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Renewable Energy Sector in Central America

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Acronyms

ALIDES	Alliance for Sustainable Development
BAU	Business as usual
CA	Central America
CAIT	Climate Analysis Indicators Tool
CDMER	MER's Steering Committee
CNE	National Energy Council of El Salvador
CNEE	National Electric Power Commission, Guatemala
CRIE	Regional Commission for Electricity Interconnection
ECLAC	Economic Commission for Latin America and the Caribbean
EES	Sustainable Energy Strategy
EOR	Regional Operating Agency
EPR	Network Owner Company
ESCOs	Energy Service Companies
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gases
ICE	Costa Rican Institute of Electricity
IRENA	International Renewable Energy Agency
LULUCF	Land use, land-use change, and forestry
MCR	Regional Contract Market
MEM	Ministry of Energy and Mines of Guatemala
MER	Central America Regional Power Market
MINAE	Ministry of Environment and Energy
MWh	Megawatt-hour
NDCs	Nationally Determined Contributions
NAMA	Nationally Appropriate Mitigation Actions
OLADE	Latin American Energy Organization
RE	Renewable Energy
R&D+I	Research, development, and innovation
RMER	Regulation of the Regional Electricity Market
RMER-PDC	Regulation of the Regional Electricity Market and its Supplementary Detail Procedure
RTMER	Transitional Regulations of the MER
RTR	Regional Transmission Network
SER	Regional Electricity System
SICA	Central American Integration System
SIEPAC	Central American Electrical Interconnection System
SOs/MOs	System Operators/Market Operators
TA	Technical Assistant
WRI	World Resources Institute

Executive Summary

Objectives of this Study

The purpose of this study is to analyze the Central American Renewable Energy (RE) market sector, its structure, current situation, trends, regulations, and sustainability, to provide recommendations for action for the EU and European Stakeholders. The study compiles information from secondary credible sources and virtual meetings with key stakeholders in this sector. Secondary sources offering recent data were used to make a structural and regulatory analysis of the national and regional electricity markets and the role of renewable energies in them. A prospective analysis of segments and subsectors with the best investment and commercial potential follows, based on current trends and the opinion of the consulted stakeholders.

General Overview of the RE Sector in Central America

The Central American region comprises an area of 522,760 km². The current report includes six countries: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. The region reached an aggregate Gross Domestic Product (GDP) of USD 254,9 billion in 2020 and its population reached 50.6 million inhabitants by the same year.

There are two types of electricity markets in Central American: the national markets, and the regional market. The last one is frequently called the MER (Regional Electricity Market, by its acronym in Spanish). When comparing total international transactions volume against total regional generation in the same year, MER only represents a mere 4.11% of the total, highly concentrated between Guatemala and El Salvador. There are several technical bottlenecks for a larger utilization of the MER; but the most significant barrier is the impossibility to use it for medium and long-term contracts, given the current regulations. This has caused the decision of Guatemala to leave the MER by 2031 according to the norms of the treaty..

As for 2020, there are 18,508 MW of installed generation capacity in the region, while power generation reached 51,521 GWh. Panama is the country with the largest installed generation capacity (4,132 MW) in the region, of which 56.8% is renewable, followed by Guatemala (4,110 MW installed, 69.5% renewable). Costa Rica has the third largest installed capacity (3,537 MW) but shows the largest share of renewables (86.6% of total capacity). Honduras has 2,817 MW installed (65.4% renewable), followed by El Salvador with 2,312 MW installed (66.6% renewable), and finally Nicaragua with 1,600 MW installed (45.6% renewable).

The largest national electricity market is Costa Rica (11,534 GWh in 2020), followed by Guatemala (11,122 GWh), Panama (10,721 GWh), Honduras (9,000 GWh), El Salvador (5,811 GWh), and Nicaragua (3,333 GWh). Maximum demand varies from 689 MW in Nicaragua to 1,969 MW in Panama. The electricity grid coverage of the population ranges from 83.1% in Honduras, to 99.4% in Costa Rica.

Regarding energy generation technologies, hydroelectricity has the largest share in the largest markets: 65.9% of total installed capacity in Costa Rica, 44.9% in Panama, and 38.4% in Guatemala. Nevertheless, in the remaining countries thermal takes the first place, while hydro takes the second or third position. Hydro represents 24.8% of total capacity on El Salvador, 29.6% in Honduras, and only 9.8% in Nicaragua. In the last country wind is over hydro, reaching 11.6% of total installed capacity.

In total, the RE and conventional technologies installed in the region amount to: Hydro (7,329 MW), Thermal (6,128 MW), Biomass (1,831 MW), Solar (1,264 MW), Wind (1,228 MW), Geothermal (708 MW), Biomass and Biogas (1,850 MW). Nevertheless, participation of the different RE technologies varies significantly from one country to other: Honduras has one of

the largest worldwide participations of solar energy in the national grids (18%), while Costa Rica only has 0.15%. The reason of this disparity is because of regulations and energy policies. Other differences are caused because of the availability of the natural resource involved: For instance, El Salvador has low availability of wind but large of geothermal and biomass. Panama has large availability of hydro but low geothermal and biomass.

Participation of private sector is affected by local policies and regulations. Private participation in the electricity market (GWh generated per year) varies from 21% in Costa Rica (2020), to 83% in Guatemala and Honduras. In other countries, the participation of private sector in total generation is 74% in El Salvador, and 94% in Panama. Nicaragua is not clear in this regard, given the lack of transparency on the real ownership of important assets in this country.

Opportunities

From the revision of the regulatory framework of the different Central American countries, it is evident that there are many features promoting renewable energies. Central America still has a significant remaining potential to increase its installed capacity in various RE technologies, both for “traditional” (such as hydro, geothermal and biomass), as well as the so-called “unconventional” (wind and solar) technologies. However, investment opportunities are currently clearer for the latter (especially for solar photovoltaics), because of continuous technological advances that have significantly reduced their cost. In addition, opportunities for distributed generation and self-consumption through solar photovoltaic are especially significant, as well as for solar water heating for the residential, agro-industrial and tourism sectors.

Since solar and wind are intermittent energy sources, the region should match them with firm-capacity solutions, like small to medium-size hydro, low enthalpy thermal, demand-side technologies, and high-capacity batteries. The last one will require the definition of sustainable solutions at the end of their life cycle. There is also a trend towards the incorporation of natural gas plants (from 300 to 500 MW each) in several countries, and a discussion on the future interconnection of Central America with neighboring countries (Mexico and Colombia).

Opportunities have been identified in: i) Small-scale solar-hydro hybrid systems (less than 10 MW) connected to the end of rural distribution networks, which are less vulnerable to the water deficit caused by climate change, ii) Bioenergy from agro-industrial waste, for thermal applications in the industry and specially by agro-industry sector in processes that require heat, iii) Low enthalpy geothermal energy (less than 150 °C), iv) Energy Efficiency technologies, especially in engines, air conditioners, compressed air, and efficient appliances, v) Green hydrogen, which raises a lot of interest but almost nothing has been done in the region (for instance, the potential utilization of the RE capacity excess in Costa Rica to produce green hydrogen and export it to the EU), vi) Smart Grid and 5G technologies.

Based on the most recent Energy Plans issued by authorities of the different countries, total additions of generation plants planned for the decade 2020-2030 amount to 6.56 GW, of which 3.76 GW would be RE (57%) and 2.80 GW thermal (43%, mainly natural gas). Of the RE share, 35% are supposed to be medium and large hydro, 26% solar, 23% wind, and 16% geothermal. However, the regional experts interviewed as part of this study agreed in that most of those Energy Plans are partially obsolete, and that solar and wind will probably take a good portion of the planned share for large hydro because of strong environmental and social opposition to the last one, its comparative higher cost and changes on availability and distribution of water flows caused by climate change.

Barriers and Challenges

There are important barriers as well, mainly caused by the persistence of monopolistic policies in Costa Rica and Honduras, outdated or unfocused stimuli, and limited technical knowledge

of new generation technologies. Several recommendations proposed by the interviewed experts to overcome these barriers were. i) Deeper consideration of demand-side technologies (e.g., smart grid¹) in energy policies and expansion plans, which traditionally focus on generation plans, ii) Promote and create incentives towards innovative and competitive business models and models based on the provision of energy services instead of ownership of energy assets, iii) Incentives and policies aimed at emerging technologies such as green hydrogen, low enthalpy geothermal, smart grids, and energy storage, iv) Higher liberalization of generation, transmission, distribution, and/or commercialization of electricity in Costa Rica, Honduras and Nicaragua, v) simplifying red type for distribution generation and self-consumption projects, including individual and mini-grid projects, vi) allow medium and long-term transactions between public and private agents in MER, vii) increase the capacity of deficient national transmission and distribution networks, viii) update of incentives and mechanisms to grant them, for new technologies like electromobility, green hydrogen, low enthalpy geothermal energy, energy storage, smart grids, RE integration with 5G technologies, and microgrids, ix) Make alliances with organized stakeholders in the energy demand-side, especially with business associations in the industrial, commercial and construction sectors, who represent an important force for energy policies change, x) Support a greater independence of regulatory bodies from central authorities (especially in Honduras and Guatemala), and of energy planning institutions, so that utilities in monopolistic markets (Costa Rica, Honduras, Nicaragua) do not control expansion plans, xi) Strengthening of independent eco-labeling for energy efficiency appliances and equipment, xii) Enhance regulations with technical specifications that promote quality and durability standards, so that price does not function as the single or most important purchase decision factor, xiii) Honduran utility financial crises should be solved through the implementation of the provisions contemplated in the General Law of the Electricity Industry, xiv) Incorporate regulations to promote greening of the construction and real estate sector, including modification to building codes, xv) Improve resilience of national distribution networks through annular configurations instead of linear, xvi) Disseminate information on new RE technologies (wind, solar, green hydrogen, distributed generation, electromobility, etc.) and EE technologies in the different economic sectors, both in the academic (technical and university education) and users' circles (final users and local financial entities), xvii) Get the support of international cooperation agencies to develop pilot projects in new technologies, with high potential to be replicated.

Recommendations for Action for the EU and European Stakeholders

Some magnitudes of investment required for prioritized market niches were estimated for the decade: a. Solar Photovoltaic connected to the grid, USD 866 MM without including distributed generation, b. Solar Thermal for water heating, around USD 200 MM, c. Wind Energy connected to the grid, USD 1,747 MM (no consideration is made to offshore wind, because of the lack of data and interest in the region), d. High-capacity deep-cycle Battery Storage (no quantitative information available), e. Hydro, especially small and medium-size plants, USD 2,800 MM, f. Low Enthalpy Geothermal (no data available), g. Bioenergy for thermal uses in the industry sector, estimated at USD 500 MM, h. Energy Efficiency technologies, with potential savings of USD 968 MM/year, but difficult to estimate the amount of investment required to achieve this savings, i) Electromobility (not calculated in this document since it corresponds to another sectoral study of the same EU cooperation

¹ Smart grid refers to the digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines is what makes the grid smart. Like the Internet, the Smart Grid will consist of controls, computers, automation, and new technologies and equipment working together, but in this case, these technologies will work with the electrical grid to respond digitally to quickly changing electric demand.

program), j) Manufacture of green hydrogen from RE sources to export to the EU and other international markets (no data available).

Regarding technology transfer and capital investment, although the Central American countries are importers of RE technologies, the technical and financial success of these projects require the continuous training of local engineers and technicians to ensure the best selection, integration, installation, operation, and maintenance. This must be accompanied by an updated regulation that guarantees the entry of RE and EE products not only based on their price, but also on quality, extended warranties, and manufacturer support. Technologies in which several stakeholders suggested a greater effort to provide knowledge transfer are green hydrogen, large energy storage in batteries, smart grid, low-enthalpy geothermal, and digital tools to integrate RE and EE measures in a single solution package.

Regarding funding, there are some venture capital funds and angel investors, but they are aimed more at the IT sector. For a later stage of business development (growth capital, or project finance), there are several mezzanine funds and European development bank funds which offer this type of financing in the region. They normally invest starting at USD 1 MM, or more. This minimum investment scale affects a good part of distributed generation and energy efficiency projects, which tend to be smaller than this threshold, especially when the sponsors are SME companies. Therefore, there is a need for more Impact Funds (risk capital type), that could invest in the execution of pilot projects in the market segments recommended in this study.

In addition to the need to provide seed capital for the most innovative initiatives, long-term capital is required to finance the scaling-up and replication of projects, as well as for the renovation and expansion of old RE installations that are reaching their useful life. The following Finance Instruments and Mechanisms can be used: i) Long-term credit lines with a green climate approach (mitigation and adaptation), offered to commercial banks and other Central American financial institutions by international development financial institutions like the IDB Group, the IFC/World Bank, the Central American Bank for Economic Integration (CABEI), the Development Bank of Latin America (CAF), and the institutions that make up the EDFI (European Development Finance Institutions); ii) Equity and Quasi-equity funds, intended to complement the equity capital contributions of project developers and share their risk. Investment modalities can include common shares, preferred shares, or subordinated debt; iii) Impact and Green Bonds, financed by development banks, cooperation agencies or international non-profit foundations; iv) Technical Assistance Facilities for financial institutions and universities in association with private guilds and companies, to develop studies and pilot projects that are scalable and replicable in the market niches that have been prioritized; v) Guarantee Funds and Parametric Weather Insurance Products aimed at mitigating the risk of generation in hydroelectric, solar or wind projects, caused by extraordinary deficits of the renewable resource; vi) Carbon Markets (national, regional, and international); vii) Increased adoption of sustainability certifications and eco-labels for buildings and energy-consumption equipment.

Updated version. This version of the document (October, 2022) contains recent changes in the RE industry. The most relevant have to do with new investments in renewables by Guatemala and Panama, as well as the push for natural gas in Panama, El Salvador and Nicaragua. In Costa Rica, the distributed generation law was signed, establishing the conditions to promote and regulate activities related to access, installation, connection, interaction and control of distributed energy resources from renewable energy sources. There is a special mention to *The Renewable Energy Roadmap for Central America (IRENEA 2022)* which provides a comprehensive pathway for the development of a sustainable and cleaner regional energy system. It explores the role of end-use sectors electrification, the

feasible expansion of renewable generation, energy efficiency solutions as well the importance of expanding the existing regional power sector integration.

1. Introduction

1.1. Background

Central America has an abundance in natural resources for producing renewable energy, an increasingly diversified matrix and a regional regulatory framework that expands market opportunities and taps on economies of scale. Over the past two decades, the region has attracted foreign investors with relative success, among them European energy firms, that have succeeded on doing business in Central America (Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, and Panama). Furthermore, technological advancements have created opportunities in several niche sectors where the region is well positioned.

1.2. Objectives

As part of a previous study carried out by AESA and EY, three priority sectors were selected, for which corresponding in-depth studies were requested. The purpose of this study is to analyze the Central American Renewable Energy (RE) market, its structure, current situation, trends, regulations, and sustainability, to provide recommendations for the EU and European Stakeholders.

1.3. Methodology

This study compiles information from trustworthy secondary sources and virtual meetings with key stakeholders in the RE sector. The recent data sets, offered by secondary sources, were used to make a structural and regulatory analysis of the national and regional electricity market along with defining the role of renewable energies within the spectra.

The report starts with a description of both the national markets and the Regional Electricity Market (MER by its acronym in Spanish). Then, it is followed by an analysis of existing regulatory and technological barriers and recommendations to achieve sustainable development of the renewable energy market in the region.

Additionally, this is followed by a prospective analysis of segments and subsectors with the greatest growth potential. This analysis is based on the current trends and the opinions of the stakeholders consulted. This group included nine experts from the financial sector (development banks and mezzanine investors), RE consultants, representatives of regulatory institutions and government agencies, private investors, and supranational organizations.

Finally, several recommendations for actions were formulated in several sections of the document.

2. Structural and Regulatory Analysis

2.1. Economic context of Central American electricity sector

The Central American region comprises an area of 522,760 km² and includes seven countries: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama. Nevertheless, because of its historic and cultural tradition Belize is frequently excluded from the group and considered a Caribbean country. For this matter, Belize is not considered.

The region reached an aggregate Gross Domestic Product (GDP) of USD 285,1 billion by 2021² and its population reached approximately 49,9 million inhabitants by the same year³. A detailed overview of each country is presented below:

Guatemala is the largest economy with the largest population on the region, though their GDP per capita is less than the region average. Almost half of the population lives below the poverty line. It is the country with the highest proportion of rural inhabitants. The country has traditionally experienced economic stability due to a combination of prudent fiscal management, inflation targeting, and a managed floating exchange rate. Low central government revenues (10 % of GDP in 2020⁴) limit capacities for public investments and restrict both the quality and coverage of basic public services, from education and health to access to water. This, in turn, perpetuates a lack of incentive in the economy for formality and tax paying.

Honduras ranks as one of the smallest economies but is second in the number of inhabitants in the Central American region. Honduras had registered the second highest economic growth rates in Central America, only behind Panama. The country has multiple strengths with the potential for a faster growth and higher shared prosperity due to, its strategic location, a growing industrial base, ongoing efforts to diversify its exports, and a young and growing population.

El Salvador is the country with the smallest geographic size on the region. Despite this, it ranks third (after Guatemala and Honduras) in terms of the number of inhabitants. Its GDP per capita is close to the Central American average. GDP growth in El Salvador reached 2.3 percent in 2019 (last year before the pandemic) but the country has been suffering from persistently low levels of economic growth. Annual GDP growth has exceeded 3 percent only twice since 2000 and averaged just 2.3 percent in recent years. The country had recently registered a moderate poverty reduction. The poverty rate (based on a USD5.5 per person per day poverty line) declined from 39 percent in 2007 to 29 percent in 2017⁵.

Nicaragua has the largest territory but its GDP per capita is the lowest in the region. It has the lowest level of electricity-service coverage at the national level. Nicaragua is still one of Latin America's least developed countries, where access to basic services is a daily challenge. Poverty - defined as living with an income below USD3.2 per person per day - is estimated to have increased from 13.5 % in 2019 to 14.7 % in 2020, pushing approximately 90,000 people into poverty. Remittances, which increased 12.1% in 2019, have supported household consumption and mitigated larger poverty increases. The pandemic had a negative impact on remittances at the start of the crisis, prompting an average decline of 3.0 % between March and April 2020. However, inflows quickly recovered, ending in an annual growth rate of 10 % for 2020.⁶

Costa Rica is one of the leading economies of Central America and its GDP per capita is one of the highest in the region. It is considered an upper middle-income country, which has shown steady economic growth over the past 25 years. This growth resulted from an outward-oriented strategy, based on the openness to foreign investment and gradual trade

² WDI, World Bank, Dec 19, 2022.

³ WDI, World Bank, Dec 19, 2022.

⁴ WDI, World Bank, Dec 19, 2022.

