy offices reflects a growing political will to promote renewables because of the social, economic, and environmental benefits they bring to the region.

Despite growing institutional capacity aimed at promoting sustainable energy, barriers related to governance and transparency hinder the growth of renewables in the region. The excessive steps that developers have to take to advance a project, as well as the lack of transparency, reliability, and accountability of the process, are major barriers (explored in more detail in Chapter 6). One of the most notable obstacles—in Central America as well as globally—is the often excessive time required to process an environmental impact assessment, approve construction permits, and obtain tax concessions for renewable energy projects. For example, the largest wind farm in the region, Honduras's Cerro de Hula, took more than a decade to complete from the feasibility study to commissioning.[15]

In many countries, the administrative process for project permitting and approval needs to be streamlined. Creating a "one-window stop" for renewable energy permitting—for example, through the newly created renewable energy agencies in many Central American countries—can help ease this administrative burden and relieve project developers and investors of the bureaucratic risk associated with long wait periods for project approval.

Mainstreaming of renewable energy incentives and measures throughout all government agencies is also essential to ensure proper implementation, as seen in the case of tax exemptions through finance ministries and customs agencies detailed above. Processes to monitor and review policies to ensure that they are being effectively implemented, as well as means to reform failing policies, will enable governments to develop a robust policy framework and provide a stable investment environment for renewable energy.

5.4 Regional and International Cooperation

At the regional level, all members of the Central American Integration System (SICA) have adopted the *Central America Sustainable Energy Strategy 2020*, drafted by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC). The goal of the strategy is "to ensure the quantity and diversity necessary to make certain that the Central American energy supply provides the foundation for sustainable development, taking into account social equity, economic growth, governance, and compatibility with the environment, in accordance with international environmental commitments."[16]

Central America is also active in international climate change mitigation and adaptation processes. All countries of the region are signatories to the Kyoto Protocol and have submitted National Communications to the UNFCCC, which include plans for renewable energy expansion, energy efficiency, and adaptation. In the early stages of the Kyoto Protocol, Central America was one of the most active regions in the successful use of the Clean Development Mechanism to support sustainable energy projects.[17]

Countries are also cooperating on climate change at the regional level. In 1993, the Ministers of Foreign Affairs of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama signed the Regional Agreement on Climate Change. In 2008, the Heads of State and Government of the SICA member countries met in Honduras to establish a political commitment to "begin a process of broad participation by all sectors of society to build a common strategy to deal with climate change impacts."[18] The 2010 Regional Strategy on Climate Change (RSCC), carried out by SICA and the Comisión Centroamericana

de Ambiente y Desarrollo (CCAD), provides an institutional framework for promoting renewables as part of climate change mitigation.[19]

SICA, created in 1991, provides a regional institution for energy integration efforts. The Energy Coordination Unit of the SICA General Secretariat (UCE-SICA) was established in 2006 to coordinate the actions, activities, and regional energy projects of SICA member countries.[20] Another sub-group, the Central America Electrification Committee (CEAC), was created in 1985 to drive regional power integration. Comprising energy representatives from SICA member countries, CEAC has supported initiatives such as the Sistema de Interconexión Eléctrica de los Países de América Central (SIEPAC), a regional grid system with 1,800 kilometers of transmission lines that connect 35 million electricity consumers from Guatemala to Panama.[21]

The current SIEPAC phase cost an estimated $494 million, and a second stage of development, which will require up to $157 million in investment, is expected to double the system's overall capacity from the current 300 MW to 600 MW.[22] SIEPAC developers officially project that the expansion will be completed between 2014 and 2015, although most experts in the region say that this near-term timeline is unlikely.[23]

After nearly two decades of effort, Central America's Regional Electricity Market (MER) was established as a supranational electricity trade regulator with its own set of rules for regional power transactions over SIEPAC lines. The MER was established by the Marco Treaty, signed in 1996 by the presidents of the six participating countries (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama), and consists of two separate protocols (1997 and 2007). Four institutions comprise the MER: the Comisión Reguladora de la Interconexión Eléctrica (CRIE), the Ente Operador Regional (EOR), the Empresa Propietaria de la Red (EPR), and the Consejo Director del MER (CD-MER), the public policy institution of the MER.

