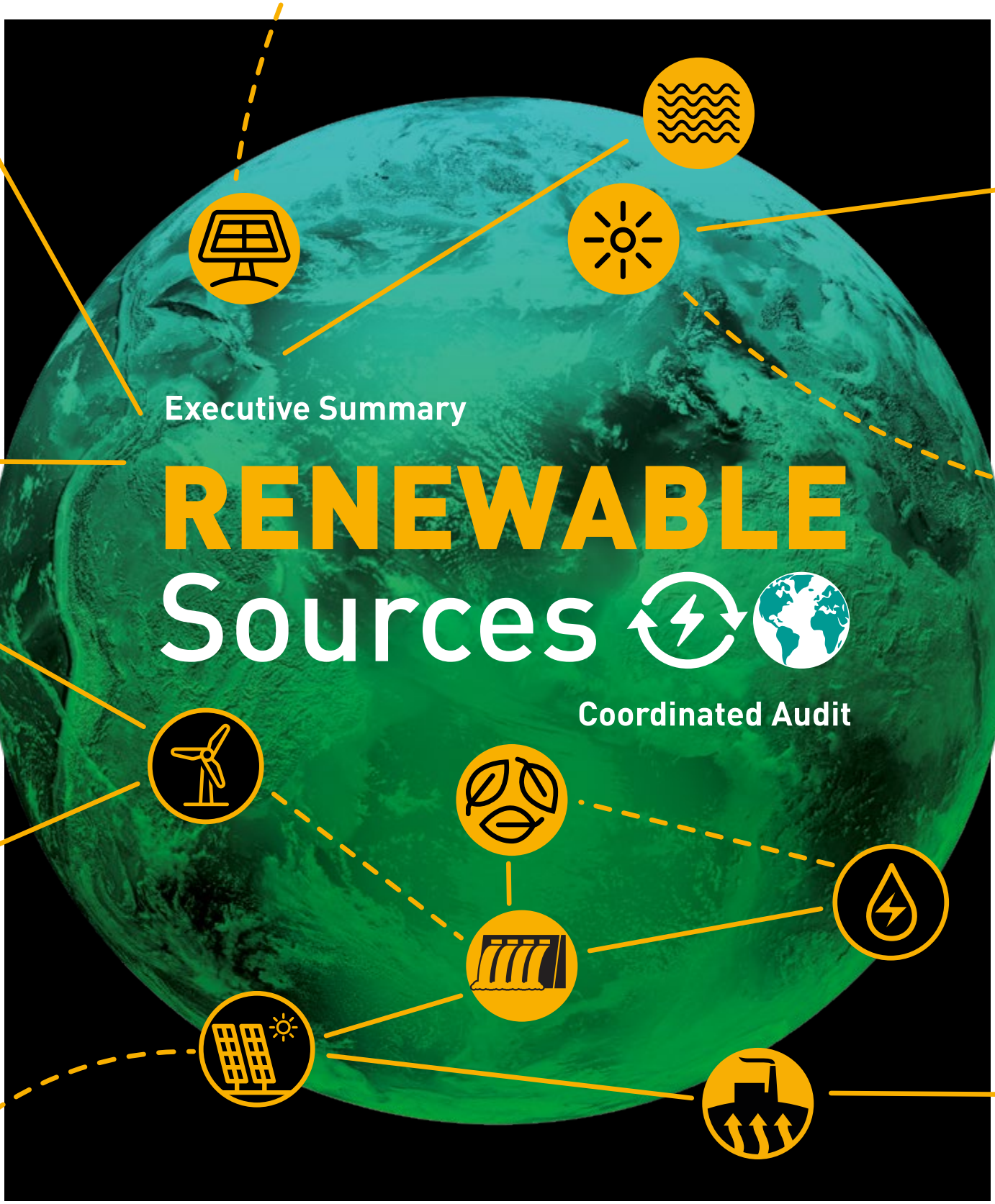

Executive Summary

RENEWABLE Sources

Coordinated Audit

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Through:
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

OLACEFS
LATIN AMERICAN AND CARIBBEAN ORGANIZATION OF SUPREME AUDIT INSTITUTIONS

GTOP

FEDERAL COURT OF ACCOUNTS TCU

Organização Latino-Americana e do Caribe de Entidades Fiscalizadoras Superiores.

Energias renováveis : auditoria coordenada / Organização Latino-Americana e do Caribe de Entidades Fiscalizadoras Superiores (Olacefs), Coordenação: Tribunal de Contas da União; Participantes: Contraloría General de la República do Chile...[et al.] - Brasília : Tribunal de Contas da União, 2019.

54 p. : il. color – (Sumário Executivo)

Esta auditoria coordenada atende aos objetivos e metas estabelecidos em dois acordos internacionais: a Agenda 2030 para o Desenvolvimento Sustentável e o Acordo de Paris.

A auditoria foi desenvolvida dentro do plano de trabalho do Grupo de Trabalho de Auditoria de Obras Públicas (GTOP) da Organização Latino-Americana e do Caribe de Entidades Fiscalizadoras Superiores (Olacefs), sob a coordenação do Tribunal de Contas da União, com a participação das Entidades Fiscalizadoras Superiores (EFS) dos seguintes países: Brasil, Chile, Colômbia, Costa Rica, Cuba, Equador, El Salvador, Guatemala, Honduras, México, Paraguai e Venezuela.

Esta ação de controle conta com o apoio técnico da Cooperação Alemã por meio da GIZ – Deutsche Gesellschaf t für Internationale Zusammenarbeit GmbH – no âmbito do projeto Fortalecimento do Controle Externo na Área Ambiental, que está sendo implementado em parceria com o TCU e com a Olacefs.

1.Auditoria coordenada. 2.Desenvolvimento sustentável. 3.Energia acessível e limpa. 4.Biocombustível. 5.Efeito estufa. I.Agenda 2030 para o Desenvolvimento Sustentável. II.Acordo de Paris. III.Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). IV.Título. V.Série.

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Executive Summary

RENEWABLE Sources

Coordinated Audit

Brasília, 2019

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OLACEFS LATIN AMERICAN AND CARIBBEAN ORGANIZATION OF SUPREME AUDIT INSTITUTIONS
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PRESENTATION

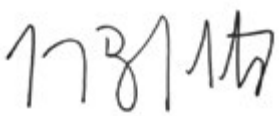
It is with great satisfaction that we present the result of this coordinated audit that carried out a diagnosis on public policies and investments related to the expansion of renewable energy in the electric power sector.

The establishment of international agreements for the reduction of GHG emissions, such as the Paris Agreement and the 2030 UN Agenda, has been an opportunity to promote the necessary energy transition, through clean sources, and also to help nations advance along the path of sustainable development. Latin America and the Caribbean, of course, are part of this worldwide effort. In particular, this audit took place in Brazil, Chile, Colombia, Costa Rica, Cuba, Equador, El Salvador, Guatemala, Honduras, Mexico, Paraguay and Venezuela.

We emphasize that, given their audit competencies, the Supreme Audit Institutions (SAI) are capable of independently and impartially evaluating government programs and public policies to contribute to their improvement. It should be stressed that the good use of public resources does not just relate to public money, but also to goods, environmental services and measures adopted to reduce GHG emissions, which have an impact on our societies, so that SAIs can make a decisive contribution to highlighting the importance and effects of such policies.

In the specific case of this audit, we hope that the identification of various lessons, opportunities for improvement and good practices can be disseminated to help the government entities of each country make the most appropriate decisions for their respective realities so that public policies for the increase of clean energy are more effective and efficient.

Finally, we are grateful for the support that the participating SAIs gave us and, in particular, the Federal Court of Accounts (TCU), SAI of Brazil, for the structuring of this initiative, its guidance and general coordination that made this work possible. We would also like to highlight the efforts made by the Comptroller General of the Republic of Chile and the Comptroller General of the State of the Republic of Equador for organizing the workshops on planning and consolidating the results. We also thank the Economic Commission for Latin America and the Caribbean (ECLAC) and the Government Accountability Office (GAO), SAI of the United States of America, for the technical support provided. We give a special mention to the support given by the *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ), which allowed us to carry out this coordinated audit within the scope of the project Strengthening External Control in the Environmental Area, a partnership between the German Federal Ministry for Economic Cooperation and Development (BMZ) and OLACEFS.



Jorge Bermúdez Soto
Comptroller General of the Republic of Chile
President of the GTOP/OLACEFS

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PART 1

1. INTRODUCTION

This coordinated audit (see Box 1) deals with the theme of **renewable energy**, which is defined as the energy in which the source (or fuel) for its production is replaced by nature in periods consistent with its energy demand (such as water, tidal, solar, wind, and geothermal sources) or whose management by man can be carried out in a manner compatible with the needs of its energy use (as in the case of biomass: sugar cane, energy forests, and animal, human and industrial waste). Because they have a lower environmental impact, at least in terms of **greenhouse gas emissions** (GHG), they are also considered as clean or sustainable sources or energy in this report. These types are in contrast to **non-renewable energy**, which are those sources that cannot be replaced in a period compatible with their use by humans (fossil fuel sources, such as coal, oil and natural gas derivatives, and nuclear fuel). Due to their GHG emission potential, in the case of fossil fuel sources, they are also known as polluting sources or energy. In the case of nuclear energy, some countries consider it to be sustainable; others do not.