⁵ WDI, World Bank, Dec 19, 2022.

⁶ World Bank County Overview. Nicaragua overview: <https://www.worldbank.org/en/nicaragua/elsalvador/overview>. Last Updated: Apr 06, 2021

liberalization. Costa Rica is also a global leader for its environmental policies and accomplishments, which have helped the country build its green trademark. The pioneering Payments for Environmental Services (PES) program has been successful in promoting forest and biodiversity conservation; making Costa Rica the only tropical country in the world to have reversed deforestation. The combination of political stability, social contract and steady growth has resulted in one of the lowest poverty rates in Latin America and the Caribbean, where the proportion of the population with incomes below USD 5.5 per person per day decreased slightly from 12.9 to 10.6 percent between 2010 and 2019.⁷ Its rural population is the lowest in Central America. Finally, it has the highest electricity coverage in the region coupled with the lowest percentage of the population living below the poverty line.

Panama is the third-largest economy in the Central American region. Its economy is centered on a highly developed services sector, which represents more than 75% of the country's GDP. The Panamanian government has promoted economic growth over the past decade in large part through open market policies and by supporting free trade. Moreover, the government actively encourages foreign direct investment through tax regulation and by guaranteeing ease of business. In 2020, because of the pandemic, the World Bank announced that Panama experienced a GDP contraction of 17.9 percent after many years of steady growth, but it is projected to have a strong rebound in 2021. The rebound, coupled with support to vulnerable segments of the population through mitigation policies, is expected to reduce poverty in the post-pandemic period.

Social advances and a good economic growth in the past decade have brought Central America closer to the standards of the more advanced economies. However, they have also brought new challenges such as ensuring access to stable energy services.

In the last 20 years, the region has gone through a series of stages that have transformed its energy matrix regardless of varying conditionalities between the countries in said region. Twenty years ago, the region was highly dependent on fossil fuels. Gradually, thanks to aggressive incentive policies, the share of hydroelectricity increased rapidly, as did geothermal in the countries with the most abundance of said resource. This was followed by the introduction of wind energy. Similarly, and most recently, solar energy and efforts to implement energy efficiency actions have taken a lot of momentum. However, contemporarily natural gas is making strong inroads, and for the next few years it is expected to further entrench itself in most countries. This would likely be followed by greater presence of solar and wind, and to a lesser extent, small-scale hydroelectric plants.

Countries are beginning to address diversification efforts in electricity systems and are working to create more enabling policy and regulatory environments, adequate to the current times. The correlation between energy consumption and economic growth is well-documented, although the pandemic demonstrated a momentary decoupling between GDP growth and electricity demand growth rates. The next table shows the historical GDP growth and short-term projections for Central America countries.

⁷ World Bank Country Overview. Costa Rica overview: <https://www.worldbank.org/en/country/costarica/overview>. Last Updated: Apr 06, 2021

Table 1. Central America: Historical GDP growth (%) (2010-2019), and projections

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020 (e)	2021 (e)	2022 (e)
Guatemala	2.806	4.445	3.148	3.485	4.444	4.092	2.678	3.023	3.215	3.846	-1.500	4.500	4.001
El Salvador	2.105	3.815	2.814	2.236	1.711	2.395	2.547	2.250	2.431	2.382	-8.580	4.200	2.840
Honduras	3.731	3.836	4.129	2.792	3.058	3.840	3.893	4.843	3.697	2.651	-8.000	4.500	3.300
Nicaragua	4.410	6.317	6.496	4.927	4.785	4.792	4.563	4.631	-3.950	-3.879	-3.000	0.237	2.700
Costa Rica	5.360	4.403	4.883	2.495	3.542	3.652	4.204	4.158	2.056	2.168	-4.796	2.595	3.296
Panama	5.828	11.314	9.779	6.903	5.067	5.733	4.953	5.591	3.598	3.040	-17.949	12.045	5.000

Source: International Monetary Fund. World Economic Outlook Database, April 2021. (e) Estimation.

In 2019, 93.42% of homes had electricity service, 92.98% connected to the electricity grid, and 1.44% connected to isolated systems with renewable energies, mainly solar systems. The table 2 indicates the electricity coverage of Central American countries. From 1975 to 2019, electricity services in the Central American countries have shown substantial progress, reflecting the region's socio-economic progress and the governments' efforts to improve services. During these four decades, the installed generation capacity in the region increased from 1,664 MW to 18,370 MW, while power generation increased from 6,491 GWh to 54,076 GWh⁸.

Table 2. Electricity coverage and demand of Central American countries, 2019.

	Guatemala	Honduras	El Salvador	Nicaragua	Costa Rica	Panama	Average
Electricity Coverage (%)	91.70	85.00	97,9	97.20	99.40	93.80	93.42
Electricity Grid coverage (%)	88.60	83.10	97.60	96.20	99.40	93.00	92.98
Isolated Systems coverage (%)	3.10	1.90	0.30	1.00	n.d.	0.90	1.44
Energy Demand (GWh)	12,228	9,253	5,672	4,057	11,313	11,552	9,013

Source: CEPAL, Statistics of the electricity subsector in Central American countries (2019- 2020).

<<https://www.cepal.org/es/publicaciones/47019-estadisticas-subsector-electrico-paises-sistema-la-integracion-centroamericana>> and World Bank, <<https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=PA>>

2.2. The regional electricity markets

The MER is a wholesale market with its own regulation and governing institutions, in which authorized agents of Central American countries make international trades of electricity.

The MER's regulatory architecture is laid down in a series of legal and administrative instruments that include the Framework Treaty of the Central American Electricity Market, signed in December 1996; the First and Second Protocols to the Framework Treaty, promulgated in June 1997 and April 2007 respectively; the Regulation of the Regional Electricity Market (in Spanish: RMER), and the Regulatory Resolutions of the Regional Commission for Electricity Interconnection (in Spanish: CRIE). These instruments define the principles, rules, procedures, and mechanisms for running the MER. These instruments establish an institutional structure that includes:

- (i) The CRIE is responsible for, among other functions, regulating commercial relations between public and private institutions (agents) connected to the regional electricity system, and for establishing remuneration and pricing mechanisms for energy exchange and transmission.
- (ii) The Regional Operating Agency (EOR) is responsible for overseeing and coordinating the technical and commercial operation of energy exchanges among agents of the Central American countries. It has the role of operator and administrator of the electricity system and the regional market.

⁸ Official statistics from the Economic Commission for Latin America and the Caribbean (CEPAL) (2020) Sustainable Energy Strategy 2030 of SICA Nations.

- (iii) The Network Owner Company (EPR) is a Public-private entity responsible for building, operating, and maintaining the regional transmission framework (in Spanish SIEPAC). The EPR is integrated by the electricity companies of the member and associated countries.
- (iv) The MER's Steering Committee (CDMER) as a policy body is responsible for promoting the development of the MER and facilitating objectives fulfillment of the Framework Treaty of the Central American Electricity Market and its Protocols and coordinating the interrelation with the rest of the regional bodies CRIE and EOR.

MER operations and organization are based on the following premises⁹, although not necessarily they are fully complied in practice:

- (i) Commercial electricity transactions are carried out in the Market through opportunity exchanges resulting from a regional economic dispatch and through contracts between market agents.
- (ii) Market agents, except transmitting agents, can freely buy and sell electric power without discrimination of any kind. Additionally, the free transit of electric power through the electric grids in the member countries of the MER is guaranteed.
- (iii) Market agents may install generation plants in any of the networks of the MER member countries for the regional commercialization of the energy produced.
- (iv) Market agents have free access to regional and national transmission networks. Regional transmission is the energy transport through the high voltage networks that make up the Regional Transmission Network or RTR.
- (v) The MER is a market with its own rules, independent of the national markets of the member countries, whose transactions are carried out through the RTR infrastructure and national networks. The connection points between the MER and the national markets are the RTR nodes.

There are two types of "submarkets" in MER:

- (i) The Regional Contract Market (MCR in Spanish), is made up of contracts for the injection and withdrawal of electricity in the MER, signed between agents, together with the rules for their administration and dispatch at the regional level. There are two main types of contracts in the MER according to their supply priority. These are (i) Firm Contracts and (ii) Non-Firm Contracts (**Table 3**). Firm Contracts establish supply priority for the purchasing party.
- (ii) The Regional Opportunity Market (in Spanish MOR), is a short-term market based on daily energy injection and withdrawal offers, for each market period, in commercially enabled nodes of the regional transmission network (In Spanish RTR). Offers to the Regional Opportunity Market are informed by the System Operators / Market Operators (In Spanish OS / OM) of each member country based on the offers of their agents. The transactions in the MOR are the product of a regional pre-dispatch and of the operation in real-time and make possible the optimization of the regional dispatch.

⁹ Regulation of the Regional Electricity Market (in Spanish: RMER), version Updated to January 26, 2021

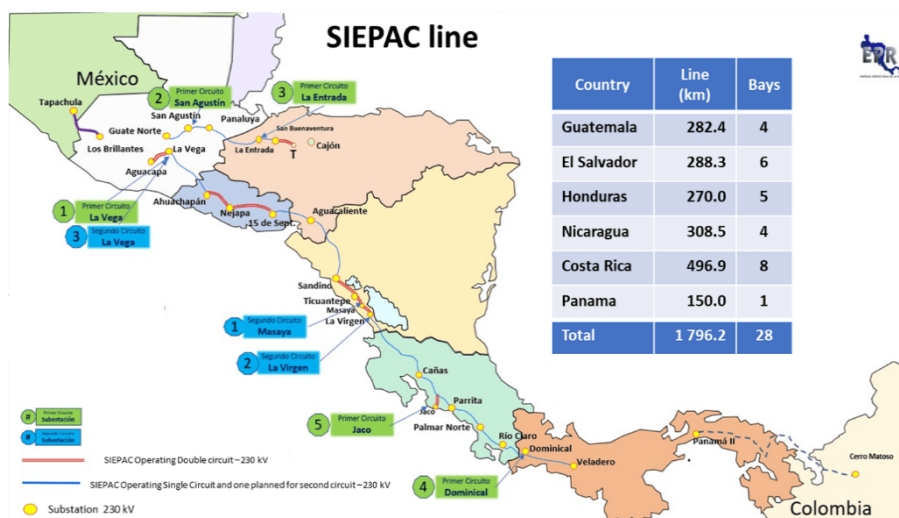
Table 3. Key aspects of MER contracts and markets

Contract Types	Description
Firm Contracts	<ul style="list-style-type: none"> The selling party agrees to sell firm energy to the buying party at the RTR withdrawal node designated in the contract. The seller can fulfill his own generation or with purchases in the Opportunity Market. The energy committed in a regional firm contract may not be engaged in a national contract.
No firm contracts	<ul style="list-style-type: none"> They are physical commitments that are made more flexible through offers to the Regional Opportunity Market, or flexibility offers, made both by the purchasing party of the contract at the withdrawal node and by the selling party at the injection node. The parties to a Flexible Physical Non-Firm Contract must make flexibility offers to the Opportunity Market for amounts of energy equal to or less than the maximum contractual commitment per market period.

Source: Regulation of the Regional Electricity Market, January 2021

The transmission network (SIEPAC) is responsibility of the Grid Owner Company (In Spanish EPR), consisting primarily of approximately 1,830 kilometers of 230 kV transmission lines with the provision (in towers) for a second future similar circuit, which are connected to 15 substations of the countries in the region, through 28 access bays. If the national transmission systems are equipped for it, the initial infrastructure allows for a reliable and safe energy transport capacity of 300 MW among the region's countries, which may be doubled when the second circuit is enabled.

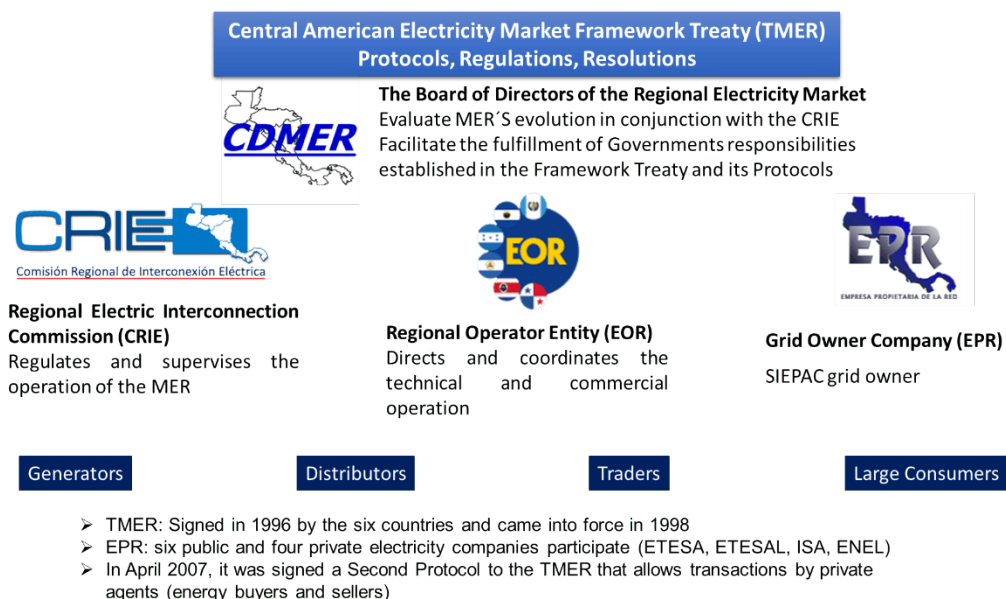
Figure 1. Distribution of transmission network per country



Source: Network Owner Company <https://www.eprsiepac.com/contenido/aperturas/>

The MER stakeholders include Generators, Distributors, Large Consumers, and Traders.

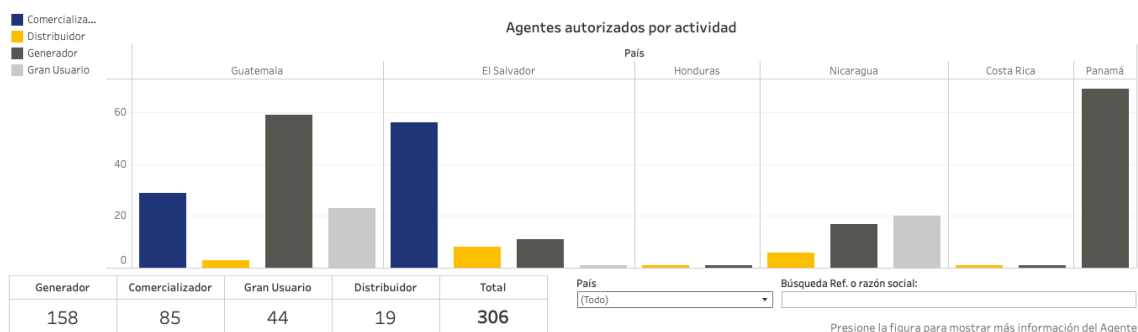
Figure 2. Stakeholders of the MER



Source: Own elaboration with information from the MER.

By 2022 the Regional Operator Entity (In Spanish EOR) has 306 agents registered with authorization to trade on the MER. **Table 4.** EOR's agents per country indicates the agents per country.

Table 4. EOR's agents per country



Source: Statical Reports 2019, 2020 of Regional Operating Agency (EOR)

Monopolistic policies in Costa Rica and Honduras are reflected in the number of authorized agents from these countries, something that is generating a lot of criticism from private investors in the RE sector of this country.

Through the MER, from 2013 until 2020, energy exports have grown from 690 GWh to 2,820 GWh (26.8% annual average), as shown in **Table 5.** Guatemala share represents 59% of energy exports, Panama 14%, El Salvador 13%, Costa Rica 12%, and Nicaragua 1%.

These transactions concentrate in Guatemala and El Salvador because of the greater convergence of the regulations of their national markets and by a long history of bilateral transactions dating back to 1986.

Table 5. Energy exports per country 2013 - 2020 (GWh)

Country	2013	2014	2015	2016	2017	2018	2019	2020	Total
Guatemala	478.40	986.40	842.60	1,110.20	1,741.10	1,798.90	1,657.10	1,066.00	9,680.70
Honduras	6.10	4.10	2.70	16.20	12.70	8.40	5.90	0.00	56.10
El Salvador	98.90	238.00	82.20	224.00	143.80	209.10	656.70	550.60	2,203.30
Nicaragua	16.20	49.00	21.50	17.90	1.00	0.20	0.20	0.00	106.00
Costa Rica	19.70	69.70	280.10	181.20	230.00	307.50	322.60	623.80	2,034.60
Panamá	71.20	98.50	139.40	397.90	318.20	327.20	431.50	580.30	2,364.20
Total	690.50	1,445.70	1,368.50	1,947.40	2,446.80	2,651.30	3,074.00	2,820.70	16,444.90

Source: Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019 -2020.- ECLAC

The energy imports have a similar trend during the same period as shows the next table. El Salvador represents 61%, Nicaragua 14%, Honduras 13%, Costa Rica 8%, Panama 3%, and Guatemala 1%.

Table 6. Energy Imports per country 2013 - 2020 (GWh)

Country	2013	2014	2015	2016	2017	2018	2019	2020	Total
Guatemala	0.00	1.40	1.90	5.20	19.20	9.70	9.50	92.10	139.00
Honduras	116.90	320.40	151.70	195.30	331.10	381.30	259.50	292.00	2,048.20
El Salvador	382.10	618.80	981.40	1,212.20	1,729.10	1,968.30	1,948.80	1,193.20	10,033.90
Nicaragua	51.90	22.30	33.50	204.80	326.60	201.10	434.40	1,070.70	2,345.30
Costa Rica	61.50	251.50	172.50	313.40	31.80	65.70	339.80	117.70	1,353.90
Panamá	75.20	189.20	17.10	30.00	6.60	14.70	96.30	97.40	526.50
Total	687.60	1,403.60	1,358.10	1,960.90	2,444.40	2,640.80	3,088.30	2,863.10	16,446.80

Source: Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019 -2020.- ECLAC

Despite all this MER legal and physical infrastructure, the participation of international transactions, compared to the total electricity generation in the region, is relatively small. In the period 2013 - 2020, the Central America countries generated 399,645.8 GWh (see next table), while the energy traded at MER only represented 4.11% of that total.