As part of the MER, the CRIE acts as the regulatory agency of the regional market and includes one commissioner from each member state. The CRIE enforces the Marco Treaty and its protocols, regulations, and other instruments while ensuring the transparent operation of the MER under a competitive framework. The EOR is responsible for directing and coordinating the Sistema Eléctrico Regional (SER) and managing the MER according to the regional regulation. The EPR is a private company responsible for building and operating the first regional electricity interconnection system. The CD-MER aims to expand the MER and facilitate compliance with the commitments of the MER's Second Marco Treaty and coordinate interactions between the CRIE and EOR.

Current efforts to strengthen electricity integration in Central America through SIEPAC and to streamline regional electricity regulation through the MER can benefit from international best practices for scaling up renewable energy through regional interconnection. For example, the implications for grid systems in Western Europe of recent efforts by Germany to accelerate its transition to renewable energy can provide Central America with valuable lessons learned with regard to managing intermittency and regulating power exchanges between countries.

6 | Outlook: Recommendations for Moving Renewable Energy Forward in Central America

A rapid transition to 100 percent renewable electricity generation is both technically possible and socio-economically beneficial in all Central American countries. To support this transition, policies need to address the key financial barriers facing the region, using an integrated, holistic approach. We suggest four key action steps in the areas of knowledge and communication, and four key action steps in the areas of finance and policy, to chart the way forward for renewable energy in Central America.

Central America is rich in renewable energy resources and has tremendous opportunity to harness this potential. The region has come far since the days, prior to the early 1990s, when hydropower was the primary electricity source. Encouragingly, despite the range of fossil fuel options now available, the region is continuing to expand its use of renewable energy, a trend that is in the global interest as well as the national economic, social, and environmental interest of Central American countries.

An important need now is to enhance research and strategy development in several critical areas in order to fill knowledge and communication gaps, and to encourage political reforms that can improve the investment environment for renewables in the region. By developing more detailed roadmaps for sustainable energy deployment in high-impact action areas, it will be possible to facilitate a process where the region will have concrete technical solutions and political recommendations.

6.1 Recommendations to Address Knowledge, Information, and Communication Gaps

1. Perform additional resource assessments and make existing assessments publicly available

Across Central America, governments, utilities, and international organizations have carried out country-wide assessments for wind, solar, and geothermal resources, as well as for bioenergy. These are not comprehensive, however, and new resource assessments will be needed for areas where they currently do not exist. Once key resources zones are identified through country-wide assessments, site-specific assessments and feasibility studies can take place.

Some countries and private developers are using existing assessments as guides for initial analysis in energy planning. While these initial assessments have been instrumental in planning recent installations in the region, it is important to make these and future analyses widely accessible to accelerate renewable energy deployment.

Stakeholder interviews have shown that, despite their existence, resource assessments by governments,

utilities, and private developers are often not widely shared. In some cases, public utilities possess detailed resource assessments for various renewable resources, but these are not made available to other energy developers. In other instances, private companies do not make their assessments available to governments or public utilities.

Coordination among policymakers, investors, and private developers is critical, both in the use of existing resource assessments and the creation of new ones. Public-private partnerships for scoping renewable resource potential can bolster joint development efforts such as renewable electricity capacity tendering.

2. Integrate technical solutions

Resource assessments alone represent only one part of an integrated and consistent energy strategy. It is also important to think about solutions in an integrated way in order to develop renewables in the most cost-effective manner. This can be done by addressing the variability in power production associated with certain technologies, such as solar and wind power, which require careful planning to ensure that baseload needs are met and overproduction is avoided.

With regard to large-scale, grid-tied renewables, there is a need for regulators and grid operators to consider not only the integration of different geographical areas within countries, but also the wider-scale trading of electricity among countries. At the same time, energy efficiency must remain a priority, and it is important to continue to integrate renewable energy and energy efficiency efforts.

Integration also means planning "smart grids" to best utilize different renewable and non-renewable resources. Utilities need to consider how certain variable renewables can complement each other seasonally—for example, by combining wind and hydropower or solar and hydropower on the same grid. As the quantity of variable generation increases, utilities can also experiment with baseload generation from renewables (e.g., geothermal and dammed hydro) in combination with existing fossil fuel sources such as oil and diesel. Meanwhile, new options such as LNG are being explored to provide back-up generation for renewables both on and off the grid.