The promotion of an electricity generation mix with a greater share of renewable sources has been growing on the world scene, either seeking to reduce greenhouse gas (GHG) emissions, reducing dependence on fossil fuels, or due to the technological evolution that makes these sources more competitive. Renewable energy contributes to the achievement of economic, social and environmental sustainability standards.

In this sense, two international agreements of great relevance to the topic stand out: the 2030 Agenda for Sustainable Development and the Paris Agreement. The objectives and goals established in these agreements directly or indirectly contemplate the increase in the proportion of renewable sources in the global electricity generation mix.

Concerning technological development related to clean sources, the significant progress of **non-conventional renewable energy** stands out. This has led several countries to adopt incentives, making these sources increasingly economically competitive, and encouraging competitive processes to increase their share in electricity production.

Considering the systematic operation of the electric power sector and the peculiar characteristics of renewable sources, the expansion of non-conventional sources adds several challenges to the planning and operation of national electric power systems, such as overcoming technical, financial and institutional difficulties in defining strategies and mechanisms for the expansion of these sources, adaptation of the regulation of electric power systems, identification of alternatives to mitigate the impacts of high variation in the generation of wind and solar photovoltaic sources which present the greatest opportunities for growth, etc.

Box 1: What is a coordinated audit?

Coordinated audits consist of a systemic and collaborative action carried out by a group of Supreme Audit Institutions (SAIs) in the exercise of external control over international or regional issues of common interest to the countries involved. In this context, they translate into an effective strategy of technical cooperation, capacity building and institutional strengthening aligned with the motto of the International Organization of Supreme Audit Institutions (INTOSAI) "Experientia Mutua Omnibus Prodest" - mutual experience benefits everyone.

The format of coordinated audits carried out by the Organization of Latin American and Caribbean Supreme Audit Institutions (OLACEFS) combines training actions, both online and face-to-face, with the performance of audits on relevant transnational issues of common interest, allowing the development of theoretical technical skills together with practical professional competences. They consist of three phases: 1st phase - joint planning of the work; 2nd phase - execution of audits by each of the participating Supreme Audit Institutions (SAIs); 3rd phase - consolidation of the results and subsequent preparation of the report, as shown in the illustration below.

1st phase: joint planning of the work;

2nd phase: execution of audits by each of the participating supreme audit institutions (SAIs);

3rd phase : consolidation of the results and subsequent preparation of the report, as shown in the illustration below.

It is necessary to mention that the performance of coordinated audits keeps the synergies foreseen in SDG 17 - "Strengthen the means of implementation and revitalize the global partnership for sustainable development."

Given the importance of government initiatives to overcome these challenges, this audit was developed within the work plan of the OLACEFS Public Works Audit Working Group (GTOP), under the coordination of the TCU, SAI of Brazil, with the participation of the Supreme Audit Institutions of the following countries: Brazil, Chile, Colombia, Costa Rica, Cuba, Equador, El Salvador, Guatemala, Honduras, Mexico, Paraguay and Venezuela. It is also noted that the SAI of Nicaragua participated in the planning phase.

The purpose of the audit was to evaluate the public policies for the inclusion of renewable sources in the electricity generation mix of the participating countries, including the international commitments assumed, as well as related governmental guidelines. To achieve this purpose, the following objectives were established:

1. To identify the current situation of the electricity generation mix in each of the participating member countries of OLACEFS;

2. To assess if there are public policies established for the scope of the national and/or international commitments

assumed for the expansion of renewable energy in the electric power sector, especially for the achievement of the Sustainable Development Goals and the Paris Agreement;

3. To analyze the investments in infrastructure for the generation of sustainable electrical energy (water, wind, solar, biomass, tidal, etc.) and possible existing barriers to the insertion/expansion of this infrastructure, especially concerning aspects related to operational challenges, regulatory issues, subsidy and promotion policies, energy security, price of energy, tariff modulation, among others.

To guide this approach, the following audit questions were defined:

Question 1: Are there clearly defined **governmental guidelines and commitments** to promote the substantial increase of the share of renewable sources in the electricity generation mix until 2030?

Question 2: Are there **public policies** for the sustainable increase of the effective share of renewable sources in the electricity grid?

Question 3: Do the **actors involved** in the policy of insertion of renewable sources in the electricity grid **act in a coherent and coordinated manner among themselves?**

Question 4: Are there **instruments or strategies aimed at adapting the electric power sector** to the characteristics of renewable sources, guaranteeing access to reliable energy, sustainable and affordable?

The link to all documentation on the preparation, execution and comprehensive audit report is available on the Internet at http://www.tcu.gov.br/energiasrenovaveis.

Finally, it should be noted that, given the importance of the expansion of renewable energy for mitigating the effects of climate change, this control action has the technical support of the German Cooperation, through the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), within the scope of the project Strengthening External Control in the Environmental Area, which is being implemented in partnership with the TCU and OLACEFS.

PART 2

2. OVERVIEW

2.1. Global agenda for a clean energy mix

After the Industrial Revolution, energy exploitation models were based mainly on the use of fossil sources such as coal and oil. For this reason, a global energy mix has been created that is extremely dependent on fossil fuels. Concerns about economic and climate issues led to a movement to develop sources that were less susceptible to changes in oil prices and less polluting. On the climate side, evidence of the effects of GHGs on global warming and their consequences contributed to the search for alternative sources.

The worldwide strategy to mitigate and confront global warming led to the signing of international commitments, such as the Paris Agreement, signed at the 21st Conference of the Parties (COP 21) in 2015, which establishes the objective of its signatories to limit the increase in the average temperature of the planet to well below 2°C, in relation to pre-industrial levels, with the adoption of efforts to limit this increase to 1.5°C, since it is recognized that this action would significantly reduce the risks and impacts of climate change. To achieve this goal, each participating government is formulating its Nationally Determined Contributions (NDCs), which outline each country's strategies for reducing GHG emissions. The transition to a cleaner energy mix is considered one of the main ways to achieve the desired goals.

The expansion of renewable energy in the energy mix is also part of the United Nations (UN) 2030 Agenda, which, in December 2015, established an international action plan structured in seventeen Sustainable Development Goals (SDGs), broken down into 169 objectives and 232 indicators, which address fundamental issues for achieving sustainable development. These topics cover three dimensions: economic, social and environmental.

The SDG 7 is directly related to the increase of renewable energy in the energy mix - "Ensure access to affordable, reliable, sustainable and modern energy for all," - more specifically goal 7.2 - "By 2030, increase substantially the share of renewable energy in the global energy mix." Other SDGs that relate to the topic of energy transition are 11 - "Make cities and human settlements inclusive, safe, resilient and sustainable" and 13 - "Take urgent action to combat climate change and its impacts."

The renewable energy mentioned in the SDGs covers several sectors, such as electricity, industry, and transport, for example. However, the insertion of renewable energy has been mostly carried out in the worldwide electric power sector, especially as a result of the marked decrease in the costs of sources such as wind and solar photovoltaic in recent years. In this sense, the concentration of this audit in the generation of electricity is justified.

The percentage of clean energy in this sector has been growing year after year, except in 2018, where there was a small increase in the percentage of non-renewable sources, as shown in Table 1.

Table 1 - Share of renewable energy in the worldwide production of electrical energy (2013-2018)

SOURCE	SHARE %					
	2013	2014	2015	2016	2017	2018
Non-renewable energy	77,90%	77,20%	76,30%	75,50%	73,50%	73,80%
Renewable Energy	22,10%	22,80%	23,70%	24,50%	26,50%	26,20%
Hydroelectric	16,40%	16,60%	16,60%	16,60%	16,40%	15,80%
Wind	2,90%	3,10%	3,70%	4,00%	5,60%	5,50%
Bioenergy	1,80%	1,80%	2,00%	2,00%	2,20%	2,40%
Photovoltaic solar	0,70%	0,90%	1,20%	1,50%	1,90%	2,20%
Geothermal, concentrated solar power (CSP), tidal	0,40%	0,40%	0,40%	0,40%	0,40%	0,40%