Table 7. Energy generated per country 2013 - 2020 (GWh)

Country	2013	2014	2015	2016	2017	2018	2019	2020	Total
Guatemala	9,270.50	9,780.70	6,450.10	10,877.90	11,489.90	12,522.40	12,228.20	11,122.20	83,741.90
Honduras	7,826.60	7,813.60	8,459.70	8,591.70	9,014.10	8,809.60	9,253.20	9,000.90	68,769.40
El Salvador	5,967.70	5,951.40	5,687.00	5,657.50	5,120.00	5,042.40	5,672.20	5,810.60	44,908.80
Nicaragua	3,744.60	3,999.20	4,169.00	4,150.80	4,076.90	4,185.40	4,056.70	3,333.30	31,715.90
Costa Rica	10,136.00	10,118.40	10,713.60	10,781.60	11,210.10	11,355.60	11,312.90	11,534.20	87,162.40
Panamá	8,861.90	9,196.00	10,197.50	10,775.80	10,937.80	11,104.90	11,552.50	10,721.00	83,347.40
Total	45,807.30	46,859.30	45,676.90	50,835.30	51,848.80	53,020.30	54,075.70	51,522.20	399,645.80

Source: Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019 -2020.- ECLAC

Transmission limitations in several sections of the transmission network (caused mainly by the postponement of essential transmission works of national systems) drastically reduce the possibilities of transactions with the southern countries (Costa Rica and Panama).

In recent years, at least three countries have suffered electricity supply crises, due to reduced electricity hydroelectric production or forced exits or delay in commissioning of major generating plants. This highlights the urgency for construction of the second SIEPAC circuit and the reinforcement of national transmission lines in Honduras, Nicaragua, and Panama.

More recently, the Central America Clean Energy Corridor (CECCA) - a regional initiative facilitated by International Renewable Energy (IRENA), was designed to support the penetration of a greater share of renewable energies in national electrical systems and the regional grid and promote cross-border renewable energy trade (PPA). The CECCA finished his first stage in 2019 and two key areas were identified as immediate actions, capacity building

support in network analysis software, and advisory support to improve the renewable energy investment climate.

In July 2020, the Guatemala government announced its decision to leave MER because it considers irregularities in fulfilling the treaty and its two protocols. Its exit, if it were to come to fruition, would take 10 years, according to the current agreement. Several experts interviewed consider that this decision taken by the Guatemala government is a way to press for a change in MER regulations to allow for long-term contracts and promote the completion of the transmission line and its second circuit¹⁰. The decision materialized in July 14 2021 and in the first official statement of the government, the Minister of Energy and Mines, Alberto Pimentel, said that the country believed that the regional electricity market would promote, through the exchange of energy, the development of the electricity industry in the isthmus and improve the living conditions of Central Americans, but over the years "it has become evident that the intentions initial of the Treaty and its protocols, are far from being realized".

Regarding other regional agreements, in February 2021 the International Energy Agency (IEA) and the Central American Integration System (SICA) signed a Memorandum of Understanding (MoU) to promote clean energy transitions in Central America. They will cooperate on energy data and statistics, energy efficiency and climate resilience of electricity systems as key areas for energy transitions and climate change mitigation in the region under SICA's Central American 2030 Sustainable Energy Strategy.

With the support of the Austrian Development Agency and the United Nations Industrial Development Organization, the Council of Ministers of Energy of Central America established the Centre on Renewable Energy and Energy Efficiency of SICA countries - SICREEE. Its objective is to contribute to the promotion of RE&EE at the regional level for the implementation of transformative projects at industrial, commercial, services and residential sector; that support the innovative technologies markets. SICREEE started operations in July 2021.

Box 1. Recent developments in the Regional Electricity Market, 2022

Central America's installed power generation capacity is expected to increase 1,195MW by January 2023, according to regional grid SIPEAC operator EOR. The forecast additions correspond to 26 projects in construction based on national expansion plans and information supplied by stakeholders, EOR said in its 2021-22 planning report. The bulk of capacity will come from natural gas-fired plants (680MW), followed by solar (217.6MW), hydro (201.4MW), wind (66MW) and bunker (30MW). The gas-to-power projects are Energía del Pacífico's 380MW complex in El Salvador and New Fortress Energy's 300MW undertaking in Nicaragua, both penciled in to come online in 2022. Among the larger plants scheduled to enter service, are hydros Patuca III (104MW) in Honduras and 3 de Febrero (65.7MW) in El Salvador, and Panama wind farm Toabre (66MW).

The region's available installed generation capacity in December stood at 18,122.5MW, of which 41% was hydro, 26.5% thermo, 6.9% wind, 6.9% biomass, 6.3% solar and 3.1% geothermal.

The outlook projects that hydro will cover 55% of Central America's demand, thermo 23%, wind and solar 12%, geothermal 8% and 2% from Mexico via Guatemala. Regarding electricity use, the grid

¹⁰ Detailed info on the Guatemala's Government <https://mem.gob.gt/blog/guatemala-denuncia-el-tratado-marco-del-mer-y-sus-dos-protocolos/> and CRIE's Press Release <https://crie.org.gt/wp-content/uploads/2021/07/Comunicado-de-Prensa-CRIE-22-de-julio-2021.pdf>

operator estimates that regional demand this year will grow 5.6% to 55,397GWh and 3.8% in 2022 to 57,524GWh.

Central America power interconnection commission CRIE has rejected several expansion projects contained in planning reports submitted by the region's power grid operator EOR.

There is a "high probability" that member countries and electricity producers will reevaluate investment projects due to COVID-19 that may lead to postponements or cancellations, according to an analysis from the regulator.

In addition, power sector agents identified as beneficiaries of the planned works have not expressed interest in assuming the cost of the infrastructure, adds CRIE.

The watchdog also points to inconsistencies, such as expansions that would be carried out in groups that are technically codependent and would therefore be impacted if one component was not implemented.

Source: EOR 2022

Box 2. Renewable Energy Roadmap for Central America (IRENA,2022)

The *Renewable Energy Roadmap for Central America* provides a comprehensive pathway for the development of a sustainable and cleaner regional energy system. It explores the role of end-use sectors electrification, the feasible expansion of renewable generation, energy efficiency solutions as well as the importance of expanding the existing regional power sector integration. Specific sector technological pathways and investment opportunities and tailor actions are important outcomes that will enrich the regional debate and help accelerate the energy transformation. The main areas of action that were identified and that are further explored in the report are:

- *Renewables expansion in electricity generation*
- *Interconnection expansion*
- *Sustainable mobility adoption*
- *Fostering of modern cooking technologies*
- *Promotion of energy efficiency*

According to the roadmap, Central America is entering a crucial decade for shaping its future energy system and is strongly engaged in the energy transition. Although the contribution by the Central American countries to the global CO₂ emissions in 2018 was just of 0.2%, the region still expects to experience climate change adverse effects such as shifts in precipitation patterns and average temperature rise. Providing universal access to electricity and clean cooking technologies are key challenges that the region is facing. Its growing population and economic progress will drive an increase in energy demand in the coming decades. Energy security and fossil import dependence mitigation will be crucial in the context of energy prices volatility and global CO₂ pricing discussions. The region has a unique opportunity to develop a sustainable energy system based on renewable energy resources that can help socioeconomic recovery from the recession caused by the COVID-19 pandemic, address climate change mitigation and adaptation strategies, while accomplishing energy security, universalisation and affordability goals.

Source: IRENA 2022

Box 3. Main conclusions: Renewable Energy Roadmap for Central America

With an integrated energy transition planning approach, the roadmap has a special focus on evaluating renewable energy technology options in the power and end-use sectors. It serves as an input for government policy makers and stakeholders to update or define their energy planning and Nationally Determined Contribution strategies, as well as inputs for local infrastructure plans and investment packages. Main conclusions are:

- a) Attracting the investment needed to decarbonise the region's energy system can foster national economies and support both COVID-19 recovery and climate resilience.
- b) Integrated regional planning for the energy transition is key, linking energy policy with climate policy and country commitments.
- c) The energy transition in Central America must focus on transforming the transport sector together with the power sector.
- d) Scaling up the annual deployment of renewables in the region three-fold (by around 1.4 gigawatts (GW) per year) compared to planned deployment is required in order to increase the renewable energy capacity share from 67% in 2018 to nearly 75% by 2030 and more than 90% by 2050.
- e) This installation of 59 GW of renewable energy could help decrease total power system costs by 7% per unit of electricity delivered between 2018 and 2050.
- f) Regional power system integration could then be fostered and improved to further exploit a total renewable energy potential of around 180 GW.
- g) Electrification in the transport sector would be crucial, covering 77% of the passenger fleet and 53% of the cargo fleet by 2050, as part of mitigation policies to decrease sector-related emissions.

Source: IRENA 2022

2.3. The national electricity markets

The following table describes the type of stakeholders participating in the electricity markets of each Central America Country.

Table 8. Electricity Market Key Stakeholders by country

Country	Guatemala	Honduras	El Salvador	Nicaragua	Costa Rica	Panama
Market Electricity	Wholesale	Monopoly	Wholesale	Wholesale	Monopoly	Wholesale
Electricity Sector Authority	Ministry of Energy and Mines (MEM) General Directorate of Energy	Secretariat of Energy General Directorate of Electricity and Markets	El Salvador National Energy Council (CNE)	Ministry of Energy and Mines (MEM) Electricity Market and Renewable Resources General Directorate	Ministry of Energy and Mines (MINAE) Energy Directorate	National Secretariat of Energy
Market operator and administrator	Wholesale Market Administrator (AMM)	National Electrical Energy Company (ENEE)	Transaction Unit (UT)	National Dispatch Center (CNDC)	Energy Control National Center (CENCE)	National Dispatch Center (CND-ETESA)
Electricity Sector Regulatory Entity	National Electric Power Commission (CNEE)	Electric Power Regulatory Commission (CREE)	Electricity and Telecommunications General Superintendence (SIGET)	Nicaraguan Electricity Institute (INE)	Public Services Regulatory Authority (ARESEP)	Public Services National Authority (ASEP)
Public Electric Companies	Electric Power Generation Company (EGEE-INDE)	National Electrical Energy Company (ENEE)	The River Lempa Hydroelectric Executive commission (CEL)	Nicaraguan Electricity Company (ENEL)	Costa Rican Electricity Institute (ICE) + 3	EGESA, ACP
Private Electric Companies	41	81	22	26	32	59
Transmission Companies	(ETCEE-INDE) (TRELEC) (Duke Energy)	National Electrical Energy Company (ENEE)	El Salvador Transmission Company (ETESAL)	National Electric Transmission Company (ENATREL)	Costa Rican Electricity Institute (ICE)	Electric Transmission Company (ETESA)
Distribution Companies	EEGESA DEORSA - DEOCSA 16 Municipal Companies	National Electrical Energy Company (ENEE)	AES Group, DELSUR, EDESAL, ABRUZZO, B&D	ENEL + 12	ICE + 7	ENSA EDEMET EDECHI
Trading companies	Electric Power Trading Company (ECO-ENDE)	National Electrical Energy Company (ENEE)	29	---	---	---

Source: Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019 -2020.- ECLAC;

<https://www.cnee.gob.gt/wp/generadores/>; <https://www.cree.gob.hn/registro-publico-de-empresas-del-sector-electrico/>; http://www.mem.gob.ni/?page_id=1445; <https://apps.grupoice.com/CenceWeb/CenceDescargaArchivos.jsf?init=true&categoria=1&codigoTipoArchivo=1001>; <https://www.cnd.com.pa/index.php/mercado-electrico/acerca-del-mercado-electrico/tipos-de-participantes>.

The total installed power capacity in the region in 2019 was 18,370 MW (Table 9), renewable energies representing 66%, and 34% corresponding to conventional thermal plants. Total generation amounted to 54,076 GWh (Table 10). 66% of the energy was produced with renewable technologies and 34% with conventional thermal energy.

Table 9. Installed capacity per county (MW) 2019

Installed Capacity (MW) 2019	Guatemala	Honduras	El Salvador	Nicaragua	Costa Rica	Panamá	Total
Hydro	1,574.50	725.90	575.30	157.42	2,343.17	1,819.30	7,195.59
Thermal	1,254.30	983.10	757.10	870.70	474.11	1,828.50	6,167.81
Geothermal	49.20	35.00	204.40	153.24	261.86		703.70
Wind	107.40	235.00	-	186.20	410.92	270.00	1,209.52
Solar	92.50	510.80	406.33	14.00	5.40	198.90	1,227.93
Biomass	1,024.90	-	307.60	-	71.00	-	1,403.50
Biogas	5.90	223.10	6.90	218.20		8.10	462.20
TOTAL	4,108.70	2,712.90	2,257.63	1,599.76	3,566.45	4,124.80	18,370.24
Public Installed Capacity (MW)	525.80	487.50	552.70	255.92	2,867.70	222.00	4,911.62
Private installed capacity (MW)	3,582.80	2,226.60	1,705.30	1,363.81	698.70	3,902.70	13,479.91
Renewable Installed Capacity (MW)	2,854.30	1,731.00	1,500.90	738.60	3,092.30	2,296.20	12,213.30
Non-Renewable Installed Capacity (MW)	1,254.30	983.10	757.10	881.13	474.10	1,828.50	6,178.23
Maximum demand (MW)	1,785.40	1,639.40	1,044.00	717.50	1,715.80	1,961.00	8,863.10
Annual gross generation (GWh)	12,228.20	9,253.30	5,672.10	4,056.70	11,312.90	11,552.50	54,075.70

Source: Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019 -2020.- ECLAC

Table 10. Power generated by country (GWh) 2019

Source	Guatemala	Honduras	El Salvador	Nicaragua	Costa Rica	Panama	Total
Hydro	4,381.10	2,405.20	1,522.40	222.80	7,826.70	5,096.30	21,454.50
Geothermal	262.10	295.90	1,372.80	703.10	1,512.60		4,146.50
Wind	330.80	818.30		716.20	1,796.30	724.60	4,386.20
Biomass	1,861.00	456.50	548.20	546.70	72.10		3,484.50
Solar	233.40	1,115.50	488.10	24.20	9.60	294.80	2,165.60
Biogas	24.70		29.10		0.00	20.30	74.10
Thermal	5,135.10	4,161.80	1,711.60	1,843.70	95.60	5,416.50	18,364.30
Total	12,228.20	9,253.20	5,672.20	4,056.70	11,312.90	11,552.50	54,075.70
Renewable	7,093.10	5,091.50	3,960.50	2,213.10	11,217.20	6,136.00	35,711.40
Non-Renewable	5,135.10	4,161.80	1,711.60	1,843.70	95.60	5,416.50	18,364.30
Public	1,510.30	1,645.30	1,441.60	152.50	8,590.50	677.00	14,017.20
Private	10,717.90	7,608.00	4,230.50	3,904.30	2,722.30	10,875.60	40,058.60
Wholesale			5,289.70				5,289.70
Retail			382.40				382.40

Source: Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019 -2020.- ECLAC

Further detail on the historical evolution of installed capacity by source per country is presented in Annex 1. The following table shows the full potential of renewable energy sources in Central American countries, identified by type of renewable source, and the estimated percentage of current utilization.

Table 11. Power potential of RE sources identified in each Central American country and utilization rate

Technology	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama	Total
Hydro potential, MW	5 000	2 165	5 000	1 760	6 500	2 341	22 766
Actual	1 575	575	726	157	2 343	1 819	7 195
% Utilization	31,5%	26,6%	14,5%	8,9%	36,0%	77,7%	31,6%
Geothermal potential, MW	1000	333	120	1200	865	40	3 558
Actual	49	204	35	153	262	0	703
% Utilization	4,9%	61,3%	29,2%	12,8%	30,3%	0,0%	19,8%
Biomass potential, MW	N/A	N/A	52	700	635	20	1 407
Actual	1025	308	N/A	N/A	71	N/A	1 404
% Utilization	N/A	N/A	N/A	N/A	11,2%	N/A	N/A
Wind potential, MW	400	50	200	600	600	400	2 250
Actual	107	0	235	186	411	270	1 209
% Utilization	26,8%	0,0%	117,5%	31,0%	68,5%	67,5%	53,7%

Source: Data on potential obtained from ARECA/BCIE, Análisis del Mercado de Energía Renovable, 2009. Adjusted and complemented with other sources from GreenLAC. Data on actual utilization (2019) from Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019 -2020.- ECLAC.

3. Renewable Energy Regulatory and Technical Barriers

3.1. Identification of specific regulatory and technical barriers for RE

From the revision of the regulatory framework of the different Central American countries, it is evident that there are many features promoting renewable energies. Nevertheless, there are important barriers as well, mainly caused by the persistence of certain monopolistic policies (especially in Costa Rica, Honduras, and Nicaragua), outdated or unfocused stimuli, and limited technical knowledge of new generation technologies. These regulatory and technical barriers were validated with a round of interviews to experts, as described later in this report.

Annex 4 presents specific barriers for each country; the following is a summary of these:

- **Energy policies and expansion plans** are focused on the supply side. They include the use of renewable energies and fossil fuels such as natural gas. They are lacking details regarding plans for distributed generation connected to the distribution network (except for Costa Rica and Panama, who have taken steps ahead in this regard).
- **The regulations** for the use of renewable energies do not favor innovative and competitive business models (ways of spreading risk and overcoming financial barriers to investing in renewable energy and energy efficiency projects, and models based on the provision of energy services instead of ownership of energy assets). There are no regulations and policies aimed at emerging technologies such as green hydrogen, low enthalpy geothermal, smart grids, and energy storage.
- **Electromobility and Battery Storage.** There are not enough regulations and technical support in the region to detonate electromobility. Only Costa Rica and Panama are developing pilot projects for public transportation.
- **Distributed generation** regulations are complex (especially in Costa Rica) regarding maximum project capacities, circuit capacity limits, operating licenses, environmental considerations, and other issues. Self-producers having surpluses are not paid for the energy injected into the local grid (Guatemala and Costa Rica). Therefore, there is significant potential power (especially solar roofs) that cannot be economically utilized. The allowed volume of self-generated energy connected to the distribution grid has a limit that is not always very clear. These technical and regulatory limitations prevent the development of mini grids in small rural communities and in urban business conglomerates; for example, in industrial parks and free zones, which is a well-developed sector in Central America. They have a captive demand, economic resources to invest, and plenty of roof space available for solar generation.
- The **regional electricity market (MER)** does not contemplate medium and long-term transactions between public and private agents. It only serves the spot market. This limits the planning of investments in RE projects aimed at that market, and alienates potential funders who, if it were not for that, would be willing to place resources in this sector. Besides this, there are technical barriers in MER. The original capacity of the distribution network is 300 MW; however, part of the infrastructure of the first circuit is not finished, and it is already in need of a second circuit that has been delayed for many years. The recent announcement from Guatemala's government that they are planning to exit MER, is clear indication that MER regulations must be updated and improved.
- **Low enthalpy Geothermal.** There are no regulations and incentives for the use of low enthalpy geothermal potential, yet efforts have been made by European agencies such as GIZ to detonate this market with the support of SICA. There are not enough technical studies to define its potential, but it is assumed to be significant given the volcanic formations that exist in the region, along with the historical experience with high enthalpy. Prospective studies will require significant investments because there is not enough knowledge about commercial and industrial applications.
- **Monopolistic Policies,** for generation, transmission, distribution, and/or commercialization of electricity in Costa Rica, Honduras, and Nicaragua.
 - In Costa Rica, the Costa Rican Institute of Electricity (ICE) is a public company that holds a monopoly over most generation capacity (85% in practice), controls several

natural resources (like geothermal), electricity transmission, distribution, transactions in the MER, dispatch priorities, requirements for distributed generation, and most of the radio spectrum bands required for the deployment of 5G networks (inextricably linked to smart grid and smart city technologies). ICE and its subsidiary CNFL are the only entities that can purchase and sell electricity, except for some relatively small allowances to a few municipalities and rural electrification cooperatives.