Both ECLAC and the Latin American Energy Organization (OLADE) have assessed certain effects of climate change (and the need for adaptation) in Central America's energy sector, particularly in light of how changing weather patterns will affect hydropower generation. Greater analysis is needed, however, on how higher temperatures will affect electricity demand for space cooling, and how more-frequent and stronger storms will affect electricity transmission and distribution.

Analysis is also needed on integrated energy planning within the SIEPAC interconnection system. Currently, only electricity generators that are allowed to participate in the national wholesale markets of member countries are allowed to tie into the regional grid, possibly limiting the potential for increasing renewable energy in the regional grid. In Costa Rica and Honduras, only the state utility companies are allowed to participate in regional electricity trading through SIEPAC. In other Central American countries, where the electricity market is privatized, renewable energy generators are not expressly prohibited from participating in SIEPAC, although their participation can be limited by the need for a connection to the national high-voltage grid. Without a streamlined process guaranteeing grid connection for renewable generators, tying to the grid can be an expensive and lengthy process.

It is not clear whether, with its current regulations, the regional electricity market favors generation from renewables or is prohibitive to their development. The structure and regulation of the regional grid need to be assessed further in order to develop the right policy mechanisms for promoting renewable energy. Strengthening the role of renewables in a larger, more widespread grid can benefit these energy sources by allowing variable generation and overcapacity to be transmitted across borders. For the first time, for example, Costa Rica—currently reliant on hydropower capacity—will be able to import wind power from Nicaragua when its hydro generation wanes in the coming years.

3. Assess and communicate the full socioeconomic impacts of different energy scenarios

A recent regional study on LCOE+ (Levelized Cost of Energy, plus externalities) provides an initial assessment of the socioeconomic impacts of different energy scenarios in Central America.[1] Although the study documents the many development benefits of sustainable versus non-sustainable energy at the regional level, a more targeted LCOE analysis of the full benefits of renewables over time in the specific context of each Central American country is needed.

The Worldwatch Institute, in its 2013 study of sustainable energy prospects in Jamaica, has conducted in-depth LCOE and LCOE+ studies that demonstrate through future scenario planning that (1) renewable energy is less expensive over time than fossil fuel-generated energy, even without considering externalities, and (2) when externalities are taken into account, the renewable advantage is even greater. This type of country-specific LCOE is necessary for every Central American country.

The comparative development benefits outlined in the regional LCOE+ study need to be further considered in energy planning, rather than continuing with business as usual. Incorporating the externalities identified in such analyses not only can help convince top government officials of the benefits of renewable energy, but also provides them with the analysis they need to generate both media and public endorsement for the shift to renewables and to gain support from the political opposition.

Further research also is needed to assess the maturity of renewable energy supply chains in the region to determine the potential employment and other economic benefits of strengthening domestic renewable energy markets.

4. Build capacity in research, public awareness, and the private sector

Across Central America, policymakers have a growing understanding of both international and local research and information relating to renewable energy. Nevertheless, knowledge of the socioeconomic and environmental benefits of renewable energy technologies remains somewhat disparate. Capacity-building efforts are needed to expand research, education, and training of renewable energy professionals. Public awareness campaigns are also essential to educate Central Americans about renewable options and to strengthen political support for a regional energy transition.

In the private sector, greater awareness of renewable energy potentials, technologies, and incentives is needed on the part of energy developers and investors. The capacity of banks to understand the value proposition of different renewable energy technologies needs to be improved; at the same time, renewable energy developers should have greater understanding of the information that banks need in order to approve a loan.

6.2 Recommendations to Strengthen Policies and Enable Investments

Governments need to produce legislation in a clear, consistent, and transparent manner over time—in other words, policymaking needs to be "long, loud, and legal." In some countries, frequent policy adjustments are sending the wrong signals to potential renewable energy investors.

1. Mainstream policies and goals among government agencies

Successes and challenges in the renewable energy sector are driven by policies. Designing and implementing successful energy policies requires the integration of diverse development goals that are addressed by a wide range of government agencies, including finance, education, labor, manufacturing, infrastructure, land use, trade policy, and foreign affairs. Policy mainstreaming between various departments requires a functional system of coordination between branches of government—that is, a process for inter-ministerial dialogue.