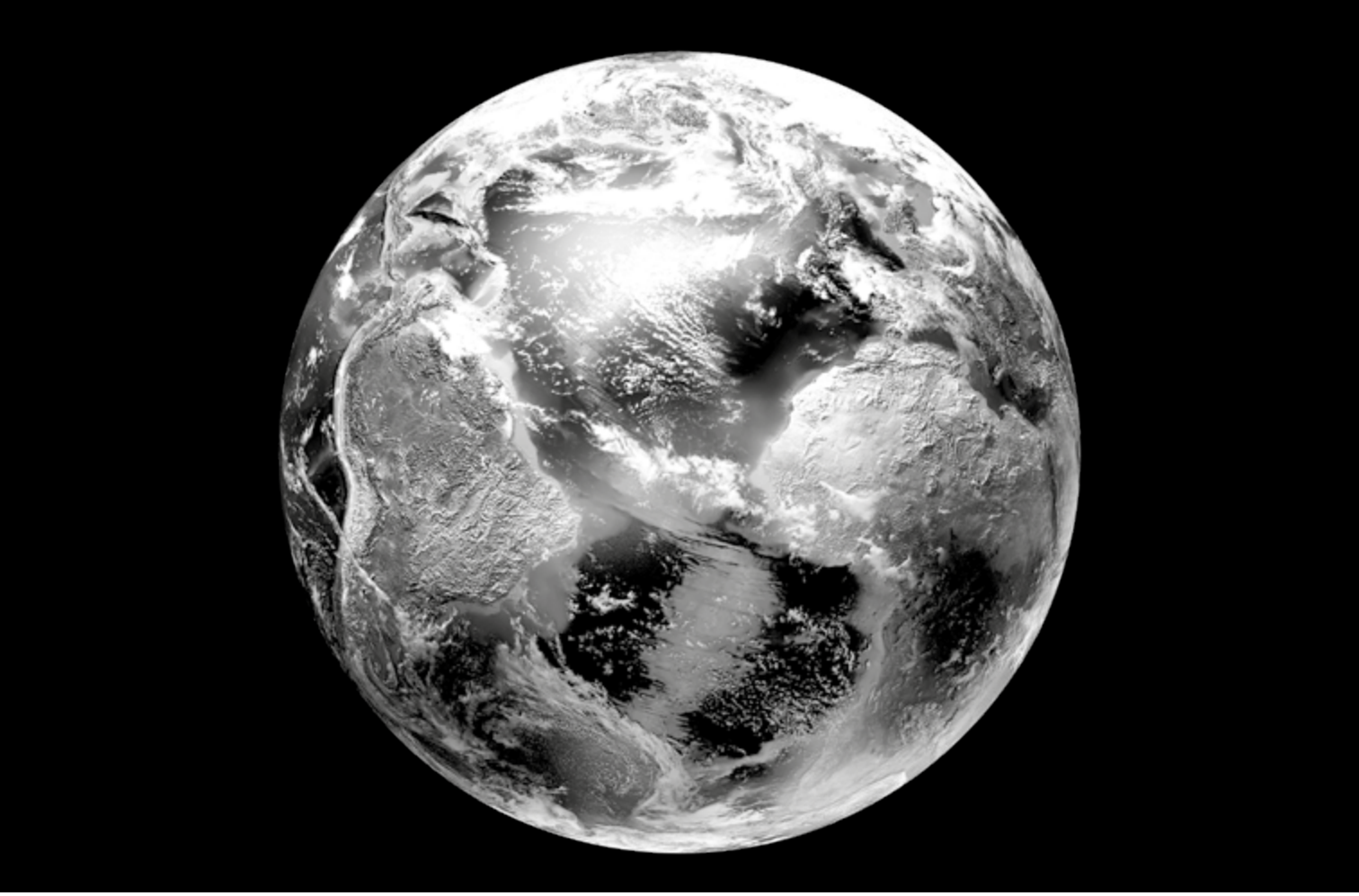
Source: REN21 (www.ren21.net, accessed: 7/31/2019)

According to data from the International Renewable Energy Agency (IRENA), in just over a decade, the installed capacity for the generation of electricity through renewable energy, including conventional ones, more than doubled from 1,058 GW in 2008, to 2,356 GW in 2018. Although it is not yet possible to correlate the growth of installed capacity for electric power generation from renewable sources with the aforementioned multilateral commitments, in the last three years, 163 GW in 2016, 167 GW in 2017 and 177 GW in 2018 were added to the worldwide electricity generation mix, as seen in Table 2.

Table 2 - World electricity supply capacity from renewable sources, including conventional sources (2008-2018)

SOURCE	ELECTRIC POWER GENERATION CAPACITY (GW)										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Hydroelectric	957	991	1024	1056	1088	1135	1174	1210	1244	1274	1295
Tidal	0	0	0	1	1	1	1	1	1	1	1
Wind	116	150	181	220	267	300	349	416	467	515	564
Solar	15	24	42	74	104	140	176	222	296	388	486
Bioenergy	55	62	67	73	78	85	91	97	105	112	118
Geothermal	9	10	10	10	10	11	11	12	12	13	13
TOTAL	**1.152**	**1.236**	**1.324**	**1.433**	**1.548**	**1.671**	**1.802**	**1.958**	**2.124**	**2.302**	**2.477**

Source: IRENA (http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=54, accessed on 7/31/2019).



The data in Table 2 also demonstrate an exponential growth of wind and solar sources in the last decade, which added, respectively, 452 GW and 471 GW to the worldwide installed capacity between 2008 and 2018. This represents 71.1% of all additional renewable energy supply in the period.

This evolution is largely explained by the concentration of investments in these two sources. In Table 3, the data on investments by technology in the period from 2013 to 2017 follow, which indicate that wind and solar generation received 92.60% of investments in renewable energy in that period.

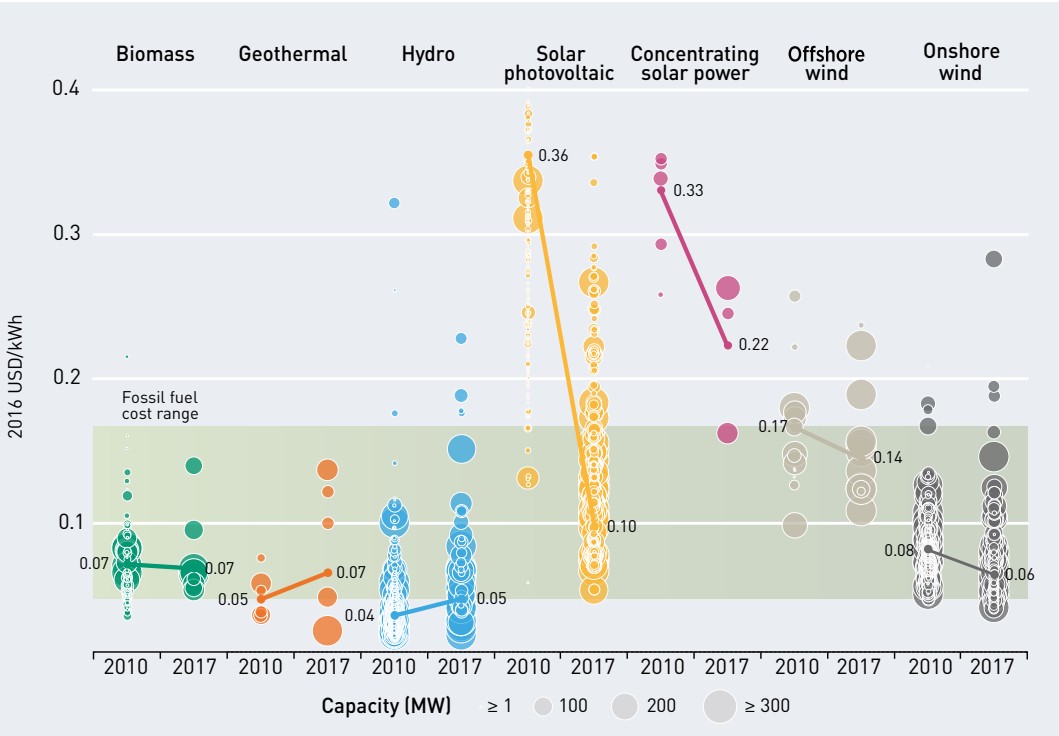
Table 3 – World investments in renewable energy - 2013 to 2017 (billions of US$)

Technology investments	2013	2014	2015	2016	2017	% of Share 2013-2017
Solar	119,9	145,3	179,3	136,5	160,8	53,15%
Wind	86,4	110,7	124,7	121,6	107,2	39,45%
Biomass and transformation of waste in energy	14,0	12,7	9,4	7,3	4,7	3,45%
Hydro <50 MW	5,8	7,0	3,6	3,9	3,4	1,70%
Biofuels	5,2	5,2	3,5	2,1	2,1	1,30%
Geothermal	2,8	2,9	2,5	2,5	1,6	0,88%
Tidal	0,2	0,3	0,2	0,2	0,2	0,08%
NEW INVESTMENTS TOTAL	**234**	**284**	**323**	**274**	**280**	**1.396**

Source: IRENA (http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=54, accessed 7/31/2019).

The increase in the capacity to generate electrical energy from renewable sources has been accompanied by a decrease in the average cost of these sources, as shown in Figure 1.

Figure 1 - Worldwide average cost of electricity generated in large-scale renewable plants - 2010 and 2017



Source: IRENA, 2018 (International Renewable Energy Agency. Statistics time series. Available at: http://resourceirena.irena.org/gateway/dashboard/index.html, accessed on Aug 20, 2018, p. 17).

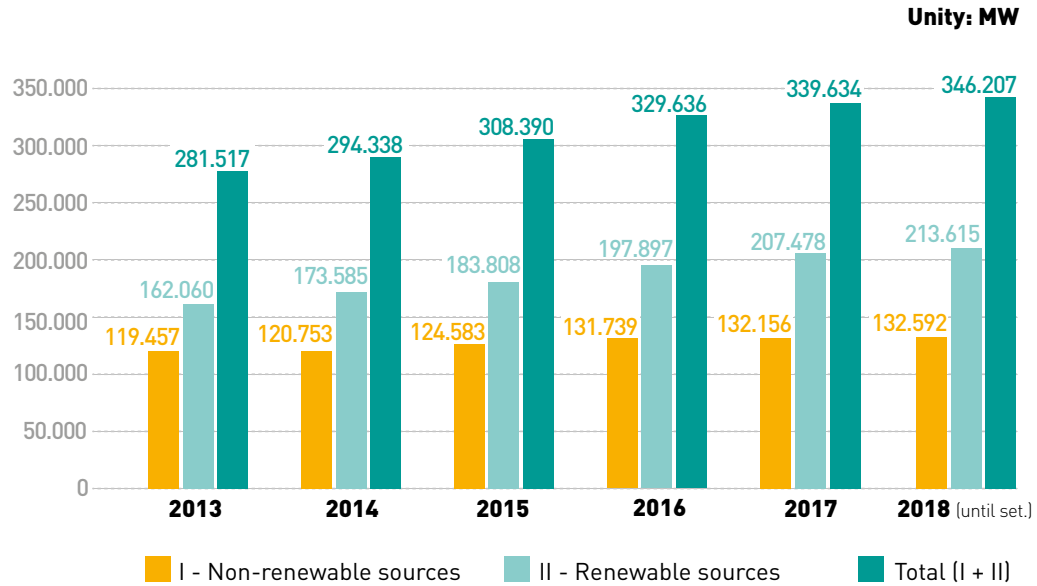
The figure analyzes the projects for the years 2010 and 2017. The size of the circles reflects the size of the undertaking according to installed capacity, and the location of the circle indicates the cost of energy in US$/MWh. The weighted average energy price is calculated for each of the years (2007 and 2017). The line indicates the price trend from 2007 to 2017.