- Honduras. Since 2014, the General Law of the Electricity Industry indicated that the national electric power company (ENEE) must separate into three segments, generation, transmission, and distribution; however, this has not happened yet, and ENEE continues working as an inefficient monopoly that constantly accumulates financial losses. These losses represent a tremendous burden for the country, funded with indebtedness currently reaching 27% of the national GDP. It is estimated that technical and non-technical losses (theft) of energy reach 30% of annual generation, and that ENEE frequently accumulates accounts payable to private generators that are up to one year old. According to specialized outlets (energytransition.org), "Since ENEE's losses are directly borne by the state budget, the new Castro administration's starting point must focus on making it functioning and profitable. Yet its real challenge is to find ways to rebuild the sector as a whole. The government needs to invest in much needed infrastructure that connects rural areas to the grid. It is therefore also important to win the support of international donors".
- On May 2022, the Congress of Honduras approved in record time a legislative initiative by President Xiomara Castro seeking to enable the Government to renegotiate electricity tariffs with renewable energy generators ("New Energy Law"). Although the New Energy Law was not made public in the Official Gazette at that time, it was reported that under this new legal framework, if a generator refuses to renegotiate, then the Government may take over the assets following payment of a "just compensation" with government bonds. The compensation and its valuation procedure of the New Energy Law are unclear.
- As part of the energy reform in Honduras initiated by the current government, the renegotiation processes of the Power Supply Agreements (PPAs) that the National Electric Energy Company (ENEE) has signed with the different generators around the country began in May 2022. This process was carried out hand in hand with the private sector, including the participation of the heads of the Ministry of Energy, the Ministry of Finance and a representative of the Honduran Council of Private Enterprise (COHEP). The initiative behind the renegotiation of the contracts is the result of the power granted to ENEE through the "Special Law to Guarantee the Electric Energy Service as a Public Good of National Security and a Human Right of Economic and Social Nature" approved and published in the official gazette La Gaceta through Decree 46-2022 of May 16, 2022.
- This Law, in its Article 1, establishes that the State of Honduras declares that the electric energy service is a public good of national security and also a human right of economic and social nature, therefore, it must be safeguarded as such. The State guarantees the provision of the electric energy service to the entire population and exercises its control through ENEE and operating as a regulatory entity the Comisión Reguladora de Energía Eléctrica (CREE). It also indicates the power of ENEE to renegotiate the contracts and prices at which the State, through ENEE, acquires all supplies of hydro, solar and thermal power plants.
- During the renegotiation process, it was verified that the generating companies had an integrated and uninterrupted provision of energy sales to ENEE. As a result, to date, 16 energy contracts have been renegotiated with 14 companies, 55% of the contracts were considered to have higher prices, representing a saving of approximately one billion lempiras per year for the country, according to state authorities.
- The renegotiation agreement entails, among other things, the reduction of tariffs and greater efficiency for ENEE in terms of distribution, commercialization and

transmission of energy to the entire population. Currently, several discussions are being developed for the approval of regulations that will bring benefits for the energy sector and for the State. All this with the purpose of restructuring and encouraging this sector and the subjects involved.

- The Nicaraguan government, or persons related with it, are taking control of all segments of the electricity market, through the 2020 ownership transfer / management control of Disnorte and Dissur (the two distribution entities), and of the generation segment through ALBANISA (the larger RE and thermal generator).
- **Deficiencies in capacity and efficiency of transmission and distribution networks.** To a greater or lesser extent, the national transmission and distribution networks need to be updated and improved their capabilities to provide better service reliability, meet future demands, integrate distributed generation, and create more exchanges between countries.
- **Long term electricity commercialization contracts (Power Purchase Agreements-PPAs),** are designed for dispatchable technologies such as coal, gas, diesel, and hydroelectricity, and ultimately voiding new wind and solar PV projects. In general, current policies and regulations are lacking an update on **incentives** and mechanisms to grant them, covering incentives for new technologies like electromobility, green hydrogen, low enthalpy geothermal energy, energy storage, smart grids, RE integration with 5G technologies, and microgrids, among other potential market niches. Table 12 summarizes the incentives that current regulations have for renewable energies.

Table 12. Incentives that each country established around renewable energies.

Incentive	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama
Exemption from customs duties for imports	X	X	X	X	X	X
VAT exemption	X		X	X		X
IT Exemption	X	X	X	X		
Tax exemption CERs-CDM		X		X		X
Contracting of a% of renewable energy in biddings				X		
Transmission and distribution fee exemption(first 10MW)						X
Superior ER price compared to other technologies			X			

3.2. Validation of identified barriers and potential actions to solve them

A series of interviews were conducted with relevant stakeholders in the renewable energy market in Central America. Their opinions were mainly considered in the preparation of this section of the report, as well as in section 4.4. (Validation of market opportunities). To keep the confidentiality, the opinions were summarized according to the topics addressed. Also, they are not presented individually but in aggregated way. The names and institutions of the stakeholders interviewed can be found in Annex 2.

Regulatory and Technical Barriers for further deployment of RE in Central America

- For some of the interviewees, the technical and financial barriers that exist in Central America for renewable energies are not very significant. However, the regulatory barriers currently are, especially in Costa Rica where many regulatory limits exist. To stimulate investment in projects of this type, one of the experts recommended getting advice on the Dutch or German distributed generation models.

- Another barrier encountered is the paperwork and the time it takes for the approval of the license to become an independent power generator.
- Investment in RE has increased mainly due to the perception of high electricity prices by the industrial sector. In most countries, this sector leads the consumer's pressure to get new energy policies from the governments.
- Another regulatory barrier is the existence of regulations indicating that final consumers cannot sell or even inject surplus energy into the grid.
- Low enthalpy geothermal energy production is a window of opportunity in several countries. However, adequate policies and regulations are still lacking, tailored to each country to avoid overexploitation or damages to other natural resources.
- Limitations in transmission capacity (both for MER/SIEPAC and at national levels in Honduras and Nicaragua especially). In Honduras, for example, the low transmission capacity in their substations means that transactions with Guatemala are limited, which is not a problem between Guatemala and El Salvador.
- Low participation of non-conventional RE (except for Honduras).
- Arguments that more firm-power sources (hydro, gas, geothermal) are needed to back-up a higher penetration of intermittent non-conventional RE (wind, solar), especially in Costa Rica.
- Lack of data and technical knowledge in certain technologies; some in the supply side (like low enthalpy geothermal, green hydrogen, hybrid plants, and battery storage), but especially for those in the demand side (like smart grids, mini-grids, distributed generation, battery storage, electromobility).

Potential actions to solve them:

- Make alliances with organized stakeholders in the energy demand-side, especially with business associations in the industrial, commercial and construction sectors, who represent an important force for energy policies change.
- Support a greater independence of regulatory bodies from central authorities (especially in Honduras and Guatemala), and of energy planning institutions, so that utilities in monopolistic markets (Costa Rica, Honduras, Nicaragua) do not control growth plans.
- Improving efficiency in the commercial field. The difference between the price paid to generators and the price paid by final consumers is significantly large in many countries.
- Strengthening of independent eco-labeling for energy efficiency appliances and equipment, validated in local EE labs (like the one existing in Costa Rica).
- Enhance regulations with technical specifications that promote quality and durability standards, so that price does not function as the single or most important purchase decision factor. SICA with European cooperation can develop these guidelines.
- The case of Guatemala can be a model to study, in terms of liberalization and modernization of local electricity markets, especially through the introduction of the commercialization role (besides the traditional generation, transmission and distribution roles).
- MER should be used not just for energy security purposes (spot market), but as a commercialization channel for long-term transactions (PPAs) between generators, distribution companies and large consumers located in different countries. The planned second circuit could be used for that, leaving the existing first circuit for spot transactions.
- Honduran utility financial crises should be solved through the implementation of the provisions contemplated in the General Law of the Electricity Industry. Tolerance to commercial losses, misuse, and direction of RE subsidies, lack of transparency in tenders, irregular planning and procedures have contributed to the crisis of this institution and the whole electricity sector.
- Incentives for RE generation should be updated, since market conditions have changed and new technologies are gaining momentum in the region, while current incentives correspond to the situation of two decades ago.
- Liberalization of the monopolistic policies in Costa Rica, Honduras and Nicaragua.

- Encourage and allow distributors to install their own RE plants through public-private partnerships (PPP) and sell their energy in national or regional markets.
- Incorporate regulations to promote greening of the construction and real estate sector, including modification to building codes to allow for connections and spaces in roofs for the installation of photovoltaic and thermal solar systems.
- Increase capacity of MER/SIEPAC and of deficient national transmission networks.
- Improve resilience of national distribution networks through annular configurations instead of linear.
- Disseminate information on new RE technologies (wind, solar, green hydrogen, distributed generation, electromobility, etc.) and EE technologies in the different economic sectors, both in the academic (technical and university education) and users' circles (potential users and local financial entities) to get knowledge on the advantages and importance of these technologies.
- Get the support of international cooperation agencies to develop pilot projects in new technologies, with high potential to be replicated. For instance, the potential utilization of the excess of RE capacity in some Central American countries (for instance, Costa Rica) to manufacture green hydrogen and export it to the EU.
- Create Technical Assistance Funds to support the introduction of innovative RE and EE technologies to Central America, the development of Climate Change Parametric Insurance Products to reduce risk of availability of natural resources like wind, water and sun, and training of final users and financial institutions on these matters.

Financial Barriers

The previous section made a series of recommendations on how regulatory and technical barriers can be mitigated. In the financial field there are also barriers, but they are especially concentrated in relatively small projects, which require investments of less than USD 100,000, typically those corresponding to small-scale distributed generation and energy efficiency projects. As seen later in sections 5.2 and 5.3, renewable energy generation projects do not normally face financial difficulties, as long as they have a long-term PPA, their rate is indexed to the US dollar, and use proven ER technologies. When it comes to new ER technologies, financial institutions and investors tend to doubt, so in those cases pilot projects and technical and financial risk mitigation schemes are welcome. Among these, extended guarantees from recognized manufacturers, accompanying technical assistance and training, experienced EPC¹¹ service providers, trained operators, mezzanine investors, guarantee funds, adequate insurance, etc.

3.3. Recommendations to achieve sustainable development of RE

The environmental and social considerations related to a greater deployment of the RE technologies currently existing in the region, and of the new ones that may be introduced, are the following:

- Medium and large-scale hydroelectricity suffer in Central America, as in many other parts of the world, a social rejection due to its environmental and social impacts. It has generated great controversy in Guatemala and Honduras, where environmental activists who have led the opposition to this type of project have even been assassinated. In Costa Rica, one of the most ambitious projects, PH Diquis, was abandoned precisely because of the opposition of indigenous communities. In Panama, the PH Barro Blanco faced a similar situation, although it was finally built. In Guatemala there are multiple cases. According to a source consulted, this country is one of the most dangerous in the world for human rights defenders who oppose business activity, and one of the sectors with the highest number of documented attacks is hydroelectric with 7% of cases.¹²

¹¹ Energy, Procurement and Commissioning.

¹² GUATEMALA: Derechos humanos e hidroeléctricas. Compendio de información que presentan organizaciones y comunidades a la Comisión Interamericana de Derechos Humanos. CIEDH-DESC. March 2017.

- Small-scale hydroelectricity without a reservoir (run-of-the-river) is one of those with great potential in the region, with a low level of environmental and social impact. They have had great recent development in Honduras. However, in other countries they receive little attention and are not even considered in expansion plans. They are highly vulnerable to climate change, so it is recommended to support hybrid solar-hydro projects, especially located at the end of distribution networks where energy is of poor quality.
- High enthalpy geothermal is very attractive as a firm power source. However, it has been overexploited in some places in El Salvador, and presents great limitations for its expansion in Costa Rica because most of the resource is located within protected areas. Other Central American countries may have similar challenges, although they do not receive as much attention as in Costa Rica. Further development of high enthalpy geothermal energy must be carried out in accordance with strict environmental regulations that minimize its impact.
- On the other hand, low enthalpy geothermal energy is a resource that has practically not been used in the region, and it presents much less environmental challenges because it is normally carried out in places where agricultural and industrial activity already exists, not in protected areas.
- Biomass has been used extensively by sugar mills in Central America to produce heat and electricity, which is largely injected into national electricity grids. Guatemala and El Salvador stand out, although it is also carried out in the other countries to a greater or lesser extent. This source of biomass is highly sustainable since it takes advantage of an agricultural residue. However, the availability of more sugarcane bagasse is practically nil, and the only way to increase the capacity of this technology is by incorporating wastes from other sources, such as the forestry sector (especially in Honduras) and other agricultural wastes from crops such as coffee, banana, pineapple, oil palm, etc. From an environmental point of view, the riskiest of these is forestry, because it must ensure the sustainability and legality of the wood source. In other crops, care must be taken that emissions from waste collection and transport do not exceed avoided emissions from electricity and heat generation, especially in countries where the electricity matrix is already highly renewable.
- The use of high-capacity battery banks, both to provide generation stability and to support distributed generation projects and for electromobility, should be studied considering the entire life cycle of the product. In Central America, technical knowledge and design of solutions for recycling and final disposal of battery waste is needed.
- Wind plants require more environmental impact studies and mitigation measures, mainly due to the impact on soil and biodiversity, and on birds and bats (collision, displacements produced by avoidance, barrier effect and loss of habitat). Central America has a great variety of these species and is a migration zone between North and South America. For the UK it is estimated that on average 33 birds / turbine / year die. In Navarra (Spain), figures of 3.6 to 64.3 dead birds / turbine / year were obtained. In the USA, the total mortality from this cause is estimated at half a million individuals per year. ¹³ Some mitigation measures are: Do not install turbines on migratory routes (flyways) of birds and bats, especially in the "bottlenecks" where a large number of migrants are concentrated due to certain geographical accidents, and do not block the routes of flight between nesting and feeding areas. Do not install turbines near forests, leaving a buffer zone of at least 200m. Group the turbines as much as possible to avoid the barrier effect and leave free corridors between groups of turbines. Implement procedures and technology to control the mortality of the affected species and their routes. Regarding social impact, noise and flickering considerations must be incorporated in project design, so as not to affect neighboring communities.
- In the case of solar technology, its environmental impacts are relatively small, although they can be significant when considering the life cycle of the panels, other components, and batteries (if the latter are used).

¹³ <https://www.avesargentinas.org.ar/noticia/la-energ%C3%ADa-e%C3%B3lica-las-aves-y-el-ambiente>.

4. Market Analysis and Opportunities

4.1. Decarbonization and RE commitments and targets per country

There are several commitments regarding decarbonization and climate change mitigation strategies in the region. Most of them include targets regarding the diversification of energy sources and the enhancement of renewable energy. Some of them are briefly described below:

The “Central American Sustainable Energy Strategy 2020” was published in 2007. The main objective was “to ensure the energy supply of Central America, in quality, quantity, and diversity of sources, necessary to guarantee sustainable development whilst, taking into account social equity, economic growth, governance and compatibility with the environment, under international environmental commitments” (ECLAC, 2007, p. 98). This strategy was updated in 2020, when the “Central American Sustainable Energy Strategy to 2030” was published. The strategy defines a set of regional actions to guide the sustainable development of the countries in the region, complying with the commitments of international and regional organizations, especially those related to the energy sector in the 2030 Agenda for Sustainable Development, the Paris Agreement on Climate Change, and the Alliance for Sustainable Development (ALIDES). Similarly, in its preparation, the provisions of existing economic and social integration treaties were considered, in a voluntary, gradual, complementary, and progressive manner through the Economic Integration and the coordination, harmonization, and convergence of social policies. Moreover, at the subsector level, the energy integration commitments established in the MER Framework Treaty were considered.

For better understanding, the following table shows a comparison among the goals of the mentioned strategies:

Table 13. Comparison among sustainable energy strategies

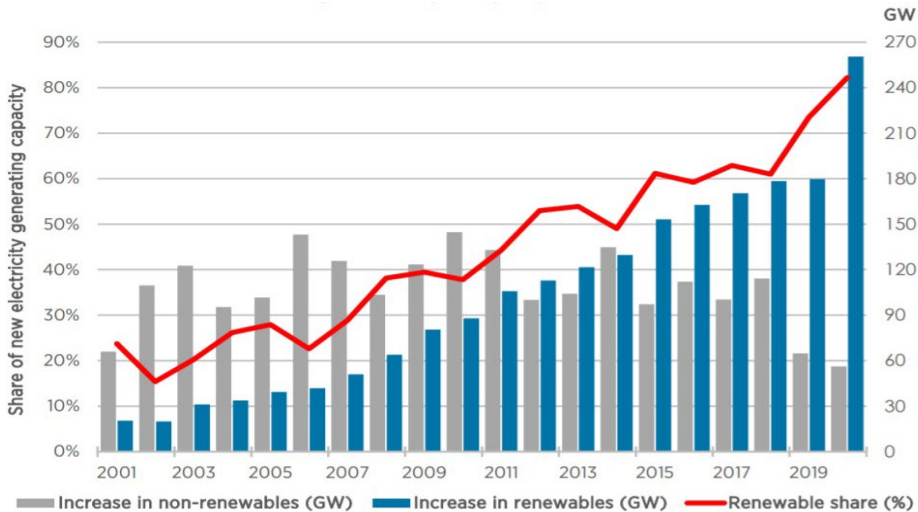
Central American Sustainable Energy Strategy 2020	Central American Sustainable Energy Strategy 2030
<ul style="list-style-type: none"> • Reduce the growth rate of the demand for petroleum derivatives (by sectors of consumption and generation of electricity). • Reduce energy dependence on imported sources, increasing the supply of renewable energy sources. • Improve efficiency and promote rational use of energy, both from the demand and supply sides. • Incorporate new technologies and less polluting energy sources. • Increase access to energy services for low-income and isolated populations. • Mitigate the effects of energy use and production on the environment. • Develop energy projects with natural resources compatible with the environment and with human settlements. 	<ul style="list-style-type: none"> • Universalize affordable, reliable, and modern energy services. • Significantly increase the share of renewable energy in the whole energy sources. Include the rational and efficient use of energy in energy plans and increase the energy efficiency improvement rate. • Diversify the energy matrix by promoting: Investment in energy infrastructure and clean technologies, and the increase in the participation of indigenous sources, especially geothermal energy, intermittent renewable sources (solar and wind), the modern use of biomass (forest residues, energy plantations, and biogas), and hydropower; and the diversification of fuels supply, favoring less polluting sources. • Promote the participation of all consumer sectors (residential, private and public sectors, municipalities, community organizations, and micro, small and medium-sized enterprises) in the use of renewable energy sources and the distributed generation of electricity. • Support the formation of energy service companies (ESCOs), which will play a fundamental role in forming the value chain and achieving the Energy Strategy 2030.