There are two primary options for mainstreaming renewable energy policy in government. The first is to create separate government agencies dedicated specifically to renewables; the second is to strengthen those branches of existing energy agencies dedicated to renewables. Because of limited public funding and the difficulty of establishing new government agencies, the former option is not presently viable for Central American countries. The region can benefit greatly, however, from strengthening the capacity and expertise of existing energy agencies, including through continued and increased funding and capacity building for branches dedicated to renewables.

Currently, nearly all existing government energy agencies in Central America have units dedicated specifically to renewables, with the exception of Belize. These units are responsible for spearheading and steering regular meetings with all relevant government agencies, creating joint understanding of goals and tools, and ensuring policy harmonization.[2] Renewable energy offices need to be responsible for assuring that new and existing incentives for renewables are properly carried out.

2. Evaluate existing policy instruments and refine the policy mix

Across Central America, countries have expressed their political will by making ambitious statements for the advancement of renewable energy. The toolbox of policies available to them—including regulatory policies, fiscal incentives, and public financing—includes mechanisms that have been successful around the world in accelerating the development of renewables. Selecting which instruments to use to advance renewables depends on each country's particular context. While most Central American countries have one or two of these policies in place, in most cases these measures are either underdeveloped or not fully implemented.

Although full policy assessments have been undertaken in some countries in the region, they are lacking entirely in others. One option for strengthening these assessments is for countries to create coordinated, multi-stakeholder initiatives that are tasked with identifying the most effective policy and regulatory reforms. These initiatives should ideally involve representatives from government, the private sector, nongovernmental organizations, and civil society. Although some Central American countries have instituted government-led commissions for new renewables, these have had less impact and occur less frequently than is needed. In addition to government-sponsored studies, regulatory assessments by renewable energy industry associations in the region have identified areas for reform.[3]

Several countries have undertaken regulatory reform, offering models that could be scaled up and replicated. Nicaragua has employed a "build, operate, and transfer (BOT)" structure for renewable facilities that relieves energy investors of some project risk, and Panama has conducted successful tenders for large-scale wind energy.

Policymakers should seek advice on international best practices when developing and reforming renewable energy policies. Resources for this information include the Low-Emissions Development Strategy Global Partnership (Latin America and Caribbean Platform), the Clean Energy Solutions Center, ClimateWorks Energy Practitioners Network, and Sustainable Energy for All initiatives.[4]

No single policy mechanism is the solution; rather, the right combination of policies depends on regional and national contexts. Feed-in tariffs and quota obligations—policies responsible for the majority of installed capacity around the world—are largely lacking in the region, but government-backed tendering schemes for renewables have had success in a number of countries. If properly implemented, tendering programs can expand the development of renewables and serve the role that feed-in tariffs and quota obligations otherwise would.

Electricity market structure is also a key factor in what policy mechanisms are needed. Thus far, five of seven Central American countries have privatized their electricity markets. In competitive markets that are open to private enterprise, the creation of stable, long-term contracts is critical. In such markets, tendering schemes associated with fixed and long-term contracts can be an effective way to spur cost-competitive renewable energy development. On the other hand, in vertically integrated markets that are dominated by a single generator, quota obligations can break the resistance to new renewable energy capacity.

3. Streamline administrative processes

In those Central American countries where support policies for renewable energy exist, the length, unpredictability, and complexity of administrative processes often hampers their full effectiveness. Complicated and non-transparent permitting processes for new renewable installations are time consuming, costly, and thus unattractive for both investors and project developers.

The streamlining of bureaucratic procedures is often complicated by a lack of capacity in lead institutions as well as the involvement of multiple agencies. In addition to reducing the overall stages for project permitting, a "one-window stop" for project developers can be a useful tool for making project approval less time-consuming, more accountable, and less costly. Such windows increase the rate of successful project implementation through active collaboration between the private sector and responsible governmental agencies, and greatly increase the attractiveness of new renewable energy investments.

4. Establish metrics for progress

Costa Rica's goal of supplying 100 percent of its electricity from renewables by 2021 and Nicaragua's goal of 94 percent renewable generation by 2017 establishes these countries as aspiring leaders of sustainable development. Yet it remains unclear whether the existing legal and financial frameworks are adequate to achieve these targets. To track progress toward these targets, periodic monitoring, evaluation, and review of support policies are needed; to enable such tracking, progress toward climate and energy goals needs to be "measurable, reportable, and verifiable" (MRV).