According to IRENA data, at the end of 2018, the five countries with the largest installed capacity of renewable energy sources were China, the United States, Brazil, Germany, and India, in that order. China alone is responsible for 29.60% of the world's total renewable energy capacity, including conventional energy, with a total of 696 GW of installed capacity, compared to 136 GW installed in Brazil, which ranks third (Renewable Energy Statistics / IRENA 2019).

2.2. Status of renewable energy in the electricity generation mix of participating countries

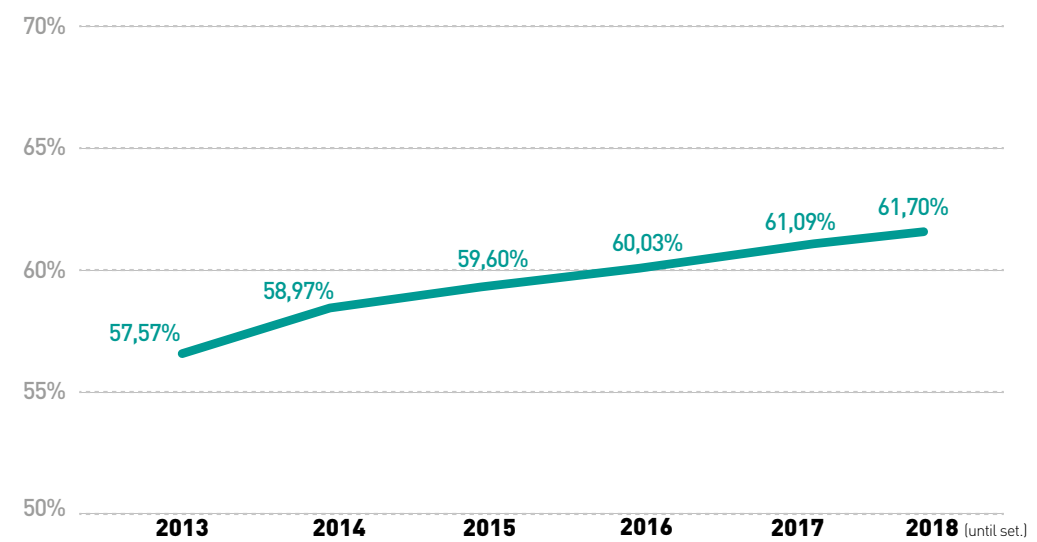
The consolidation of the evolution data of the installed capacity of the participating countries in the last five years shows the evolution of renewable and non-renewable sources, as shown in Figure 2.

Figure 2 - Evolution of installed capacity for generation of electrical energy in participating countries - 2013 to September 2018



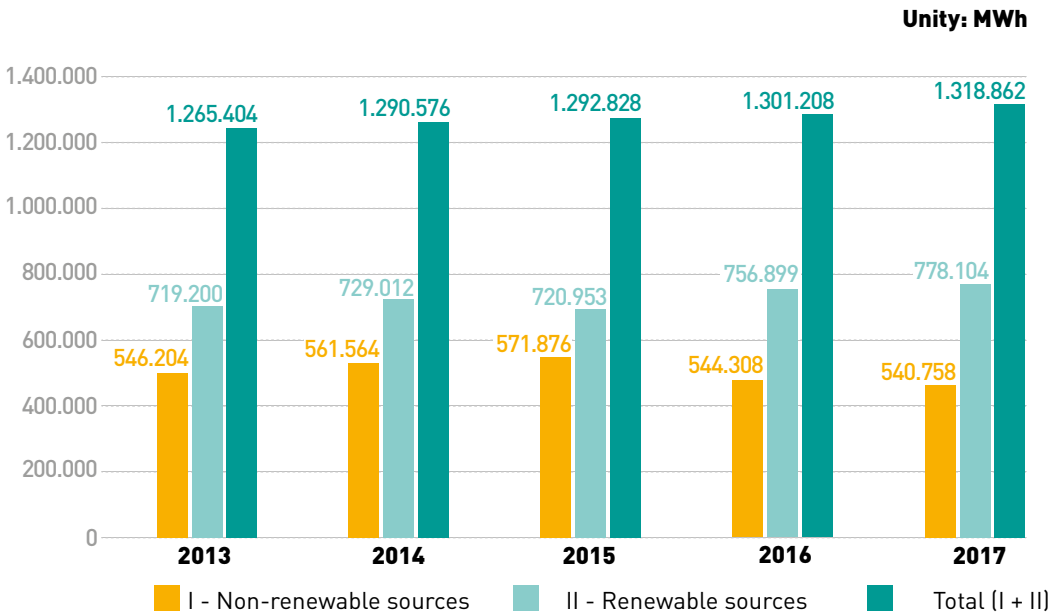
It is also noted that the growth of renewable energy is higher than non-renewable energy. When comparing the percentage of clean energy in the installed capacity in 2013 and in September 2018, an evolution from 57.57% to 61.70% is verified, according to Figure 3.

Figure 3 - Percentage evolution of renewable sources in the installed capacity for the generation of electrical energy in the participating countries - 2013 to September 2018



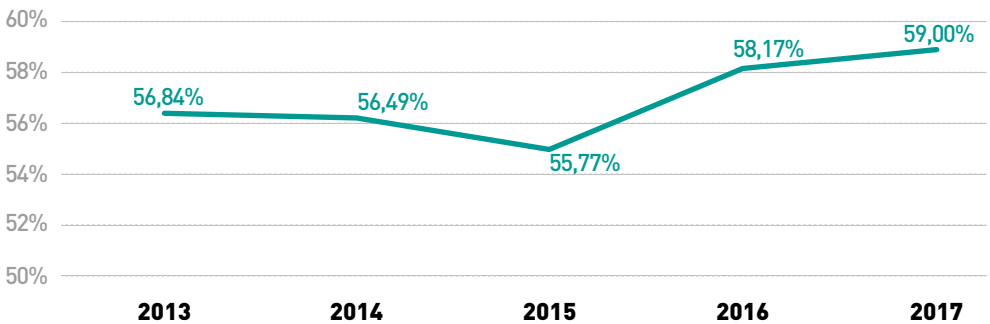
The effective generation of electricity also grew continuously in the period from 2013 to 2017, according to Figure 4.

Figure 4 - Evolution of effective generation of electrical energy in the participating countries - 2013 to 2017



Although the percentage of installed capacity of renewable energy grew steadily in the period, it did not occur in terms of effective generation, as there was a slight decrease in 2014 and 2015. However, considering the entire period, there was an increase from 56.84% in 2013 to 59.00% in 2017, according to Figure 5.

Figure 5 - Percentage evolution of renewable sources in the effective generation of electrical energy in the participating countries - 2013 to 2017



It is noteworthy that much of the evolution of installed capacity and the effective generation of electricity is explained by the behavior of the electric power sectors of Brazil and Mexico, given their high representation in the consolidated results of the countries, as shown in Table 4.

Table 4 - Share of each country in the installed capacity and total effective generation

	INSTALLED CAPACITY		EFFECTIVE GENERATION	
	MW	Relative share of participating countries, in%	GWh	Relative share of participating countries, in%
BRAZIL	161.019	46,47%	587.962	44,57%
CHILE	23.655	6,83%	74.136	5,62%
COLOMBIA	17.313	5,00%	66.667	5,05%
COSTA RICA	3.545	1,02%	11.210	0,85%
CUBA	6.479	1,87%	20.148	1,53%
Equador	8.162	2,36%	28.033	2,12%
EL SALVADOR	1.969	0,57%	6.652	0,50%
GUATEMALA	4.074	1,18%	11.490	0,87%
HONDURAS	2.637	0,76%	8.629	0,65%
MEXICO	76.825	22,17%	329.162	24,95%
PARAGUAY	8.883	2,56%	59.212	4,49%
VENEZUELA	31.958	9,22%	115.961	8,79%
TOTAL	**346.519**	**100%**	**1.319.262**	**100%**

Note: The installed capacity data refers to September 2018 and the effective generation data corresponds to energy production in 2017. This data includes all sources of electricity production, whether renewable or non-renewable.

In the appendix of the audit report, the main incentive policies and strategies for the insertion of renewable sources in the electricity generation mix of the participating countries are listed.