	<ul style="list-style-type: none"> • Promote the participation of women in all activities in the energy sector to disseminate efficient and clean energy technologies, manage ESCOs, and develop energy entrepreneurship. • Advance in regional electricity integration and support cooperation and complementarity in other energy subsectors, including harmonizing national markets (oil, natural gas, regulatory frameworks, and standards). • Incorporate the "SICA Energy Sector Plan to face the COVID-19 crisis" within the EES-SICA 2030 to minimize the risks to the sustainability of the countries' energy sector, derived from the health crisis of the coronavirus pandemic. • Advance in creating monitoring, reporting, and verification system of the goals established in the 2030 Energy Strategy.
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Source: SICA < https://www.sica.int/documentos/estrategia-energetica-sustentable-2030-de-los-paises-del-sica-ees-sica-2030_1_124775.html >

To provide a global context, there is an upward trend reflecting not only the rapid and increasing growth of the use of renewables, but also the declining expansion of non-renewable capacity. At the global level, the latter is also affected by the large amount of net decommissioning that has occurred for many years in some regions.

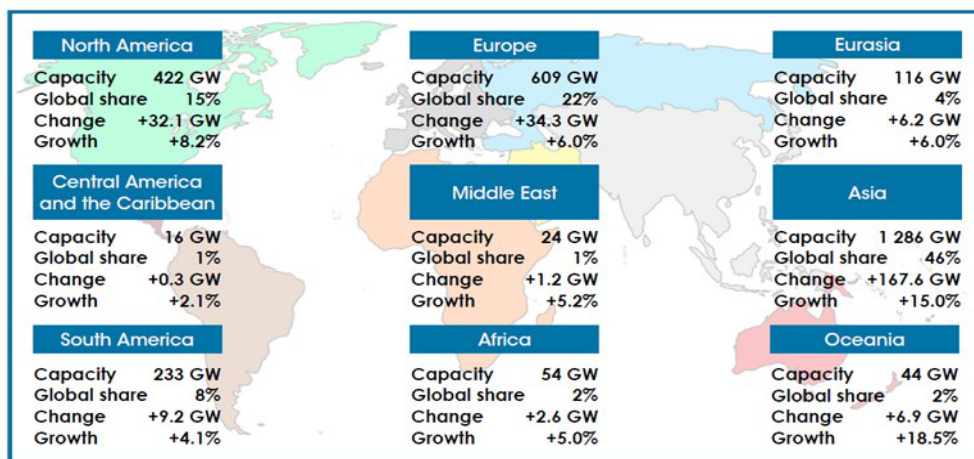
Figure 3. Renewable share of annual power capacity expansion



Source: Jeong, J. and H. Ko (2021), *Bracing for climate impact: Renewables as a climate change adaptation strategy*, International Renewable Energy Agency, Abu Dhabi.

Unfortunately, when compared with other regions, Central America is showing a very timid growth rate for renewables in recent years.

Figure 4. Renewable generation capacity by region.

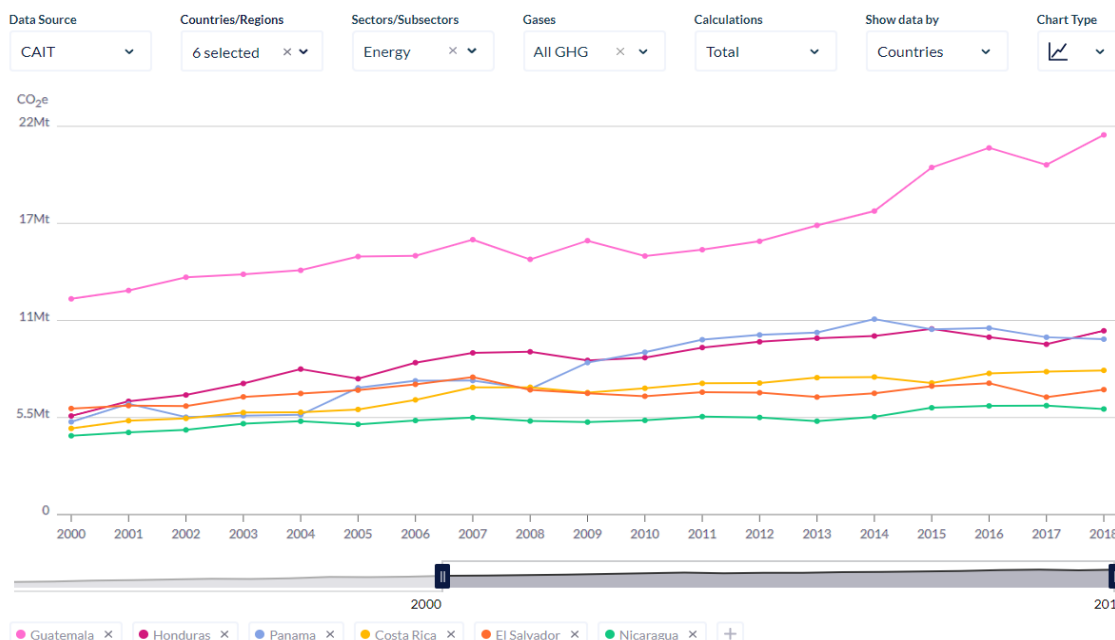


For the complete dataset see: IRENA (2021), Renewable capacity statistics 2021, available at: www.irena.org/publications.

After the ratification of the Paris Agreement, countries had the option to provide updated Nationally Determined Contributions (NDCs). All the SICA nations have proposed a series of goals in an energy transition process, based on measures that contemplate all dimensions of sustainable development. The information on the ratified mitigation measures, targets and priority sectors for adaptation of SICA countries in their NDCs is described in the Annex 3. They are aimed at facilitating access to energy for vulnerable population, making efficient use of energy, increasing the use of renewable energies, and defining an adequate strategy against climate change according to the commitments assumed in the NDCs.

The World Resources Institute’s (WRI’s) Climate Analysis Indicators Tool (CAIT) is a database of anthropogenic sources and sinks of GHGs worldwide. The next figure describes the historical GHG emissions from the energy sector of the countries under study.

Figure 5. Central America: Historical GHG emissions from the energy sector (2000-2018) per country



Source: World Resources Institute’s (WRI’s) Climate Analysis Indicators Tool (CAIT), a database of anthropogenic sources and sinks of GHGs worldwide. Energy sector emissions include those related to electricity generation, transportation, and other uses of fuel.

The current carbon emissions growth rate is especially unsustainable for Guatemala, but also significant for Honduras and Panama. Depending on policy adoption, GHG emissions from the

energy sector in the region can grow from the current 65 Mt/yr (2020) up to 115 Mt/yr in 2050 and 260 Mt/year in 2100 if no policy is implemented according with the WRI's projection.

Deloitte and Enel are analyzing different energy scenarios and proposing public policies so that countries such as Costa Rica, Guatemala and Panama meet their commitments on decarbonization. Through a study and modeling, carried out this year, the companies hope to produce a final report that will serve as a "**Roadmap for the Energy Transition**" in each market surveyed.

In the case of Guatemala, professionals in charge of this study concluded that hydroelectric and geothermal energy are "key" technologies for the decarbonization of the country. Specifically, they pointed out that there is a potential of approximately 6,000 MW of hydroelectric energy and 1,000 MW of geothermal energy in Guatemala; of which, only 23.1% and 3.5%, respectively, are used.

The Roadmap recommends the following:

- Promote a regulatory framework that facilitates the creation of PPA-type contracts based on renewable generation, thus enabling the participation of the industry in investments in renewable energy production.
- Promote the digitization of electricity networks, thus allowing a greater penetration of renewables, distributed generation, electrification of final energy uses.
- Ensure investments in new electrical networks, for a greater incorporation of renewable energies.

4.2. Segments and subsectors with the greatest potential for growth

As mentioned in the previous sections of this report, the Central American countries still have a significant remaining potential to increase their installed capacity in various renewable technologies, both traditional (such as hydro, geothermal and biomass), as well as the "unconventional" (wind and solar). However, investment opportunities are currently clearer for the latter (especially for solar photovoltaics), because of continuous technological advances that have significantly reduced their cost.

The opportunities for distributed generation and self-consumption through solar photovoltaic are especially significant. Additionally, solar technology also presents growth opportunities for water heating in the residential, agro-industrial and tourism sectors of Central America; in other words, it is an important technology on both the demand side and the supply side of energy.

To take advantage of the remaining potential of solar and wind technologies in the region, it is necessary to solve the problem of high variability and intermittency, through technologies that are complementary to them, namely:

- Implementation of intelligent transmission and distribution networks ("Smart Grid"), which allow the bidirectional flow of information and electricity. This allows, among other benefits, that homes and businesses can become small producers of electricity and not just be consumers as before.
- Base energy support with geothermal energy¹⁴, and better interconnection within Central America and with neighboring countries (Mexico and Colombia).¹⁵
- The deployment of electricity storage with high-capacity, deep-cycle batteries.
- Manufacture of green hydrogen from RE sources, for transportation or productive uses in the region or in foreign markets.

On the other hand, within the "traditional" technologies, opportunities have been identified in:

¹⁴ Low-cost natural gas plants (from 300 to 500 MW each) can also help, but pros and cons must be considered (including the results of COP26).

¹⁵ The utilization of gas should be analyzed considering pros and cons, especially now that there is an international trend to end overseas financing of oil and gas projects (COP-26).

- Small-scale solar-hydro hybrid systems (less than 10 MW) connected to the ends of the distribution networks. These are less vulnerable to the water deficit caused by climate change because they can operate both in the rainy season and in the dry season, reduce losses in the networks, improve energy quality, and reduce dependence of rural distribution companies from large nationally centralized plants.
- Bioenergy from agro-industrial waste, for thermal applications in the industry and specially by agro-industry sector in processes that require heat. Much research is also required to ensure the supply and logistics of new biomass sources, such as waste from sawmills, from agricultural crops (coffee pruning, pineapple, sugar cane, palm oil, etc), and livestock farms.
- Low enthalpy geothermal energy (less than 150 °C): Projects can be developed for industrial, agricultural, and recreational activities. Because of the volcanic formations along the Central American Pacific coast, this technology allows the direct use of soil heat to generate electricity, drying agricultural products, greenhouse production, aquaculture, absorption cooling, and swimming pool heating. Opportunities especially strong in Guatemala, El Salvador, Nicaragua, and Costa Rica.

Likewise, significant investment opportunities have been identified in the following demand-side technologies:

- Energy Efficiency, especially in engines, air conditioners, compressed air, and efficient appliances. As well as Combined Heat & Power (CHP) projects in the industry sector of those countries that are willing to introduce natural gas into their energy matrix (Panama, El Salvador and Nicaragua already doing so).
- Sustainable Transport, especially electric transport, but also with alternative energies such as hydrogen. Not only for vehicle fleets (trains, buses, trucks, and private vehicles), but also for the accompanying infrastructure (recharging stations, battery recyclers, etc).
- Deployment of 5G technologies in the region, which will make it possible to increase the efficiency of cargo and passenger transport, both public and private. For example, this technology prevents information from having to travel over long distances and enables vehicles to communicate with each other and with road infrastructure. 5G enables a diverse set of use cases and applications. With the data collection and processing power to more efficiently monitor and control city resources and transportation systems, 5G helps cities and transportation leaders provide improved services, especially in smart cities and intelligent transportation.

4.3. Market gaps and installed capacity

To be able to determine market gaps, it is convenient to first present the starting point for 2020. The following table illustrates the total current (2020) installed capacity (MW) for the different Central American countries and the different RE technologies used.

Table 14. Installed RE Capacity per Technology and Country, 2020

Installed Capacity (MW) 2020	Guatemala	Honduras	El Salvador	Nicaragua	Costa Rica	Panamá
Hydro	1,577.20	833.80	574.40	157.40	2,331.30	1,855.00
Thermal	1,252.50	974.90	771.10	870.70	474.10	1,784.90
Geothermal	49.20	39.00	204.40	153.20	261.90	-
Wind	107.40	235.00	36.00	186.20	393.50	270.00
Solar	92.50	510.80	426.90	14.00	5.40	214.10
Biomass	1,024.90	223.10	293.60	218.20	71.00	-
Biogas	5.90	-	5.50	-	-	8.10
TOTAL	4,109.60	2,816.60	2,311.90	1,599.70	3,537.20	4,132.10
Public Installed Capacity (MW)	525.80	566.50	552.70	252.10	2,872.00	204.00
Private installed capacity (MW)	3,583.80	2,250.10	1,759.20	1,347.70	665.20	3,928.10
Renewable Installed Capacity (MW)	2,857.00	1,841.70	1,540.80	729.00	3,063.10	2,347.20
Non-Renewable Installed Capacity (MW)	1,252.50	974.90	771.10	870.70	474.10	1,784.90
Maximum demand (MW)	1,787.20	1,617.60	1,010.00	689.00	1,737.70	1,969.00
Annual gross generation (GWh)	11,122.10	9,000.80	5,810.60	3,333.30	11,534.20	10,721.10

Source: Electricity Subsector Statics of the Central American Integration System (SICA) Countries 2019-2020.- ECLAC

Based on the most recent Energy Plans, issued by the authorities of the different countries, the following table shows the expansions that are projected for the main RE technologies. Note that the data is based on plans that have not been updated during the last three or four years, a period in which there have been significant changes in the market (sharp drop in demand, impact of COVID-19, continued reduction in prices of photovoltaic panels due to market oversupply, significant reduction in the prices of storage systems with batteries, etc.).

Table 15. Planned Additions per Technology and Country, 2020-2030

**Central America planned additions in new power generation plants, period 2020-2030
by technology (MW)**

Country	Hydro (MW)	Thermal (MW) *	Geothermal (MW)	Wind (MW)	Solar (MW)	Biomass/ biogas (MW)	Added Capacity (MW)	Scenarios selected from current National Energy Plans
Guatemala	200,00		369,00	330,00	130	5	1 034,00	PMMS42
Honduras	268,00	1 095,00		100,00	-	N/A	1 463,00	Scenario 3
El Salvador	65,70	730,00	106,00	90,00	250,00	N/A	1 241,70	High Scenario
Nicaragua	428	300	85	173	120	N/A	1 106,00	Reference Scenario
Costa Rica	19,00	-	61,00	90,00	150,00	N/A	320,00	Proposal
Panama	350,00	670,00	-	64,00	310,00	N/A	1 394,00	Scenario 1
Total	1 330,70	2 795,00	621,00	847,00	960,00	5,00	6 558,70	

* Includes Bunker and Natural Gas

Sources: Guatemala: Generation and transportation system expansion plan 2020-2034. PMMS42 scenario.

Costa Rica: Electricity generation expansion plan 2018-2033.

El Salvador: Indicative plan for the expansion of electricity generation in El Salvador 2019-2028. High scenario plus other non-mandatory capacity additions.

Honduras: Indicative plan for the generation expansion of the interconnected national system 2020-2029. Scenario 3.

Nicaragua: Electricity generation expansion plan 2019 - 2033. The baseline scenario was used.

Panamá: The expansion plan of the National interconnected system 2018 - 2032. Alternate scenario.

There is a strong growth planned for thermal systems, mainly natural gas, especially in Guatemala, Honduras, and El Salvador. Thermal increase is also significant in Nicaragua, considering its size proportional to that of other technologies. This, as pointed out by some of the stakeholders consulted, shows a return of the region towards fossil fuels, caused by the following factors:

- Abundance of natural gas in the international market (although all countries in the region are net importers) and its relative low cost, which Panama has already introduced.
- The increasing difficulties to develop medium-size hydroelectric projects (10-50 MW) and large-size ones (50-100 MW or more) in the region, mainly because the best sites have already been developed and because those that remain face strong environmental or social criticism (impact on protected areas, indigenous or rural communities, etc).
- The need to strongly support the increasing investments in solar and wind plants, due to their intermittent nature.
- The environmental limitations and high costs of exploration and development of high enthalpy geothermal energy since they are mainly found within or in areas close to protected areas (volcano peaks).
- The oversupply of energy experienced by some countries, such as Guatemala and Costa Rica. Thermal plants allow to acquire energy with little anticipation of its use, being able to adjust along the way.

With the sole exception of Costa Rica, the next years will see an increase in the presence of natural gas in Central America, however, recent spikes in international prices could hamper its deployment. The Ukraine conflict and the subsequent decision by many nations to reduce their reliance on Russian oil and gas has caused energy prices to soar. The upside is that this is leading to greater investment in renewable energy sources. .

Considering the information on the capacity additions planned for the 2020-2030 shown in the previous table, and the list of prioritized niches in section 4.2. of this report, some magnitudes of investment required for these niches could be estimated.

Box 4. Central America Recent natural gas-powered plants

Panama: Natural gas-powered electricity plant 670MW. \$1,000 million dollar investment. Operation will start in 2024. The project is operated by Gas Panama Energy Group, made up of the London-based firm InterEnergy Group, with a 51% stake, and the US subsidiary AES Panama, with 49%.