Although Central American countries do not yet take part in the international MRV process for receiving climate finance, the MRV requirement is a prerequisite for receiving credit for climate action through the United Nations climate regime under the 2009 Copenhagen Accord.[5] MRV is also a prerequisite for receiving additional financial support for Nationally Appropriate Mitigation Actions (NAMAs) under the Global Environment Facility and other international and bilateral support mechanisms.

6.3 Conclusion

The above areas for improvement are key components of what is needed to help Central America realize a sustainable energy system. The region is already a world leader in geothermal and hydro electricity. Its non-hydro renewable generation share of 13 percent is impressive when compared to the global average of only 5 percent. The region has turned to locally generated renewables both by necessity due to the lack of significant domestic fossil fuel resources, and as a result of political will that led to early policies and investment in clean energy.

The urgent challenge for the region now is to avoid locking in economically, socially, and environmentally costly fossil fuels for decades to come. With new thermal power plants already under construction, the ongoing rise in fossil fuel imports will likely continue. Central American countries are purportedly pursuing these options in the interest of economic development needs, but, as this report shows and future research will confirm, renewable technologies are often the more affordable solution when costs are assessed over the whole life cycle of new installations. If the full societal costs are taken into account, the price advantage grows even larger.

Accounting for only 0.16 percent of global carbon emissions, Central America's annual contribution to climate change is miniscule compared to the world's largest emitters; however, the recent announcement by climate scientists that the Earth's atmosphere has crossed the 400 parts per million threshold reinforces the need for all countries to participate in climate protection efforts. Renewable energy technologies have an enormous advantage over conventional, centralized energy systems in that they can help countries to both mitigate climate change as well as adapt to changing climate patterns and more-extreme weather events. Renewables are thus an important component of "climate-compatible development."

Central American communities are demanding the advantages provided by clean energy: access to clean energy for rural communities; greater energy security and reduced dependence on imported fuels; opportunities for green growth in local economies; job creation and increased local ownership; and reduced local environmental and social impacts.

The status assessment, best-practice highlights, and gap analysis summarized in this report provide decision makers with lessons learned from the ongoing efforts to support renewable energy in Central America, as well as with key insights into remaining barriers that need to be addressed. The lack of coordinated strategies at the country and regional levels, the underdevelopment of concrete support mechanisms, and the ineffectiveness in policy administration all continue to impede the rapid adoption of clean energy that is needed. Thankfully, these shortcomings can be overcome through measures and reforms that have proven to be successful within the region and around the world.

Detailed energy roadmaps are needed to assess the technical, socioeconomic, finance, and political

challenges faced by each country, and to identify enabling policies and measures to promote sustainable energy development. Only the collaborative effort of governments, the private sector, and civil society to build and implement effective policies and to scale up market solutions will result in the timely deployment of renewables in the face of competition from well-established conventional energy sources. The promising examples of political follow-through, innovative entrepreneurship, and public participation documented in this report should serve as a guide for future efforts to advance and accelerate the sustainable energy transition already under way in Central America.

Endnotes

1. Developing a Regional Renewable Energy Roadmap

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The Way Forward for Renewable Energy in Central America

Central America stands at an energy crossroads. The seven countries of the region—Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama—rely on ever-growing use of fossil fuels for transportation and electricity generation, while fuel wood, used primarily for cooking, is consumed at unsustainably high rates. The result is rising greenhouse gas emissions, worsening air and water pollution, and major health and societal costs. Will the region continue down this damaging path, or will these countries choose clean energy futures?

Central America is already a world leader in hydropower and geothermal energy production. But truly revolutionizing the region's national energy sectors will require not only the continued—and sustainable—expansion of these energy sources, but also harnessing the region's largely underdeveloped solar, wind, and biomass resources, coupled with the deployment of energy efficiency and smart transmission, distribution, and storage technologies. To achieve their full clean energy potential, Central American countries will have to assess and document their renewables endowment, communicate broadly the potential of these assets, and create the necessary financial and political mechanisms for supporting them.

This report identifies important knowledge and information gaps in the development of renewable energy in Central America; evaluates key finance and policy barriers; and charts the course for a climate-compatible energy development path that fosters a socially, economically, and environmentally sustainable future for the region.

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