2.2.1. Brazil

Given the country's great hydroelectric potential, the Brazilian electricity generation mix has historically developed through the exploitation of hydroelectric energy, which led to the achievement of a fairly renewable energy mix. The composition of the installed capacity was complemented by thermoelectric power plants, both biomass and fossil fuels, which led to the formation of a hydrothermal mix. However, since the massive introduction of the wind source in recent years, the mix has changed its characteristics, although conventional hydroelectric generation prevails. The evolution of new renewable sources in the country was driven by holding auctions.

In September 2018, the installed capacity of renewable energy reached 132,159 MW, which corresponds to 82.08% of the country's total. In addition to the hydroelectric power plant with 63.55%, biomass and wind sources stand out with 9.15% and 8.31% of the total, respectively. The most notable feature is the low use of solar energy in relation to the country's potential - only 1,749 MW installed, which is equivalent to only 1.09% of the total

capacity. Regarding effective generation, in 2017, total production was 587,962 GWh, which 79.15% came from renewable sources.

2.2.2. Chile

The formation of the Chilean electricity generation mix was based on the use of thermoelectric power plants powered by fossil fuels, especially mineral coal and natural gas. More recently, the need to expand electricity supply and reduce greenhouse gas emissions, either through international agreements or duly legislated internal commitments, has forced the development of renewable energy in the country, especially wind and solar photovoltaic sources. This latter source has stood out even on a worldwide level since, given the existing public policies along with the excellent geographical and territorial conditions, the country managed to achieve one of the lowest prices for solar energy production.

In September 2018, renewable energy reached 10,933 MW, equivalent to 46.22% of the country's total installed capacity. Wind and solar represent, respectively, 6.44% and 9.61% of the electricity generation mix. Although these two sources have developed strongly in recent years, the country's main renewable energy is still hydroelectric, with 28.05% of the total. In terms of effective generation, the total electricity produced in the country in 2017 was 74,136 GWh, which 42.93% came from renewable sources.

2.2.3. Colombia

The Colombian electricity generation mix has historically been formed by taking advantage of the country's water resources through the construction of a predominantly hydroelectric system with a significant part of the thermoelectric power plants powered by fossil fuels, which eventually constituted a hydrothermal system. Non-conventional renewable energy such as biomass, wind and solar have not been meaningfully exploited yet. However, there is an ambitious government goal for 2022 that indicates 1,500 MW of non-conventional renewable sources in the country.

The installed capacity of renewable energy reached 12,010 MW in September 2018, which represents 69.37% of the total. Hydroelectric energy continues to stand out with 68.37% of the total, while combined non-conventional renewable energy - wind, solar and biomass - reaches only 0.97%. With respect to the production of electrical energy, in 2017 there were 66,667 GWh, which 86.98% of that amount came from clean sources.

2.2.4. Costa Rica

The development strategy of the Costa Rican electric power sector, since its inception, was based on the use of renewable sources, consolidating a predominantly hydroelectric mix. Shortly after, other clean sources, such as geothermal, wind, solar and biomass, were added, with a small part of thermal generation from fossil fuels. Even with a greater share of **intermittent sources**, the safety and quality of service aspects were not neglected. It is noteworthy that virtually the entire population of the country has access to electricity (99.39% of the population).

In September 2018, the installed capacity of renewable energy reached 2,973 MW, which corresponds to 83.86% of the country's total. In addition to hydroelectric energy with 65.98%, wind and geothermal sources, with 10.66% and 5.84% of the total, respectively, should be noted. As for the effective generation, in 2017, the figure was 11,210 GWh, which 99.67% was produced from renewable sources. Given the high percentage of renewable energy already achieved, the greatest challenge facing the Costa Rican electric power sector is to optimize the use of available sources.

2.2.5. Cuba

There has not yet been a significant evolution in renewable energy sources in Cuba. The electric power system is based on thermoelectric power plants driven mainly by imported fossil fuels. However, given the country's renewable energy potential, there is a forecast for the addition of clean energy. Government planning includes the construction of 19 thermoelectric power plants using biomass produced from sugar cane (approximately 755 MW); 13 wind farms (633 MW); 700 MW from solar photovoltaic energy, as well as 74 small hydroelectric power plants, representing a total addition of 2,144 MW of clean sources.

Currently, the total installed capacity of renewable energy reached 682 MW in September 2018, the equivalent of only 10.53% of the total. Sugarcane biomass stands out among the clean sources, with 7.53% of the total. In relation to effective generation, in 2017, production reached 20,148 GWh. Only 3.56% of this amount came from the production of electricity from renewable energy.

2.2.6. Equador

Thermoelectric power plants based on fossil fuels predominated in the formation of the Equadorian electric power system. However, the addition of more than 2 GW of hydroelectric energy in 2016, mainly as a result of the completion of the construction of the Coca Codo Sinclair hydroelectric power plant, has changed this perspective and made the electricity generation mix predominantly renewable. However, non-conventional renewable sources have not yet taken off in the country.

In September 2018, the country reached 4,779 MW of installed energy from renewable sources, equivalent to 58.55% of the total. Hydroelectric energy represents almost the entire renewable potential of the country with 54.93% of the total. In terms of effective electricity production, 28,033 GWh were generated in 2017, with renewable generation representing 73.69% of this total.

2.2.7. El Salvador

El Salvador has a predominantly renewable electricity generation mix, although thermoelectric power plants based on fossil fuels have an important share. There is a good diversification of clean sources, with a significant share of biomass, geothermal plants and the recent growth of solar energy. However, wind power has not been introduced in the country yet.

In June 2018, renewable capacity reached 1,212 MW, which corresponds to 61.55% of the total installed. Among the clean sources, hydroelectric, biomass and geothermal stand out, with 29.21%, 15.09% and 10.38% of the total, respectively. Although the wind source has not prospered in the country, solar photovoltaic energy has already reached 6.52% of total capacity with increases made since 2015. Regarding electric power generation, in 2017 there were 6,652 GWh, of which 56.99% came from renewable energy. The country's strategic planning foresees an even greater increase in the share of clean sources in electricity production, forecasting a 15% increase in relation to all energy produced.

2.2.8. Guatemala

Guatemala's electricity generation mix is predominantly renewable, but with a relevant share of thermoelectric power plants based on fossil fuels. The addition of renewable energy in recent years has reduced the dependence on fossil fuels for the production of electricity, which means that there has been an evolution towards clean sources in the mix. The national energy policy foresees that, by 2027, 80% of the electricity generation mix will be made up of renewable energy.

To get an idea of the evolution in the analyzed period, the share of clean sources in the Guatemalan electricity generation mix

increased from 55.46% in 2013 to 69.44% in September 2018 of the total installed capacity. This was the result of a 71.53% increase in installed renewable capacity in this period, with an increase of 1,180 MW. Among the clean sources, hydropower and biomass stand out, with 36.80% and 26.36% of the total installed, respectively. However, the installed capacity of other renewable energy is not yet representative, since geothermal, wind and solar sources together represent only 6.11% of the total. Regarding electricity generation, 11,490 GWh were produced in 2017. Of this amount, 69.89% came from the production of renewable plants.

2.2.9. Honduras

The increase in clean energy in recent years has considerably reduced the dependence on fossil sources in the electricity generation mix. It should be noted that this increase was due to the greater diversification of sources, since the insertion of non-conventional clean energy, such as solar, wind and biomass, was quite representative in the period analyzed. The country's planning is even more ambitious, as it estimates the share of renewable energy will reach 80% of total electricity generation by 2038.

The percentage of renewable energy in the installed capacity of the electric power sector increased from 43.80% in 2013 to 61.69% in September 2018. The growth of solar energy stands out, which did not exist in the country until 2014, but which, since 2015, was responsible for adding 451 MW to the mix and now corresponds to 17.10% of the total installed capacity. Other notable renewable sources of energy are hydroelectric, biomass and wind sources with 26.77%, 7.96% and 8.53% of the total, respectively. Regarding electricity generation, 8,629 GWh of electricity were produced in 2017, of which 61.20% came from renewable generation.

2.2.10. Mexico

Although non-conventional renewable sources such as wind and solar have grown considerably in recent years, the electricity generation mix remains predominantly fossil-fuel based. The main fuel for electricity generation is natural gas since the thermoelectric power plants that work with this energy represent more than half of the country's installed capacity.

The country's renewable capacity represented 26.56% of installed capacity, according to data from June 2018. Among the clean sources, hydroelectric, wind and solar stand out with, respectively, 16.40%, 5.68% and 2.14% of the total. Moreover, nuclear energy, considered clean in this country, represents 2.09%. In relation to generation, 329,161 GWh of electrical energy were produced in 2017, the second largest production among the countries analyzed. The share of renewable energy in this total was 15.55%. However, in the Mexican NDC, a goal was established to increase clean energy generation to 37.7% of the total in 2030.

2.2.11. Paraguay

Paraguay's electricity generation mix is practically formed by **conventional renewable energy** (water) due to the country's share in the binational hydroelectric dams of Itaipú and Yacyreta, which are among the largest in the world, and for the use of the Acaray national hydroelectric power plant. It is noteworthy that, even with the large installed energy capacity available from these hydroelectric power plants, the energy consumption per inhabitant is low due to the lack of adequate infrastructure (transmission and distribution) that allows better utilization of this great potential.

The country has plans to make improvements to the system of transmission and distribution of electrical energy to allow access to energy at all social levels, as well as the expansion of other clean energy, such

as solar photovoltaic and the installation of small hydroelectric power plants.