El Salvador: Invenergy's US\$900 million Energía del Pacífico project in Acajutla, El Salvador, is set to come online in 2022, providing 378MW of installed generation capacity to the national grid, while a new storage and regasification unit will process 280Mf3/d and store up to 137,000m3 of imported liquefied natural gas (LNG).

a.1. Solar Photovoltaic connected to the grid and for distributed generation. The expected growth according to the Energy Plans consulted, shows 960 MW of additional capacity in this decade, only to be connected to the networks (without considering distributed generation). However, if it is possible to incorporate backup energy of firm power (natural gas, as it seems to be the case, and geothermal to a lesser extent), and there are significant advances in the costs of large storage in batteries, it is possible that this figure is underestimated. There is also a lot of political pressure for new policies and regulations for distributed production, where solar technology is an important player. Therefore, it could be ensured that at least **1,000 solar MW** will be added to the Central American market throughout this period. According to data from IRENA¹⁶, updated as of 2020, the total installed costs for solar photovoltaics fluctuates depending on the specific market. The closest reference

¹⁶ IRENA (2021), Renewable Power Generation Costs in 2020, International Renewable Energy Agency, Abu Dhabi.

to Central America mentioned by IRENA is Mexico, where the total installed cost for utility-scale solar PV is USD 866/kW (residential and commercial rooftops for distributed generation would be higher because of their smaller scale). Therefore, without including distributed generation, the estimated investment in Solar PV would be **USD 866 MM**.

a.2. Thermo-solar for water heating. Information was obtained for the Costa Rican market where a strong potential is identified in the residential sector, where 50% of homes already have domestic hot water, using electricity. Apart from the migration of a part of this market towards hybrid systems (solar backed with electricity), there is potential for solar thermal installations in new homes of the medium-high and high socioeconomic groups. It is essential to reach agreements with real estate development companies, so that they consider this technology from the beginning. In the case of solar water heating technology for industries and businesses, the applications with the greatest potential are those that can provide the needs of hot water to eliminate the use of boilers for hot water and low-pressure steam, which is carried out currently on electricity or diesel. There is potential to increase the installed area from 17,580 m² (2017) to 108,707 m² (2030), with an approximate investment of USD 56.8 MM. With this reference amount, it could be assumed that the total solar thermal potential for all Central American countries could be around **USD 200 MM**.

b. Wind energy connected to the grid. The total planned capacity increment is 847 MW. Using IRENA's 2020 total installed costs figure for this technology (USD 2,062/kW in Central America and the Caribbean), this would represent **USD 1,747 MM** for this decade. No consideration is made to offshore wind, because of the lack of data and interest at this time in the region.

c. High-capacity deep-cycle battery storage. There is no quantitative information available on market potential for this technology yet. Its prioritization has been based on qualitative opinions from RE stakeholders.

d. Hydro plants. Although the Energy Plans of the different countries estimate an increase of 1,330 MW for this decade, the experts consulted believe that this figure is outdated due to the lag of these plans with respect to the reality of the market, and that surely much less capacity will be installed than what is forecasted. Medium and large hydroelectric plants, apart from the environmental and social difficulties, face lengthy study and approval processes along with great risks due to climate change. The best opportunities are for small plants (10 MW or similar size) that are often not even considered in the Energy Plans and their corresponding expansion plans. However, this technology cannot be completely ruled out when estimating the market potential, so a total of **800 MW** is assumed for this decade, which is at the total cost of installation based on IRENA references for projects in Central America and the Caribbean. (USD 3,500 / kW), implies an investment amount of **USD 2,800 MM**.

e. Low enthalpy geothermal energy. There is no data available, since it is a technology that is just starting to be considered in Central America.

f. Bioenergy plants for thermal uses in the industry sector. There is not enough information about this potential market. However, a study carried out in Costa Rica indicates a potential of USD 235 MM in this country, to finance boiler equipment in the industrial sector, biodigesters and equipment for the treatment and preparation of biomass. A conservative figure for all Central America could be **USD 500 MM**.

g. Energy efficiency technologies. To estimate the potential of this technology, information from a study conducted in 2019, sponsored by SICA and GiZ¹⁷, was used. According to this study, the potential for economic savings (by reducing electricity consumption at the prevailing electricity tariffs in the region), because of the implementation of energy efficiency

¹⁷ Potencial de Expansión de Tecnologías Eficientes en Centroamérica (2019-2030). SICA, GiZ. 2019.

technologies such as lighting, air conditioning, refrigeration, and sustainable building (average values of the decade to 2025), vis a vis “business as usual” scenario, is USD 968 MM/year. It is difficult to estimate the amount of investment corresponding to this savings, but it is obviously a very significant potential.

Box 5. Guatemala. Cement efficiency technologies

CEMEX, S.A.B. de C.V. (“CEMEX”) announced that it has signed a power purchase agreement with Enel Green Power, who will supply clean electricity for CEMEX’s cement operations in Guatemala for the next five years. The agreement reaffirms the commitment of CEMEX and the Enel Group to lead their respective industries in climate action and facilitate the transition to clean energy. The supply contract aligns with CEMEX’s ambitious Scope 2 goal to achieve 55% clean energy by 2030. The approximately 164 GWh of clean electricity supplied under this agreement is equivalent to the CO₂ emissions avoided by planting more than 240,000 trees. “This agreement with Enel Green Power will allow us to operate our cement facility in Guatemala with 100% clean electricity. Transitioning to renewable energy sources is an integral part of our climate action strategy,” said Jesús González, President of CEMEX South, Central America, and the Caribbean. “We remain committed to becoming a net-zero CO₂ company and are taking decisive steps to achieve this goal.”

h. Electromobility. Not calculated in this document since it corresponds to another sectoral study being developed simultaneously as part of the same EU cooperation program.

i. Manufacture of green hydrogen

ATOME Energy (AIM: ATOM), the only pure international green hydrogen and ammonia production company on the London Stock Exchange with current large scale projects in Europe and South America as well as hydrogen mobility projects, announced a new joint venture developing green ammonia and fertiliser projects with the focus on Central America and the Caribbean. ATOME has entered into a joint venture with Cavendish, the renewable energy arm of Grupo Purdy S.A., one of the largest corporations in Costa Rica. ATOME and Cavendish have established a new enterprise, National Ammonia Corporation S.A (“NAC”), owned equally with Cavendish and headquartered in San Jose, the capital of Costa Rica, and which has a mandate to develop projects across Central America and the Caribbean with its initial focus in Costa Rica. Through NAC, ATOME aims to capitalise on its capability to roll out its large scale hydrogen and ammonia production model now being implemented in Paraguay. In this regard, material and constructive discussions are already taking place with relevant stakeholders in the areas of focus for NAC. Investments in this area could total \$500 million.

Box 6. Costa Rica: Green Hydrogen

Draft law. First debate approved in Congress April 2021. Tax exemption for the importation of machinery and equipment and local taxes.

- *Finance with special conditions*
- *Streamlining of immigration procedures for professionals who participate on research and development, technical execution and operation of projects.*

Chaves administration is reluctant to go forward as incentives are deemed to be a fiscal burden.

“Green hydrogen for a decarbonised economy” project. Its objective **is** to induce a transformative change towards the application of hydrogen as an energy carrier and chemical input. Importantly, the hydrogen production supported by the NAMA support project (NSP) will be drawing only from renewable energy sources within Costa Rica.

The financial cooperation (FC) component is expected to include targeted incentive schemes for hydrogen production facilities and off-takers in the industrial, agricultural and transport sectors, combining commercial financing with concessional funds and grants. The technical cooperation (TC) component of the NSP will support the national government in creating enabling conditions for the production and consumption of green hydrogen and in the identification and development of business models for the deployment of hydrogen in different sectors, including the development of pilot projects. The availability of green hydrogen as well as financial instruments and an enabling policy framework will facilitate the use of green hydrogen for various - primarily domestic - applications in industry (metallurgy, cement, glass), and agriculture (sugar, coffee), helping decarbonise Costa Rica's economy.

This Project is supported by GIZ and IFC.

Panama has also launched a green hydrogen strategy, focused on transport and storage, primarily. Incentives are in the process of being published. IDB is actively supporting the strategy. The first phase of the green hydrogen roadmap was adopted on January 24th 2023¹⁸. Its main objective is the development of the regulatory political framework for the promotion of investment and implementation of activities associated with green hydrogen and other hydrogen-based energy sources. Incentives to be considered are the modification of the legal framework for hydrocarbons in Panama that include the authorization of free Zones for trade and storage of Green Hydrogen, as well as the development of "fast track" lines to encourage national and foreign investment.

The rationale for becoming an energy hub comes from the current geopolitical context. Panama is already a maritime hub, air hub, financial hub, among other areas. The potential to become an energy hub has already been identified and explored for different purposes. This same geographical position lends itself to serve as a connection between hydrogen production centers and the consumers with the highest demand.

4.4. Validation of market opportunities

Regarding main investment opportunities in renewable energy and energy efficiency markets, collected stakeholders' opinions were as follows:

Central America has one of the world's highest shares of renewable energy, due to the abundance of natural resources and the large historical development of hydropower, that stands out as distinct features of the region. Nevertheless, since 2014 no major bids have been launched for the installation of RE projects in Central America, only small individual projects have been tendered in Honduras and El Salvador in recent years.

During the last five years, the energy market in Central America has shown atypical trends. One of the most significant is the decoupling between the behavior of GDP and energy demand. While the region has seen a moderate growth in GDP, electricity demand is growing in a lesser extent. During the current pandemic, the residential sector demand experienced a growth while GDP significantly decreased.

In countries like Costa Rica and Guatemala there is an excess supply of energy, due to a very low demand resulting from the lack of greater economic growth and recent significant capacity additions that are not fully used. Since the region does not have large electricity-consuming industries either, migration to electric transport is expected to stimulate demand. Thus, the main economic barrier for the development of new RE plants connected to the grid is the low

¹⁸ https://www.gacetaoficial.gob.pa/pdfTemp/29461_A/GacetaNo_29461a_20220124.pdf

economic growth and fiscal crises in several Central American countries, which increased with the pandemic, except for the demand of the residential sector.

Several experts mentioned the global trend towards distributed generation and self-production of renewable energy, which has not really arrived in Central America because distribution companies are viewing it as a threat and not looking to develop win-win business models with final consumers. International cooperation can provide a hand in helping to define and implement these models and corresponding pilot projects. This represents a large business opportunity for distributors if they can handle it correctly.

One interviewed stakeholder, representative of one of the larger generation and distribution groups operating in the region, declared that they currently are only working on distributed generation because its strong market traction. Current business is more on distribution and self-sufficiency instead of in production.

The use of high load capacity batteries is set to grow strongly in the mid-term as it is happening in other Latin American countries such as Chile and Brazil. However, small progress has yet been made in Central America on this issue, especially regarding regulations and incorporation of their cost in tariffs, and the final disposal or recycling of batteries. This issue must be solved from the beginning by designing and enforcing legislation and technical knowledge on how to manage these batteries accordingly.

European manufacturers are regarded as reliable sources of quality RE and EE products, and especially for their capacity to integrate solutions. Unfortunately, the lack of regulations on quality and sustainability turn price the most significant parameter of selection, making Asian products more competitive. For example, China offers low prices in batteries, but it doesn't offer any further solutions, while European suppliers tend to offer turn-key solutions, long quality lifecycle, and sustainability certifications. Yet, their prices are comparatively high, even against North American suppliers. European suppliers can benefit for regional market opportunities by providing long-term funding, quality & sustainability certifications, technical assistance, personnel training, and extended warranties. They can also support the introduction of new technologies like green hydrogen, low enthalpy geothermal, and electromobility.

SICA and GIZ are promoting the development of low enthalpy geothermal energy in the Central American countries that have it available (Guatemala, El Salvador, Nicaragua, and Costa Rica to a greater extent). There are many applications that can be developed in the productive sectors, but political will, incentives and specific regulations are needed to allow and encourage them. Nevertheless, at a political and regulatory level it doesn't seem much interest yet for this technology in the region.

Electric Mobility is also very important, and many governments are interested in developing some pilot projects. SICA is supporting the migration to electromobility, and electricity distributors are seeing it as a business opportunity. However, tariffs and incentives should be designed and approved. European car manufacturers, which are rapidly migrating to electric cars, will have a good opportunity in the Central American market, given their good market share in this market. This will stimulate demand for electricity and electric stations, creating opportunities for the installation of more renewable energy plants.

In biomass there are several projects especially in sugar cane mills, but there is not much biomass available for new projects due to the lack of supply at an adequate cost. There is biogas availability for heat and electricity in large industries, however technical barriers persist.

The region has interest in small hydropower projects. Large projects however are not a viable option anymore because of the environmental and social impacts and because of the implications of climate change on water security. The greatest investment opportunities are in microgrids for small, isolated communities in Guatemala, Honduras, and Nicaragua, and for hybrid solar-hydro small projects (under 10 MW).

Eolic and solar technologies will receive the most attention, but they must be backed with firm power technologies (hydro, geothermal, natural gas) and with investments in distribution networks. This situation is conditioned by market prices, dispatch conditions and the possibility of long-term contracts and transport capacity in the MER/SIEPAC. It is necessary to make distribution investments in the most remote areas which require energy policies that support rural development.

Many experts agreed that wind and solar technologies represent better market opportunities in the region. In Guatemala, Honduras, El Salvador, Nicaragua and Panama, investments in solar plants have grown strongly in recent years. Only in Costa Rica the growth of this technology is not being promoted, due to the excess capacity installed in state plants, especially hydroelectric.

Other comments were:

- **Honduras** has open and flexible regulations for private investment. Nevertheless, the electricity sector is highly dependent and seriously affected by the difficult financial situation of the national utility.
- **Panama** has the best market potential at a macroeconomic level, which is reflected in the energy policies that aim for the national grid modernization and higher introduction of all type of RE technologies, combined with natural gas.

The Ministry of Energy of Panama launched for public consultation for 30 days starting on September 27, 2021, the National Distributed Generation Strategy (ENGED) project, considered in the Guidelines of the 2030 Energy Transition Agenda.

The strategy proposes that Distributed Generation (DG) be a determining factor in the diversification of the energy matrix using renewable sources, reducing greenhouse effect emissions, and decentralizing the electricity service in Panama.

The conservative and optimistic scenarios project that distributed generation would represent 7% and 14% of the projected generation for 2030, which means the installation of 950 and 1700 MW, respectively. The residential sector represents 58% of the technical and economic potential, and 36% corresponds to the commercial and government sectors. The final document has not been issued as of the consultation date (December 2021).¹⁹

- **El Salvador** provides market opportunities in several RE technologies, especially outstanding for solar PV, due to their policies to support investment in them, despite their financial situation.

On November 21 and three months after adopting bitcoin as a currency (September 7, 2021), Salvadorian President Nayib Bukele announced that his government will build "Bitcoin City," almost tax-free (only VAT will be charged). 50% of the city will be dedicated to residential areas; 20% will be sectors for social recreation; 10% will be green areas; industries and offices will occupy 8%; 7% will be destined for the installation of digital equipment; 3% will be for "eco-infrastructure", and the remaining 2% will be infrastructure necessary for the transportation. Bitcoin City will be built in the eastern region of La Unión department, near the Conchagua volcano to harness geothermal energy to produce electricity.²⁰

- **Nicaragua** is uncertain because of its political situation, which does not provide legal security for long-term investments.

¹⁹ Source: Ministry of Energy , <https://www.energia.gob.pa/mdocs-posts/resolucion-n-mipre-2021-0036199-de-24-de-septiembre-de-2021-consulta-publica-enged-2/>

²⁰ Sources: Government of El Salvador <https://www.presidencia.gob.sv/presidente-nayib-bukele-anuncia-construccion-de-bitcoin-city-en-el-cierre-de-bitcoin-week-feel-the-bit/> and <https://www.criptonoticias.com/comunidad/asi-sera-bitcoin-city-metropoli-circular-salvador/>

- **Costa Rica.** On December 8 (2021) the President of the Republic of Costa Rica signed the “Law 10086: Promotion and Regulation of Distributed Energy Resources from Renewable Sources”. It establishes the conditions to promote and regulate access, installation, connection, interaction, and control of distributed energy resources from renewable energy sources. With this law, consumers can generate their own energy in the same place where they consume it. The old practice of setting up a fixed limit of 15% on the capacity of the distribution circuit where the project is going to be connected, is eliminated. The new law makes this limit subject to the results of studies of penetration capacity by distribution circuit. A maximum period of one year is established to have the regulatory and technical conditions necessary to make this law operational, including, among other, the definition of tariffs and pertinent regulations.²¹
- **Guatemala** has the most modern electricity market structure in the region, but currently has an energy oversupply and depends on the opening of the regional market to continue growing.

²¹ Sources: http://www.asamblea.go.cr/glcp/Lista_Mociones/22009-I-001.pdf

<https://www.presidencia.go.cr/comunicados/2021/12/firmada-ley-que-regula-la-generacion-de-energia-distribuida-en-el-pais/>

5. Recommendations for Action for the EU and European Stakeholders

5.1. European Green Deal and Paris Agreement

The proposed recommendations made are aligned with the European Green Deal, especially with the third principle of energy: "Prioritizing energy efficiency, improving the energy performance of our buildings and developing a power sector based largely on renewable sources." Also, there is also an alignment with articles 9, 10 and 11 of the Paris Agreement.

The European Commission adopted a set of proposals to make the EU's climate, energy, transport, and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.²²

Actions:

1. Climate
2. Energy
3. Agriculture
4. Industry
5. Environment and oceans
6. Transport
7. Finance and regional development
8. Research and innovation

European Green Deal	Recommendations on this Report
Principle on energy: 3. Prioritizing energy efficiency, improving the energy performance of our buildings and developing a power sector based largely on renewable sources	<ul style="list-style-type: none"> • Support hybrid solar-hydro projects (small scale), mainly located at the end of distribution networks where energy is poor quality. • Further development of high enthalpy geothermal energy must be carried out under strict environmental regulations that minimize its impact. • The use of high-capacity battery banks, both to provide generation stability and support distributed generation projects and for electromobility, should be studied considering the product's entire life cycle. • Medium and large-scale wind and solar power plants are still recommended but taking care of environmental impacts on soil and biodiversity. • 5.1 Desired policy and regulatory changes. • 5.2 Gap analysis of technology transfer and capital investment. • 5.3 Recommendations on financial mechanisms to invest in RE market niches.

The Paris Agreement aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including:

- Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.
- Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and

²² Source: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

- Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.²³

Paris Agreement	Recommendations on this Report
Article 4 Each Party shall prepare, communicate, and maintain successive nationally determined contributions that it intends to achieve.	
Article 7 Parties hereby establish the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development.	
Article 9 Developed country Parties shall provide financial resources to assist developing country Parties with respect to both mitigation and adaptation in continuation of their existing obligations under the Convention.	5.3. Recommendations on financial mechanisms to invest in RE market niches
Article 10 Parties share a long-term vision on the importance of fully realizing technology development and transfer to improve resilience to climate change and to reduce greenhouse gas emissions	5.2. Gap analysis of technology transfer and capital investment
Article 11 Capacity-building under this Agreement should enhance the capacity and ability of developing country Parties..., to take effective climate change action, including, inter alia, to implement adaptation and mitigation actions, and should facilitate technology development, dissemination and deployment, access to climate finance	5.1. Desired policy and regulatory changes

More specifically, the results of COP26 (Glasgow, Nov.2021) show an alignment with the actions proposed in this report to the EU. The summit resulted in the Glasgow Climate Pact (GCP) – agreed to by all participating countries, which in combination with other commitments made to date, could limit the growth of atmospheric temperatures to less than 2 degrees Celsius. However, those commitments alone do not deliver the change necessary to limit climate change; without the appropriate policies, investment, and technologies, any agreements are likely to fail to achieve their stated aims.²⁴ COP26 main results focus on collective commitments to curb methane emissions, to halt and reverse forest loss, align the finance sector with net-zero by 2050, ditch the internal combustion engine, accelerate the phase-out of coal, and end international financing for fossil fuels.

Moreover, cover decision of COP 27, known as the Sharm el-Sheikh Implementation Plan, highlights that a global transformation to a low-carbon economy is expected to require investments of at least USD 4-6 trillion a year on renewable energies. Delivering such funding will require a swift and comprehensive transformation of the financial system and its structures and processes, engaging governments, central banks, commercial banks, institutional investors and other financial actors. Serious concern was expressed that the goal of developed country Parties to mobilize jointly USD 100 billion per year by 2020 has not yet been met, with developed countries urged to meet the goal, and multilateral development banks and international financial institutions called on to mobilize climate finance.

²³ Source: https://unfccc.int/sites/default/files/english_paris_agreement.pdf

²⁴ The Results of COP26. Ewelina Czapl. November 17, 2021. Downloaded from: <https://www.americanactionforum.org/insight/the-results-of-cop26/>

5.2. Desired policy and regulatory changes

From the documentary reviews and the interviews with the experts, the proposals for changes are oriented in several directions.

National Energy Policy

There is a robust political speech towards renewable energy in the region, but at the same time, several countries are pushing for natural gas projects (for instance in Panama and Honduras) due to technical issues to guarantee the energy supply with firm power technologies. So, it is necessary to review and update the energy policies and the regulations associated to:

Ensure that the electricity generation matrix has a technical (dispatch conditions) and economic (prices, long-term contracts) balance between traditional (hydro) and non-conventional renewable energies (wind and solar) in one hand, and non-renewable energies in the other hand, according to the context of each country.

Establish technical, economic, and monitoring mechanisms so that each candidate RE project is subject to a strict cost-efficient review to avoid expensive facilities that finally impact consumers' pockets. In Honduras, for instance, the high rates contemplated in the Power Purchase Agreements with solar generators are driving the increase in user tariffs, and the high rates of penetration in the south of the country are already causing blackouts and instability in the supply network.

Distributed Generation

Simplify the requirements to develop distributed generation projects. Modify the tariff structure to allow that residential, commercial, and industrial users receive a payment for the net surplus energy injected into the grid. The Dutch or German models for distributed generation can be analyzed to stimulate investment in projects of this type.

Modify regulations, based on independent technical-economic studies, to allow for a higher participation of distributed generation projects in the same distribution circuit. In Costa Rica, for instance, there is a limit of 15% (maximum allowance to connect distributed generation equipment vs capacity of the corresponding distribution circuit).

Promote that the new buildings (residential, commercial, industrial) should incorporate self-generation measures from the beginning to cover part of their consumption.

Allow RE private generators to consume energy at a point different from the one where energy was generated, paying a toll to the owner of the grid.

Regional Energy Market (MER)

Update the Central American regional market (MER) to maximize its potential, allowing for medium and long-term transactions between public and private agents located in different countries.

Accelerate the commitments of the countries to complete the infrastructure of the first circuit of the transmission network (300MW) and facilitate the conditions to build the second circuit (300 MW).

Ensure that SIEPAC is used mainly for international transactions, not to transfer energy internally (as it happens in Nicaragua).

Low Enthalpy Geothermal

Develop specific regulations for the use of low enthalpy geothermal energy, facilitating the conditions for potential identification studies, development of local and regional economic, technical, and service capacities.

SICA and GIZ are promoting the development of low enthalpy geothermal energy in the Central American countries that have it available (Guatemala, El Salvador, Nicaragua, and Costa Rica to a greater extent).

Local Markets

Modify policies and regulations to develop open electricity markets, create agents in the generation, transmission, distribution, and commercialization segments, and allow trade between private agents. In this regard, Guatemala is probably the best model in the region, and in a lesser extent El Salvador. Nicaragua and Costa Rica do not show the political will to do so.

Improve economic incentives and attract funding to upgrade the transmission and distribution infrastructure that allow for a greater use of RE and distributed generation.

Incentives

Update incentive policies and regulations to promote the new set of non-conventional technologies that are gaining momentum worldwide (supply and demand sites).

Promote national, regional, and international carbon credit markets in line with the Paris Agreement. National carbon market models can be inspired on the Mexican and Colombian carbon markets, which are among the most developed and active in Latin America.

Simplify the red type required to deploy RE projects in the region and to become self-generator.

Electromobility and Battery Storage

Stimulate electromobility ecosystems (financing, incentives, technology, infrastructure, business models, public-private partnerships).

The implementation of policies and regulations to impel the introduction of large capacity and deep cycle batteries are needed to financially justify many distributed energy projects and the possibility to inject their surplus energy to the grid at attractive prices. More studies, pilot projects, and incentives are required. The problem of the final disposal or recycling of batteries must also be solved from the beginning.

Goods and Services from EU

European suppliers compete well for quality and durability, but not for price. It is advisable to pursue the development of stricter specifications and regulations such that there is a better balance between quality and price. SICA could work with European cooperation to develop more stringent regulations and prevent the entry of low-quality products.

5.3. Gap analysis of technology transfer and capital investment

Gap analysis of technology transfer

The International Energy Agency (IEA) has identified a group of important technology gaps that are holding back the further deployment of renewable energy technologies worldwide. They were contrasted against the current situation and trends in Central America, and the opinions of the experts interviewed. The list of the main technology gaps identified for the region is as follows:

- Wind and solar are internationally subject to continued R&D into next generation modules, cells, turbines, and system designs, as well as into balance-of-system components to ensure cost reduction trends are maintained. For example, in solar

technology there have been recent advances in flexible panels, adhesive fixings (instead of screws, which prevent roof leaks), panels with PERC -passivated emitter rear cell- a technology that allow higher efficiencies, bifacial modules that produce energy on both sides of the panels, hybrid panels that produce electricity and hot water at the same time, etc.

- Although the Central American countries are importers of these technologies, the technical and financial success of these projects require the continuous training of local engineers and technicians to ensure the best selection, integration, installation, operation, and maintenance. This must be accompanied by an updated regulation that guarantees the entry of RE and EE products that not only compete on price, but also on quality, extended warranties, and manufacturer support. For example, actions are taken to mitigate market risk through long-term energy sales contracts (PPAs) and rates indexed to the dollar and inflation, but actions to mitigate the technological risk caused by the lack of regulations have yet to be implemented.
- Four technologies in which many stakeholders suggested a greater effort to provide knowledge transfer are green hydrogen, large energy storage in batteries, smart grid, and low-enthalpy geothermal. SICA and GiZ, for instance, has teamed up to promote the last one in the region, but more effort is required to generate a pipeline of projects and improve regulations allowing it.
- Wind and solar are criticized for being intermittent technologies. In most cases, the Central American distribution companies are opting to limit in a very general way the percentage of energy from these technologies that can be injected into their networks, in a static way instead of doing it dynamically using techniques of Smart Grid and Probabilistic Forecasting. For example, in Costa Rica distributors establish a fixed maximum of 15% that can be injected with energy from these technologies in each circuit. A combination of modern regulation and grid codes and more innovative solutions for providing ancillary services and other services related to dispatchability can solve this gap. For instance, solar smart inverters at higher PV penetrations will need to incorporate communication equipment that interacts in real time with utilities, increasing the visibility of the overall condition of low- and medium-voltage grids. Increasingly, they will also need to offer ancillary services such as reactive power or ramping controls.
- Improve resource assessment and spatial planning. Interviewees noted that the lack of good planning and periodic adjustment of incentives for renewable energy in some Central American countries has led to the approval and construction of many renewable energy projects that have not been successful. In many cases, the lack of adequate studies of the resources involved (water, wind, sun, biomass) has been the cause of these failures.
- As penetration increases and electricity systems become more complex overall, it is important to minimize the uncertainties of modelling solar and wind production. Model outputs can be refined and validated against measured data, and higher-resolution grid models can be developed as well as methods for estimating the economics of co-locating renewables and storage.
- Distributed generation with solar PV. There is a global trend towards innovation in digital technologies applied to solar PV systems, which allows for the delivery of a higher share of mini- and off-grid systems and increase energy access in developing countries. Off-grid technologies (such as stand-alone solar home systems), mini-grids and energy-efficient appliances are complementing efforts to provide electricity access from grid expansion. Such decentralized systems can help fill the energy access gap in remote areas by delivering electricity at a level of access that is currently too expensive to be met through a grid connection, help to implement climate change mitigation actions (irrigation for instance), and in urban areas by providing back-up for an unreliable grid supply or blackouts caused by technical or natural reasons (i.e.

natural disasters). Central American universities and research centers can look for to play a role in this process, making alliances with international developers to test those digital technologies in the region, although the main barrier for this deployment of distributed generation is not technological, but regulatory.

- In the regional industrial and commercial sectors, a combination of solar generation and energy efficiency measures increases the investment return on the solar systems. It is common in the region that solar PV installers do not make a detailed analysis of the different technology options that can improve a Solar PV-Energy Efficiency package. Better training for the integration of this type of technology, as well as on energy storage, would allow to achieve successful and profitable projects.
- Beyond its use for billing and asset monitoring purposes, the wealth of data generated by many off-grid systems could be subjected to big data analytics and artificial intelligence interpretation to enable better tailoring of equipment and modular asset scale-ups, better planning, improved device management and maintenance, and wider commercial offerings. This can be achieved with the participation of final users (industrial, commercial, residential), distribution companies, technical advisors and suppliers of equipment and ancillary services.
- For green buildings, integration of RE and EE technologies with better design and construction, especially in Central American coastal areas where tourism requires high consumption of energy for air conditioning; and in large cities like Managua, San Pedro Sula and Panama, where average annual temperature can reach 35 °C. Transitioning to high-performance buildings by 2030 will require technical innovation to meet the energy needs of a variety of building types in multiple regions. Innovation is particularly needed to raise investment returns for high-performance building envelope technologies, advanced air flow, air sealing and ventilation controls, highly insulated windows, integrated storage, and building-integrated photovoltaics (BIPV).
- Better regional interconnection models with neighboring countries should be undertaken, as part of the ramp up of the Central American Energy Market (MER in Spanish) that countries like Guatemala are demanding from the other ones. As mentioned before, these models should consider the possibility of long-term contracts, grant access to large private stakeholders and allow for transactions between those private agents (especially, distribution companies).

Gap on early-stage seed capital, and project finance capital needs

In the Funding Life Cycle, once an idea has surpassed the concept stage, the next stage of a new venture is known as the "seed stage". Since Central American countries are not developer agents of new renewable energy technologies, but integrators of them, the concept of "seed stage" would apply to the following business initiatives:

- **Impact Funds**, risk capital type, that invest in the execution of pilot projects that incorporate the latest advances in renewable energy technologies and energy efficiency. Not only projects on the supply side (generation), but also on the demand side (distribution and final consumption). For example, pilot projects for Smart Grid, Big Data, mini- and off-grid systems, low enthalpy geothermal, deep cycle and high-capacity battery storage, small-scale solar-hydro hybrid systems connected to the grid, biogas plants in agro-industrial facilities, Combined Heat & Power (CHP), fleets of electric vehicles and electric charging stations, bioenergy plants for thermal uses, hydrogen for electricity, 5G communication networks. Distributed generation and self-consumption projects are a priority in this regard.

- **Seed capital and working capital** for: i) companies that develop clean energy projects: EPC²⁵ companies in the case of renewable energy projects, and ESCO²⁶ companies in the case of energy efficiency; ii) companies that provide services for the measurement and evaluation of natural resources, which incorporate the use of low-cost prospective technologies, especially for wind and geothermal, technologies that require high investments in their prospecting stage; iii) outsourcing service companies for measurement, reporting and certification of the amounts of renewable energy generated, energy saved and carbon emissions reduced. The availability and transparency of this information is essential to be able to justify the issuance of carbon credits, green bonds and green credit lines for clean energy projects.

There is currently no source in Central America offering seed capital for clean energy ventures. There are some venture capital funds and angel investors, but they are aimed more at the IT sector. For a later stage of business development (growth capital, or project finance), there are some mezzanine funds operating in the region, such as MPC Capital, MGM Innova Capital, HREFF-CABEF and some European development bank funds that offer this type of financing. They normally invest starting at USD 1 MM, and some from much larger figures than that. This minimum investment scale affects a good part of distributed generation and energy efficiency projects, which tend to be much smaller than this threshold, especially when the sponsors are SME companies.

In addition to the need to provide seed capital for the most innovative initiatives, long-term capital is required to finance the scaling-up and replication of projects, as well as for the renovation and expansion of old RE installations that are reaching their useful life.

5.4. Recommendations on financial mechanisms to invest in RE market niches

The following **Finance Instruments and Mechanisms** can be used to support a further expansion of Renewable Energy and Energy Efficiency markets in Central America:

- Long-term credit lines with a green climate approach (mitigation and adaptation) which are offered to commercial banks and other Central American financial institutions by international development financial institutions, among which: the IDB Group, the IFC/World Bank, the Central American Bank for Economic Integration (CABEI), the Development Bank of Latin America (CAF), and the institutions that make up the EDFI (European Development Finance Institutions), such as BIO, CDC, COFIDES, KfW/DEG, Finnfund, FMO, IFU, Norfund, PROPARCO, Swedfund, among others.
- Equity and Quasi-equity funds, intended to complement the equity capital contributions of project developers and share their risk, while complying with the minimum requirement established by banks in the region to be able to grant a loan. These minimum requirements usually imply an equity contribution of at least 30% (in some cases it rises to 35%) of the total amount of the initial investment. Equity and quasi-equity funds allow sponsors to only contribute a part of this percentage (for example, 10% or 15%, with the Venture Capital Funds taking care of the rest. For this, the investment modalities include the purchase of common shares, preferred shares, or subordinated debt. This means that the investment is either unsecured or has lower priority than senior debt provided by the banks.
- Impact Bonds, financed by development banks, cooperation agencies or international non-profit foundations, are a form of results-based financing often used for social

²⁵ Engineering, Procurement and Construction. A form of building contract under which the builder (the EPC contractor) will deliver a completed project on a turnkey basis.

²⁶ Energy Service Company (or Energy Savings Company), is a company or an entity that delivers energy services or other energy efficiency improvements in an energy user's premises, and accepts some degree of financial risk in doing so.

services and environmental programs. Generally, they are structured so that the investor provides initial capital, and the investment is repaid when the project achieves predetermined goals (like a threshold of annual mitigation of GHG). Repayment of the bond is contingent on the project realizing set outcomes; if necessary, to attract investors, it is possible to mitigate repayment risk with a guarantee. The focus of impact bonds shift from the mere construction of a project to its real environmental outcomes.

- Technical Assistance Facilities for financial institutions, public institutions and universities in association with unions or private companies, to develop studies and pilot projects that are scalable and replicable, especially in the market niches that have been prioritized in this study.
- Guarantee Funds, which make it possible to cover part of the eventual losses of financial institutions when investing in non-conventional or innovative RE projects, when they have failed in their projections, beyond the coverage offered by insurance for material damage or temporary business interruption.
- Carbon Markets. Greater penetration of renewable technologies in Central American transmission and distribution networks should be accompanied by the development of national and regional carbon markets, and integration into international carbon credit markets when the application of Chapter 6 of the Paris Agreement has been clarified. This chapter is the one that will regulate these types of transactions in the future (when the parties agree on it). During the term of the Kyoto Protocol, many renewable energy projects in the region signed agreements with the Clean Development Mechanism, and some even keep the registry of their carbon credits active while waiting for a new market to open for them.
- Green Bonds. These are fixed-income financial instruments, which can be placed for both public and private offerings, just like any bond that circulates in the stock market. The difference is that green bonds focus on projects that help mitigate the effect of climate change (which is why they are also called “climate bonds”), such as renewable energy, efficient buildings and infrastructure, and low-emission transportation.
- Parametric weather insurance products for Renewable Energy projects can also be promoted, aimed at mitigating the risk of generation in hydroelectric, solar or wind projects, caused by extraordinary deficits of the renewable resource. Central America is one of the regions of the World with higher vulnerability to Climate Change and extreme weather conditions like storms, floods, and droughts. As the participation of the mentioned technologies increase, so is the need for better weather risk management strategies for RE developers and other stakeholders in the industry (banks, insurers, and insurance regulatory agencies). Big fluctuations on production pose a credit risk on RE entrepreneurs, many of which do not have the possibility to diversify weather risk among different projects, different regions and/or different complementary technologies. Parametric weather insurance products are insurance policies based on a selected weather parameter (or index) like rainfall, wind flows or solar radiation in a defined period, or a combination of a few agreed parameters. If the correlation between the selected parameter and the income loss resulting from a severe deficit is high, loss compensation can be triggered when the parameter falls under a predefined threshold. The RE developer will manage to sustain a deficit until a point in which the insurance will take care of it.
- Increased adoption of sustainability certifications for buildings²⁷, and energy-consumption equipment²⁸, as part of financing requirements.

²⁷ Green Building certifications like: Excellence in Design for Greater Efficiencies (EDGE), Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM).

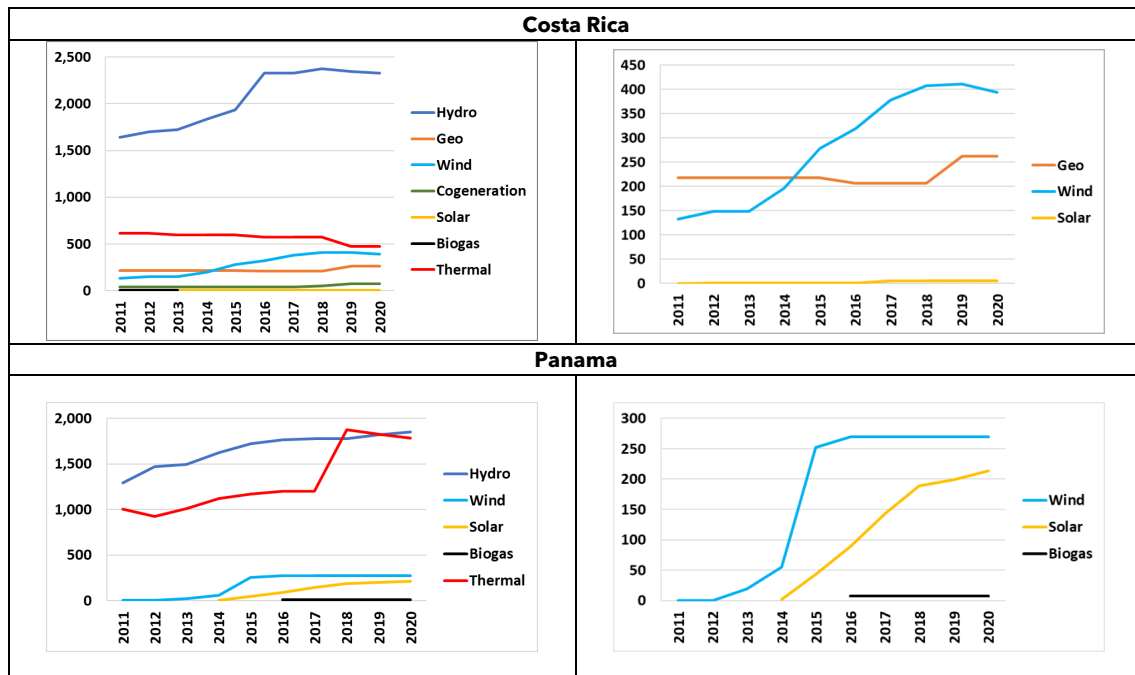
²⁸ Energy labels like Energy Star (USA), the EU Energy Label, FIDE in Mexico and PROCEL in Brazil.