2.2.12. Venezuela

Venezuela has a well-divided electricity generation mix between thermoelectric power plants based on fossil fuels and large hydroelectric power plants. Non-conventional renewable energy has not yet gained ground in the country. The existence of subsidies for fossil fuels, which make these sources more competitive, in addition to the lack of private market participation and the economic blockade suffered by the country, limit investments in new technologies and slow down a larger diversification of clean sources in the Venezuelan electric power system. There are goals for the installation of photovoltaic wind and solar systems, mainly to serve isolated communities.

In 2016, renewable sources reached 47.53% of total installed capacity. Hydroelectric energy stands out with 47.36% of the total, that is, practically all of the installed renewable potential. In terms of electricity generation, Venezuela had a production of 115,961 GWh in 2016, which 54.12% came from hydroelectric generation.

PART 3

3. AUDIT RESULTS

3.1. Government commitments and guidelines for the expansion of renewable sources in the electricity generation mix

All countries participating in the audit are signatories of the 2030 Agenda for Sustainable Development and the Paris Agreement. These countries formulated their NDCs at the national level and presented them to the United Nations Framework Convention on Climate Change.

In general, each country has assumed GHG reduction commitments through one or more global goals, i.e., goals that are transversal to the entire economy. Regarding the specific contribution of the electric power sector to the NDCs, Cuba, El Salvador and Venezuela presented mandatory goals. Brazil, Colombia, Guatemala and Mexico, in turn, have established only optional/indicative goals to achieve the planned total reduction, which means that failure to meet the objective related to the electric power sector can be compensated by exceeding the guidelines of other sectors. Chile, Costa Rica, Equador, Honduras and Paraguay did not set specific goals in the text of their NDCs, however, they established them in national plans, programs, and laws.

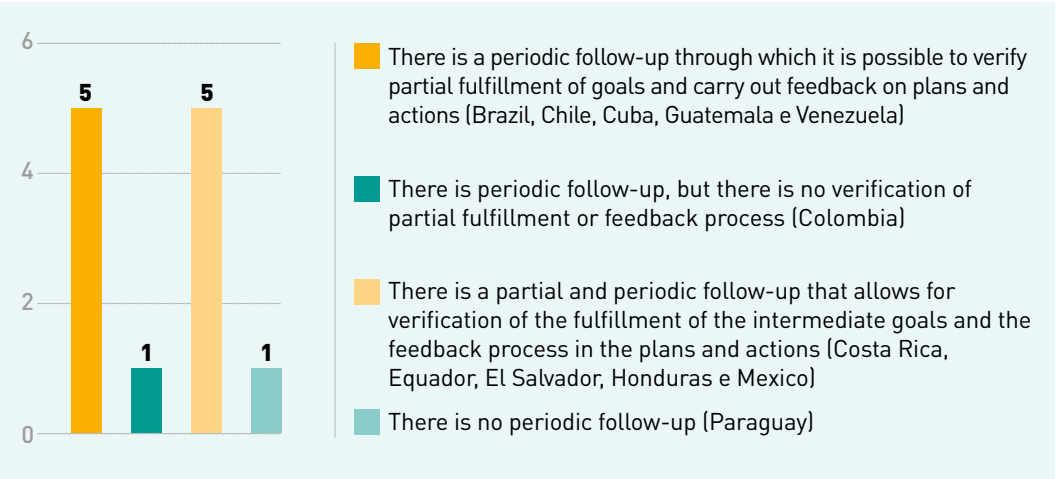
Concerning the relevance of the electric power sector for the reduction of GHG emissions, it is considered that, in the cases of Cuba, Chile, Equador, Guatemala, Honduras, Mexico and Venezuela, the greater substitution of fossil fuels by renewable sources in electricity production is important, since more than 10% of total emissions come from this sector. In other countries - Brazil, Colombia, Costa Rica, El Salvador and Paraguay – electricity generation does not reach this percentage of share in emissions. However, in a likely scenario of an increase in the fleet of electric vehicles, with the consequent increase in electricity consumption, the transition to renewable energy in this sector may gain greater importance in the future in terms of GHG reduction.

Regarding the existence of national guidelines and goals for the expansion of renewable sources, Figure 6 shows four different situations identified in the audited countries, namely: clearly defined goals; defined but partially clear goals; partially defined and partially clear goals; partially defined goals; and unclear goals.

Figure 6 - National guidelines and goals for the expansion of renewable sources

Regarding the periodic follow-up of the objectives and goals established in SDG 7.2, NDC and national targets, as shown in Figure 7, the following situations were found: there is a periodic follow-up through which it is possible to verify partial fulfillment of goals and carry out feedback on plans and actions; there is periodic follow-up, but there is no verification of partial fulfillment or feedback process; there is a partial and periodic follow-up that allows for verification of the fulfillment of the intermediate goals and the feedback process in the plans and actions; currently, there is no periodic follow-up.

Figure 7 - Periodic follow-up on objectives and goals



Concerning the effort related to the established goals, it was considered that Colombia, Cuba, El Salvador, Honduras, Mexico and Venezuela adopted commitments that portray a real governmental effort for a greater introduction of renewable sources in their electric power sector, which means that the guidelines are bold in the sense of providing substantial progress in the sector concerning the increase in

renewable sources in the mix and, therefore, demand relevant action from the government for their achievement. In the cases of Brazil, Equador, Guatemala and Paraguay, it was verified that the established goals portray only a partial government effort since the established goals will probably be reached, demanding a reasonable participation of the government to make them concrete. In the case of Costa Rica, given its almost 100% renewable electricity generation mix, it was considered that the commitments established do not represent a government effort, which should be more to optimize existing capacity rather than a greater addition of clean sources per se.

In addition to the overview of guidelines and goals, the audit findings described in Box 2 were found.

Box 2 - Guidelines and goals: findings and opportunities for improvement

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Outdated data on GHG emissions, which makes it difficult to follow possible progress in relation to reductions (Brazil, Colombia, Costa Rica, Cuba, Equador, El Salvador, Guatemala, Honduras, Mexico, and Paraguay).	Periodic communication of the evolution of the share of electric power generation in total emissions to identify the effectiveness and efficiency of policies to increase renewable energy in the electricity generation mix (Brazil, Colombia, Costa Rica, Cuba, Equador, El Salvador, Guatemala, Honduras, Mexico, and Paraguay).
Deficiencies in the definition of guidelines and goals, which are fundamental for the further expansion of renewable sources in the electricity generation mix (Brazil, Costa Rica, Equador, El Salvador, Honduras, and Paraguay).	Establishment of a national policy for the expansion of **distributed generation** (Brazil, Paraguay).
	Establishment of guidelines for the best use of existing installed capacity to optimize the system (Costa Rica).
	The planning instruments include the forecast of specific goals for the increase in non-conventional renewable energy (Equador).
	Updating or formalizing a national policy for the evolution of the energy mix to establish guidelines and goals to realize the energy transition (El Salvador, Honduras).

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Problems in the follow-up of the goals or guidelines due to the lack of adequate monitoring or deficiencies in the established indicators (Colombia, Costa Rica, Cuba, Equador, Honduras, Mexico, and Paraguay).	Establishment of annual goals for more precise follow-up on the scope of the established guidelines (Colombia).
	Establishment of indicators that measure the evolution of the optimization of installed capacity (Costa Rica).
	Development of a single regulatory instrument for systematizing the process of follow-up, reviewing and providing feedback on goals and guidelines (Cuba).
	Improvement of the articulation between government bodies to implement adequate technical instruments and methodology to carry out the follow-up, monitoring, and evaluation of results, as well as feedback on planning instruments (Equador, Honduras, Mexico and Paraguay).

The following were also identified as good practices:

CHILE: Preparation of the national inventory of evolution of GHG emissions with a long-term series (1990-2016) including the methodologies, activity data and emission factors used for the estimation in all the sectors analyzed.

EQUADOR: The establishment of a pilot project by the Equadorian government in the isolated system of the Galapagos Islands. In this project, called the "Zero Fossil Fuels Initiative in Galapagos", a set of goals and guidelines are designed for the replacement of electric generation based on thermoelectric power plants powered by fossil fuels for energy production through renewable sources, especially for the use of solar and wind energy.

3.2 Public policies for the sustainable increase of renewable sources in the electricity generation mix

Regarding the definition of incentive policies and strategies for the insertion of renewable sources, it was observed that in a large part of the countries - Brazil, Chile, Colombia, Costa Rica, Guatemala, Honduras and Mexico - these initiatives are properly regulated, structured and systematized. On the other hand, in Equador, El Salvador, Cuba, and Venezuela, the absence of a better structuring of these policies was verified.

In the case of attributions and responsibilities for the implementation of public policies, it was observed that, in all countries audited, there is already a clear definition of the role of each government body or entity in the process of increasing renewable sources for electricity production.

Concerning the alignment of incentive policies with the established strategies, in the following countries, there is a provision of their initiatives with the positive guidelines: Chile, Colombia, Costa Rica, Cuba, Honduras, Mexico and Venezuela. In the other countries - Brazil, Equador, El Salvador and Guatemala - this provision was found to be partial.

Similarly, it was detected that policies and incentives are coherent among themselves in the following countries: Chile, Colombia, Costa Rica, Cuba, Honduras, and Mexico, while in the others - Brazil, Equador, El Salvador, Guatemala and Venezuela - inconsistencies were found among the established strategies, given there are contradictory incentives regarding a greater insertion of renewable sources in the electricity generation mix.