6. Annexes

6.1. Annex 1. Historical installed capacity per country

Historical Installed Capacity (MW)



Cont. Historical Installed Capacity (MW)**6.2. Annex 2. List of stakeholders interviewed**

Name	Organization	Sector
Jorge Dengo	CELSIA (Honduras, Costa Rica, Panama)	Leader of Regulatory Affairs and Market Development for Central America at Celsia Energia. Celsia is a Colombian company, one of the largest developers and operators of generation plants, distribution networks and distributed generation in Central America.
Mario Cerna and Shirley Hernandez	CABEI (regional)	Business Structuring Executive and Energy Specialist; Portfolio Management Executive. CABEI (Central American Bank for Economic Integration) is the development bank of the region, and one of the main players in the financial market for renewable energies. It makes direct investments, technical assistance, and lines of credit for commercial banks in the region.
Mario Caceres	National Energy Council (CNE), El Salvador	Director of Energy Efficiency. The CNE is an important actor within the structure of the Salvadoran energy sector, in matters of renewable energies and energy efficiency.
Ricardo Espinoza	Independent Consultant and former Regulator of Electricity in Honduras (Honduras)	Former president of CREE, the Electric Power Regulatory Commission of Honduras. It is responsible for regulating the activities of the agents of the market and institutions in the Honduran electricity subsector.
Gustavo Jimenez	Independent consultant (Costa Rica and Nicaragua)	Experience with investors in wind, solar and hydro projects. Experience comparing proposals from European, North American and Asian suppliers for RE projects in Costa Rica and Nicaragua. Experience providing training on RE to companies and financial institutions in the region.
Alejandra Arias	SICREE/SICA	Expert in Renewable Energy and Energy Efficiency of SICREE (Regional Center for Renewable Energy and Energy Efficiency of the SICA countries) and former officer at OLADE. SICA is the most important political body for Central American integration. OLADE is the Latin American Energy Association.
Lorena Rodriguez	IFC (Guatemala, El Salvador and Panama)	Country Officer for Guatemala, El Salvador and Panama of the IFC (International Finance Corporation / World Bank). This organization has provided financing and technical assistance for RE projects in Central America, both directly and through commercial banks.
Ramon Candia	CIFI (regional)	Investment Officer at CIFI (Inter-American Corporation for Infrastructure Financing). It is a non-banking financial institution

		with extensive experience in the financing of infrastructure and renewable energy in Latin America and the Caribbean.
Fernando Alvarado	RE and EE Impact Investor	CEO of DISE (Deetken Impact Sustainable Energy), impact capital investor specialized in financing of renewable energy and energy efficiency in Central America and the Caribbean.

6.3. Annex 3. NDC's of Central American countries

Country	Mitigation	Adaptation (sectors)	RE Targets for 2030
Guatemala	<p>NDC (2016) <i>Unilateral Contribution</i> Reduce up to 22.6% of its total GHG emissions from the base year 2005 projected to 2030. This reduction of 22.6% implies that emissions, in a trend scenario (BAU) of 53.85 million tons of CO2 equivalent by 2030.</p>	<ul style="list-style-type: none"> • Human health • Coastal marine areas • Agriculture, livestock, and food security • Forest resources, protected areas • Conservation and management of strategic ecosystems • Infrastructure • Integrated management of water resources • Quality of the productive infrastructure • Soil protection • Comprehensive Disaster Risk Reduction Management. 	Achieve 80% of electricity generation (2030) with renewable energies
Honduras	<p>NDC (2016) <i>Unilateral Contribution</i> Honduras has a relative goal of reducing emissions by 15% compared to the BAU scenario for 2030. This commitment is conditional on the support being favorable, predictable, and making climate financing mechanisms viable. Additionally, as a sector objective, the Republic of Honduras commits itself to afforestation and reforestation of 1 million hectares of the forest before 2030. Likewise, the NAMA of efficient stoves expects to reduce firewood consumption in families, helping fight against deforestation.</p> <p>NDC (updated 2020) By 2030, Honduras is committed to promoting the implementation of the "conservation and functional restoration of the rural landscape", reaching 1.3 million hectares of forest in the process of restoration. By 2030, Honduras is committed to 1) Reducing 16% the emissions by promoting renewable energies, strengthening energy efficiency, fostering electromobility, and 2) Reducing family firewood consumption by 39%, helping in the fight against deforestation.</p>	<ul style="list-style-type: none"> • Infrastructure • Agri-food Sector and Food Sovereignty • Biodiversity and Ecosystem Services • Water resources 	<ul style="list-style-type: none"> • No explicit targets
El Salvador	<p>NDC (2016) <i>Unilateral Contribution</i> El Salvador has a series of contributions to establish a legislative and institutional framework that can guide economic and social development towards low emissions and adaptation to climate change. In October 2016, El Salvador established a 46% reduction of GHG emissions concerning growth without concrete mitigation actions or business as usual (BAU) by 2025.</p>	<ul style="list-style-type: none"> • Human health • Coastal Marine Zones • Agriculture, Livestock and Food Security • Forest Resources • Ecosystems and Protected Areas • Infrastructure • Water Resources 	<p>Increase in renewable energy by 2025 not less than 12%.</p> <p>The prioritization of energy efficiency and renewable energy projects and, additionally, the reduction of emissions from the transport sector is mentioned</p>

Nicaragua	<p>NDC (2016) Unilateral Contribution</p> <p>- Nicaragua has an unconditional sectoral goal that establishes that 60% of the installed capacity of the electricity matrix must come from renewable energy sources by 2030.</p> <p>- Likewise, it proposes to conserve the absorption capacity of carbon sinks concerning the Reference Scenario by 2030. Its conditional goal establishes the increase of the carbon absorption capacity by 20% concerning the Reference Scenario by 2030.</p> <p>NDC (2020) Conditional: increase the energy matrix up to 65% with renewable energy sources by 2030.</p>	<ul style="list-style-type: none"> • Energy • Infrastructure • Agriculture, livestock, and food security • Forest resources, protected areas • Biodiversity 	<p>Increase the participation of renewable sources in electricity generation to 60% in 2030 (starting from the 53.5% existing in 2017).</p>
Costa Rica	<p>NDC (2016) Unilateral Contribution</p> <p>The country committed to an absolute maximum of emissions of 9,374,000 net TCO₂eq by 2030, with a proposed trajectory of per capita emissions of 1.73 net tons per capita by 2030; 1.19 net tons per capita by 2050, and -0.27 net tons per capita by 2100. This limit is consistent with the global trajectory necessary to meet the 2 °C goal. The national commitment implies a reduction of GHG emissions of 44%, compared to a Business as Usual (BAU) scenario, and represents a reduction of GHG emissions of 25% compared to the 2012 emissions. To achieve its goal, Costa Rica will have to reduce 170,500 tons of GHG every year until 2030.</p> <p>NDC (updated 2020)</p> <p>- Costa Rica commits to an absolute maximum of net emissions by 2030 of 9.11 million tons of carbon dioxide equivalent (CO₂e), including all emissions and sectors covered by the corresponding National Emissions Inventory.</p> <p>- Costa Rica commits to a maximum budget of net emissions in the period 2021 to 2030 of 106.53 million tons of carbon dioxide equivalent (CO₂e), including all emissions and all sectors covered by the corresponding National Emissions Inventory.</p> <p>Energy Contribution: By 2030: Maintain the electric generation 100% renewable with a minimum necessary thermal generation. Upgrade the energy efficiency standards of end-use technologies.</p>	<ul style="list-style-type: none"> • Energy • Infrastructure • Agriculture, livestock, and food security • Forest resources, protected areas • Biodiversity • Soil protection • Comprehensive Disaster Risk Management 	<p>The aspirational goal of this contribution is to achieve and maintain 100% renewable electricity generation by 2030. The country will maintain the necessary thermal capacity to ensure the reliability of the system, seeking to eliminate it as soon as there exists other technically and economically viable alternatives.</p>
Panama	<p>NDC (2016) Enhance the use of other types of renewable energy sources: By 2050, 30% of the installed capacity of the electricity matrix must come from different types of renewable energy sources</p> <p>Reforestation of degraded areas <i>Unilateral Contribution</i> Increase in Carbon absorption capacity by 10% concerning the Reference Scenario to 2050. <i>Supported Contribution</i></p>	<ul style="list-style-type: none"> • Energy, • Forests • Integrated Management of Hydrographic Basins, • Marine-Coastal System, • Biodiversity, • Sustainable Agriculture, Livestock and Aquaculture, • Resilient Human Settlements, • Public health • Sustainable Infrastructure and 	<p>The country defined as an objective of mitigation in the energy sector to increase installed capacity of other energy sources renewable (solar, eolic and biomass) by 15% in 2030 and 30% in 2050.</p>

	<p>Increase in Carbon absorption capacity by 80% concerning the Reference Scenario to 2050</p> <p>NDC (updated in 2020) *</p> <p>Energy Sector - By 2050, Panama will reduce total emissions from the country's energy sector by at least 24% and by at least 11.5% by 2030, concerning the trend scenario, which represents an estimated 60 million tons of accumulated CO2 equivalent between 2022-2050 and up to 10 million tons of CO2 equivalent accumulated between 2022-2030.</p> <p>Land use, land-use change, and forestry (LULUCF sector)- Panama is committed to the forest restoration of 50,000 ha nationwide, which will contribute to the carbon absorption of approximately 2.6 million tons of CO2 eq by 2050.</p>	<ul style="list-style-type: none"> • Circular Economy, 	
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**By 2020, all the countries in the SICA region began to provide updated commitments.*

6.4. Annex 4. Additional regulatory and technical barriers identified for each country

Guatemala

Barriers	Description
Regulatory	
The indicative expansion plan of the Generation System 2020-2050	Little used geothermal resource, there is still availability of 966 MW. Incentives are required to trigger additional exploration activities and definition of usable potentials.
Energy Policy 2019 -2050	Lack of promotion and mechanisms for the self-sufficiency of electricity using renewable energies in commerce and industries. Develop activities, business models, additional incentives to promote self-sufficiency.
The technical standard of distributed generation. Art. 40	The end-user's Self-producers with Surplus Energy will not receive any payment for energy power injected into the Distribution System. Create business models to stimulate this potential market.
Technical	
The indicative expansion plan of the Generation System 2020-2050	Little used geothermal resource, there is still availability of 966 MW. Additional services are required to explore and define technologies that take advantage of the potentials that is found.
Energy Policy 2019 -2050	Promote electricity self-sufficiency through renewable resources in industry and commerce. Develop additional offers of services and technologies to supply the potential market in this sector while considering the residential sector.
Technical standard for renewable distributed generation and Self-producing users with surplus energy. CNEE	The standard considers defined project capacities: 50kW - 5 MW. It is not clear if there are experiences of distributed generation in consumer sectors. Develop projects in the residential, commercial, and industrial sectors connected to the distribution grid.
Biomass	It is no clear the degree of efficiency and technological advance of the Sugar mills; they are the primary users. Carry out current technological studies on sugar mills to identify areas of opportunity.

Sources: Ministry of Energy and Mines (MEM, Spanish acronym) < <https://mem.gob.gt/> >; National Electric Power Commission (CNEE, Spanish acronym) < <https://www.cnee.gob.gt/wp/> >; Wholesale Market Administrator < <https://www.amm.org.gt/portal/> >.

Honduras

Barriers	Description
Regulatory	
Electricity Industry General Law 2014	Art. 29 indicates that the national electricity company must separate into generation, transmission, operation, and distribution. To date, the company is a monopoly, and there is no competitiveness in the sector. With the opening of the electricity market, the regulatory framework will need to be reviewed and adjusted.
Electricity Industry General Law 2014 and its regulation	Art. 15 D indicates that the distributors must buy surplus electricity from renewable energies generated by residential and commercial users at a specific rate. The rate for the purchase of surpluses is not defined. There are not enough incentives for the massive use of these technologies in the sectors mentioned above. Establish promotion mechanisms and models appropriate to the current context.
Technical	
Products and Services offer.	There is not enough offer of products and services for solar energy in the residential and commercial sectors. Define what kind of products and services are appropriate in the current context.
Large-scale production with renewable energies	Continue exploring renewable energy potential.
Current electrical infrastructure	The country has transmission and distribution systems that are not stable to transmit and distribute electricity. Investments are needed to redesign and strengthen both systems.

Source: <https://www.cnee.gob.gt/wp/marco-legal/>

El Salvador

Barriers	Description
Regulatory	
National Electricity Policy	The CNE has defined five long-term strategic lines for energy development 2020-2050. 1.-Update regulatory frameworks to increase the use of renewable energies 2.- Sustainable energy supply raising the use of renewable resources. 4.- R&D+I exploration of new energy. A more comprehensive energy plan and clear objectives are needed.
National Electricity Policy The expansion plan of the electrical system	The expansion plan of the electrical system, must address the problem of operational flexibility in the electricity system when thinking about increasing the capacity by using renewable energies and the rising distributed generation on the demand side.
General Electricity Law	The law indicates the use of geothermal resources to generate electricity. Using geothermal heat for air conditioning, agricultural industry, tourism or medicine, requires complying with environmental regulations and municipality construction requirements. It is needed to define the geothermal resources using enthalpy ranges and create regulations to exploit them in different direct uses.
Geothermal Direct Uses	It requires regulations to set the basis for direct geothermal uses and promote products and services.
Technical	
Distribution grid, National Electric System	"Standard for end-users electric energy producers with renewable resources" has allowed growth mainly in the use of photovoltaic solar panels in roofs. Studies are needed to define the limit of distributed generation in the distribution network to ensure the system's stability and market.
Geothermal Energy	Greater participation of technologies for direct use is required in the industry, commerce, services, and residential sectors.
Geothermal Energy	More experts and promoters are required to drive direct uses.

Sources: IRENA, < <https://www.irena.org/publications/2020/Dec/Renewables-Readiness-Assessment-El-Salvador-ES> >; CNE < <https://www.cne.gob.sv/> >; SICA < https://www.sica.int/documentos/infografico-de-geotermia-y-sus-usos-directos_1_124299.html >; SICA < https://www.sica.int/documentos/factsheet-proyecto-fomento-de-la-geotermia-en-centroamerica_1_124296.html >.

Nicaragua

Barriers	Description
Regulatory	
	There have been constant changes in the electricity industry's regulatory framework and is perceived legal uncertainty for investments in these fields.

Source: <https://www.enatrel.gob.ni/wp-content/uploads/2017/05/Ley-No.-1056-Ley-de-Aseguramiento-Soberano-y-Garantia-del-Suministro-de-la-Energia-Elctrica.pdf>

Costa Rica

Barriers	Description
Regulatory	
Art.44 Distributed Generation Regulation for Self-Consumption N° 39220-MINAE	The maximum capacity of all generation systems connected to the same circuit, including the proposed system, shall not exceed fifteen percent (15%) of the maximum annual demand of the circuit. Due to unspecified criteria, this limit was imposed, which does not contribute to the growth of distributed generation systems, protecting the distribution company.
Art. 34 Distributed Generation Regulation for Self-Consumption N° 39220-MINAE.	The producer-consumer may only withdraw up to 49% of the energy deposited in the distribution network. This criterion does not foster the injection of electricity not consumed to the grid.

Art. 13 Distributed Generation Regulation for Self-Consumption N° 39220-MINAE.	The electricity produced by RE must be consumed at the same place that is generated. So, the producer cannot consume its own electricity in a different location.
Law No.5961 Declares as public interest the Geothermal Resources	The research, exploration, and exploitation of the country's geothermal resources will be the exclusive responsibility of the Costa Rican Electricity Institute. There are no definitions of low enthalpy and high enthalpy. Geothermal potential with different temperatures and pressures not unique to ICE has not been explored or exploited widely. If the law is not changed specifying definitions for low and high enthalpy and the possibility of exploring and exploiting low enthalpy springs for private or public entities different from ICE it wouldn't be possible to create markets around the geothermal low enthalpy potential.
Technical	
Low enthalpy geothermal technologies	There is not enough knowledge on low enthalpy geothermal technologies for industrial uses. So, it's essential to change the law to impel the exploration and exploitation of geothermal low enthalpy potential.

Source: Legal framework on Energy in Costa Rica, <https://energia.minae.go.cr/?page_id=1444>

Panama

Barriers	Description
Regulatory	
National Energy Plan 2015-2050	In 2050, the installed capacity to produce electricity will be 76% with renewable energies (2350 MW Hydraulic, 668 MW Wind, 250 MW solar, 8.2 W Biomass) and 24% with fossil sources (2820 MW Coal, 6612 Natural Gas, 558 MW Bunker, 308 MW Diesel). Evaluate investment incentives under market conditions and with a focus on PPAs.
National Energy Plan 2015-2050	Integrating more renewable energies into the electrical system requires planning processes that consider the uncertainties and risks associated with these energies. It is necessary to develop planning processes and models of the electrical system with high percentages of renewable energies and institutional strengthening of the relevant parties.
National Energy Plan 2015-2050 Geothermal Source potential	There are no detailed studies to estimate the geothermal potential and evaluate its use. Public policies, investments, and technical capacities for these studies are required.
Technical	
National Energy Plan Sceneries 2015- 2050	In 2050 there will be an installed capacity of up to 878 MW with solar panels in the residential sector. A wide range of associated products and services to install these solar panels is required. It is necessary to create technical and business capacities to strengthen the wind and solar energy market.
National Energy Plan 2015-2050	Promote the offer of photovoltaic solar generation products and services for the commercial and industrial sectors

Sources: OLADE <<http://biblioteca.olade.org/opac-tmpl/Documentos/cg00467.pdf>>; IRENA <<https://www.irena.org/-/media/Files/IRENA/Agency/Events/2016/Oct/18/National-Energy-Plan-20152050-by-Eng-Isaac-Castillo-SubSecretary-of-Energy-Panama.pdf?la=en&hash=323452FABF4A8B067F609F0755C775B25D20709E>>; ASEP <https://www.asep.gob.pa/wp-content/uploads/COVER_2018/Autoconsumo_ Renovables_Limpias/procedimiento_centrales_limpias_2017.pdf>