In regards to the access to information, it was found that in most of the participating countries - Brazil, Chile, Costa Rica, Cuba, Equador, El Salvador, Guatemala, Honduras and Mexico - there is already technical information available to those interested in the development of public policies in the energy area. Colombia and Venezuela were the only countries in which some kind of hindrance to access to information requiring government measures for the expansion of transparency was found.

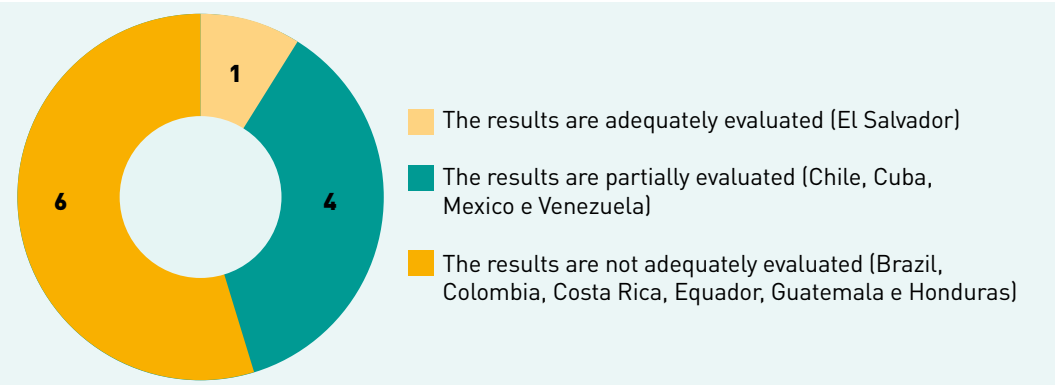
Regarding the influence of citizens in the processes of formulation and review of public policies, it was found that Brazil, Chile, Costa Rica, Cuba, Equador, El Salvador, Paraguay and Venezuela have already adopted transparency practices that stimulate such participation. However, in Colombia, Guatemala, Honduras and Mexico, only partial citizen engagement practices have been adopted, indicating the need for measures to expand these practices.

It was verified that the definition of incentives for the increase of renewable sources was made according to studies or objective criteria in: Chile, Costa Rica, Cuba, Equador, El Salvador, Guatemala and Venezuela, while in others - Brazil, Costa Rica, Honduras and Mexico - not all incentives started from studies or objective criteria, exposing the opportunity for improvement in the processes of policy definition.

Another important perceived situation was the lack of mechanisms of progressive reduction in the incentives established in most countries, which can culminate in an undue perpetuation since policies established at present may be unnecessary or inefficient in the future. Honduras was the only country in which there was, systematically, concern with the establishment of mechanisms of progressive reduction of incentives for the increase of renewable sources in the mix.

Regarding the evaluation of the results of the incentives, three different situations have been found, illustrated in Figure 8: the results are adequately evaluated; the results are partially evaluated; the results are not adequately evaluated.

Figure 8 - Evaluation of incentive results



It is emphasized that the lack of adequate evaluation results in problems in the process of monitoring and reviewing the incentives since it prevents knowledge of the effectiveness and efficiency of the established strategies.

Finally, it is highlighted that, in the case of Paraguay, the evaluation was impaired concerning this topic since there are no standardized incentive policies that seek to increase renewable sources in the electricity generation mix; however, there are initiatives such as Decree 6092/16, which approves the Energy Policy, where objectives and targets are mentioned to contribute to and encourage the use of alternative, non-conventional sources."

In addition to the initial outlook, the following audit findings were observed, described in Box 3, related to public policies for the sustainable increase of renewable sources in the electricity generation mix.

Box 3 - Public policies for renewable energy: findings and opportunities for improvement

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Scarcity of incentive policies for the sustainable expansion of the electricity generation mix (Brazil, Colombia, Costa Rica, Equador, El Salvador, Honduras, and Mexico).	Definition of objective criteria taking into account economic, social and environmental aspects to choose the sources that will be the objective of the auctions for the expansion of the supply of electrical energy (Brazil).
	Conducting preliminary studies to measure the advantages and disadvantages of each strategy, so that they can help in making decisions to make them more efficient (Colombia and Honduras).
	Formulation of policies to further optimize the sources already available in their installed capacity (Costa Rica).

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Scarcity of incentive policies for the sustainable expansion of the electricity generation mix (Brazil, Colombia, Costa Rica, Equador, El Salvador, Honduras, and Mexico).	Establishment of specific strategies for non-conventional renewable energy for higher diversification of the electricity generation mix (Equador, El Salvador, Mexico, and Venezuela).
	Improve the interconnection of the electrical grids between the different regions as a way of mitigating the variability of wind and solar sources (Equador, Honduras, and Mexico).
	Creation of incentives for distributed generation, efficient **cogeneration**, technologies that use biofuels, **smart grids** and tax collection on fossil fuel production (Mexico).
Inconsistency between established strategies and government guidelines to increase the percentage of renewable sources (Brazil, Equador, El Salvador, Guatemala, Mexico, Paraguay, and Venezuela).	Revision of the regulation that brings incentives for the generation of electrical energy from fossil sources (Brazil, Equador, El Salvador, Mexico and Venezuela).
	Revision and approval of laws that are consistent with government goals for increasing renewable energy (Guatemala).
	Strengthening of the institutions responsible for energy policies (Paraguay).
Incentive policies are not at an adequate level of transparency or lack of support for popular participation in the formulation of initiatives (Colombia, Guatemala, Honduras, Mexico, Paraguay, and Venezuela).	Creation of incentives to the participation of diverse actors through greater integration of communication spaces in channels with two-way interactions that guarantee the engagement of citizens in the formulation of policies (Colombia, Guatemala, Honduras and Paraguay).
	Clear definition of guidelines and mechanisms for promoting citizen engagement, so that positive initiatives such as **public hearings** and **consultations** can be taken (Guatemala and Mexico).
	Opening of information from the electric power sector in order to allow a greater influence of different stakeholders in the formulation of government strategies for the insertion of renewable energy in the electricity generation mix (Venezuela).

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Lack of evaluation of the results of the incentives granted to renewable sources, which creates a risk that the strategies adopted are not justified in terms of cost-benefit.	Adoption of an action plan for the systemic evaluation of the results of public policies aimed at increasing renewable sources to provide inputs for their improvement including, if necessary, an evaluation of the need to maintain incentives or to foresee their gradual reduction (Brazil, Chile, Colombia, Costa Rica, Cuba, Equador, El Salvador, Guatemala, Honduras and Mexico).

The following were also identified as good practices:

BRAZIL: the creation of mechanisms to value and encourage the adoption of more economic and less polluting solutions in auctions for the contracting of energy for isolated systems, such as the possibility of building **hybrid plants (hybrid systems)** that use two or more sources.

BRAZIL AND COSTA RICA: the holding of public hearings (in person) and public consultations (online) on government proposals related to the formulation, modification or regulation of the main policies, the development of planning instruments, and other activities related to the public sector, including issues related to renewable sources

CHILE: the establishment of schedule blocks in the tender criteria, allowing for certain intermittent renewable sources to be favored, for example, the solar photovoltaic, which can offer better prices on its optimal production schedule.

The consolidation of an integrated and long-term national energy policy called Agenda 2050, built through the collaboration of a wide range of relevant actors and that favors the sustainable expansion of the electricity supply.

The participation of indigenous communities in the formulation of energy policies.

The following were also identified as good practices:

EL SALVADOR: the creation of the "National Council for Environmental Sustainability and Vulnerability (Conasav)", a plural and autonomous consultative body for dialogue and agreement in terms of environmental sustainability and vulnerability that seeks to respond to the country's needs in terms of inclusion and citizen engagement.

HONDURAS: the systematic presentation of mechanisms of progressive reduction of incentives granted to renewable sources, facilitating their withdrawal or not postponing them in case they are inefficient.

VENEZUELA: the implementation of a government program called "Sembrando Luz" for the supply of electrical energy in isolated communities through hybrid systems of wind and solar energy.

3.3. Coordination between actors involved in the expansion of renewable energy

Regarding the coordination of actions necessary for the increase of renewable energy in the electric power sector, it was verified that the coordinating authority is well defined in Brazil, Chile, Colombia, Costa Rica, Cuba, Equador, Guatemala, Honduras and Mexico. However, only in Chile and Cuba it was considered that the coordinating entity fully exercises its function of articulating and aligning actions among the various key actors. El Salvador, Paraguay and Venezuela present an unsatisfactory definition of the coordinating authority, which also results in failures in the articulation of actions.

Concerning the functions, actions or competencies of the various bodies and entities responsible, no overlap was identified in their attributions in most of the countries - Brazil, Chile, Costa Rica, Cuba, Equador, El Salvador, Guatemala and Mexico. However, Honduras and Paraguay presented a wide overlap of functions, resulting in an undefined definition of responsibilities of each government entity involved. In Venezuela, on the other hand, there is no institutional coordination for policies to increase renewable energy, which potentiates the risk of overlapping functions.

In regards to the participation of governmental entities that have attributions attached to the entities of the energy sector, such as the environmental bodies, it was found that their opinion is considered at the moment of defining and implementing public policies in Brazil, Chile, Colombia, Cuba, Equador, Honduras and Mexico. Costa Rica, El Salvador and Paraguay have their entities partially considered, while in Venezuela and Guatemala their opinion is not taken into consideration in any way.

Concerning the coordination between actors involved with the expansion of renewable sources, the situations described in Box 4 were found.

Box 4 – Coordination and articulation between actors: findings and opportunities for improvement

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Failures in the coordination of policies for the insertion of renewables in the electricity generation mix (Costa Rica, El Salvador, Mexico, Paraguay and Venezuela).	Formalizing and systematizing coordination actions and mechanisms (El Salvador and Mexico)
	Creation of a ministry responsible for energy policy (Paraguay).
	Application of controls by the granting power so that grid expansion occurs in a way that optimizes existing energy resources (Costa Rica).
Deficiencies in the articulation between the actors responsible for the policies of the insertion of renewables in the electricity generation mix(Brazil, Colombia, Cuba, Equador, El Salvador, Honduras, Mexico and Paraguay).	Formalizing a document that systematizes the articulation between the different actors (Cuba, El Salvador, Mexico, and Paraguay).
	Formalizing how articulation occurs between entities for the development of planning instruments and the inclusion of the entity responsible for the area of transportation in discussions that serve as subsidies for energy policy decisions (Brazil).
	Unification of committees for monitoring policies regarding GHG emission reduction objectives (Colombia).
Failures in the participation of important actors for the formulation of more effective and efficient policies (El Salvador, Guatemala and Paraguay).	Developing and formalizing a document that systematizes the articulation and participation of key actors in public policymaking, especially social and environmental entities (Paraguay and Guatemala).
	Updating energy policy to make it compatible with national environmental policy (El Salvador)

The following were also identified as good practices:

CHILE: the formulation and implementation of the national energy policy were carried out with the broad and structured participation of government bodies and other stakeholders who were integrated into groups, committees and roundtables. Particularly noteworthy is the participation of public entities responsible for socio-environmental licensing processes and climate change adaptation and mitigation measures, private-sector entities, universities, experts, industry associations, organized civil society and representatives of indigenous communities.

The following were also identified as good practices:

COSTA RICA: the participation of universities in the formulation of energy policies with actions aimed at research and innovation on several important themes for the increase of renewables in the mix, such as energy storage and the development of new technologies from non-conventional sources.

CUBA: existence of a national university network for the study of renewable energy sources, with working groups related to the development of these sources or solutions that favor their highest increase in the electricity generation mix, such as the creation of laboratories for the technological development of the photovoltaic solar energy and the study of energy storage technologies.

3.4. Instruments for adapting the electric power sector to the characteristics of renewable sources

As mentioned, the insertion of renewable sources in the electric power system encompasses several challenges to be faced that require adaptation measures to enable an increase in the energy mix. These measures are largely related to the high daily variability in the generation of energy from wind and solar photovoltaic sources, which present more viability for their expansion. The increase of these new intermittent sources causes a significant part of the installed capacity to become uncontrollable and often unavailable, compromising the possibility of injecting liquidity into the system in the traditional way.

This situation produces a new paradigm in the reliability of the system since the response capacity of residual generation to this variability is as important to guarantee the supply as the installed capacity is to attend the peak demand. Thus, the increase of solar and wind sources in electrical grids may lead to an increase in the use of **dispatchable plants** such as, for example, thermoelectric power plants, predominantly driven by fossil fuels, or hydroelectric power plants with storage reservoirs.

In other words, the increase of intermittent clean energy in the system may lead to a danger of increased GHG emissions due to the need for more frequent construction and distribution of plants with a higher level of GHG emissions. Therefore, it is necessary to look for alternatives that do not necessarily assume an increase in environmental impacts, as is the case with the development of energy storage systems, for example, restructuring the distribution for use of hydroelectric power plants with reservoirs as batteries, as well as chemical storage devices; expanding the use of biomass as fuel in thermoelectric power plants; construction of hybrid plants or systems that take advantage of the complementarity of the sources used; greater interconnection among electrical grids between regions or countries that make it possible to compensate for surpluses generated with reductions in local generation and, likewise, alternatives for optimizing existing installed capacity, such as demand management, the use of smart grids, and the use of price formation with higher **time granularity** in the

short-term market. These alternatives should be encouraged by public policies and by the adaptation of regulatory instruments.

Another challenge to be overcome in the field of renewable energy is the rational economic and environmental expansion of distributed generation. However, for the success of this new model, several adaptations are necessary, such as the adaptation of electrical grids for the injection of energy by **prosumers** and **self-producers** to enable the compensation of the energy produced, which requires investments. Also, adaptations to the legal regulatory framework are necessary to promote distributed generation since, while incentives are needed in this modality, such as the regulation of **Net Metering** or the **Compensation System**, it is also necessary to create mechanisms that indicate the value of the use of the electrical grid by prosumers, under penalty of damages to the distributors and the most vulnerable consumers who do not have sufficient resources for the initial investment required. In addition to providing a boost to new renewable sources, this distribution modality brings several advantages, such as avoided costs of centralized generation distant from consumer centers (and electric power losses along the transmission and distribution grids), as well as the postponement of investments in new plants and transmission and distribution lines, resulting in the reduction of environmental impacts caused by the construction of enterprises that would no longer be necessary. However, it has associated disadvantages, such as the absence of scale income from centralized generation, preparation of the distribution grid for energy flows - referring to the consumer unit - in all directions, and the absence of information that may induce consumers to make non-rational investments.

Faced with these challenges, it was verified that, in the audited countries, there are already several strategies, some already established and others still planned, for the adaptation of the electric power sector to a greater increase in renewable sources. Boxes 5 and 6 show, respectively, the existing and planned strategies, as well as the countries in which they are already applied or there is an implementation forecast.

Box 5 – Existing strategies for adapting the electric power sector to increasing renewable energy

STRATEGY	COUNTRIES
The model underlying decisions for an expansion of the electric power sector considers the intrinsic characteristics of the sources.	Costa Rica
Consideration of the impact of climate change in planning the expansion of the electric power system.	Brazil
Introduction of the **intraday market** of energy price formation in short-term market.	Chile
Use of studies or strategic plans that indicate the limit of the introduction of renewable sources, notoriously **intermittent**, as well as regulatory and technical solutions to guarantee a safe, reliable and economic operation of the system by adding these sources.	Chile | Colombia Costa Rica El Salvador Guatemala México
Establishment of hourly blocks in the tender criteria, allowing a greater insertion of **intermittent renewable energy** and its adequate price scale.	Chile

STRATEGY	COUNTRIES
Limiting self-production to a maximum percentage of own demand to prevent the production of energy by these users from affecting the role of the entities responsible for energy generation and distribution and, consequently, guarantee the balance of the system.	Costa Rica El Salvador
Establishment of distributed generation systems that allow for the supply of small loads in the event of natural disasters.	Cuba
Establishment of strategies for the installation of solar panels on premises that minimize transmission costs and variability problems.	Cuba
Use of an indicative plan for the expansion of electric power generation with a forecast of the sources that will enter the system.	Brazil | Costa Rica El Salvador
Prioritization of sending intermittent renewable energy sources (photovoltaic and wind) to generation plants.	Brazil | El Salvador Guatemala Honduras
Long-term contracts for the supply of electrical energy backed by renewable distributed generation.	El Salvador
Annual contracts that oblige the distribution companies to guarantee the supply of energy necessary to satisfy user demand, with penalties being imposed if the programmed requirements are not met.	Guatemala

Box 6 – Planned strategies for adapting the electric power sector to the increase in renewable energy

STRATEGY	COUNTRIES
Possibility of resuming the system's expansion strategy through the construction of new hydroelectric power plants with regularization reservoirs considering that the environmental impacts may be less than other dispatchable generation alternatives to compensate the intermittency.	Brazil Cuba
Introduction of the intraday market of energy price formation in the short term.	Brazil Colombia
Construction of a model that allows consideration of the increase in the complexity of the system with a greater introduction of renewable sources in the future planning of the expansion of the national electric power sector.	Brazil Costa Rica México
Improvement and expansion of the transmission and distribution system.	Chile Colombia Venezuela
Improvement in **auxiliary (complimentary) services** necessary for the adaptation of the operation of the electric power system to the increase in renewable energy and distributed generation.	Chile Colombia Costa Rica Honduras
Integration of battery systems into the electric power system.	Colombia

STRATEGY	COUNTRIES
Control by demand-side management of power system.	Colombia Costa Rica
Application in the planning of evaluation tools with higher time granularity.	Costa Rica
Higher diversification of the energy mix with a predominance of renewable energy through the implementation of geothermal plants, optimizing and potentiating hydroelectric power plants, and greater communication of solar and wind energy sources.	Guatemala
Revision of the law on the production and independent transport of electrical energy.	Paraguay
Carrying out studies to determine the potential of biomass as energy that can be dispatched to the interconnected system, including economic, technical and environmental variables.	Venezuela

Given the existence of strategies, planned or already implemented, in Chile and Cuba it was considered that the initiatives contemplate adequate solutions to reduce the environmental impacts of adaptation measures to intermittency. In other countries - Brazil, Colombia, Costa Rica, Equador, El Salvador, Guatemala, Honduras, Mexico and Venezuela - it was concluded that the strategies only partially contemplate solutions for this adaptation. In Paraguay, in turn, it was understood that the strategies do not contemplate the concern regarding the environmental aspect.

Another point highlighted concerning the expansion of renewable sources in the electric power system refers to the economic impact of the measure on electrical energy rates. The insertion of clean sources should not generate an increase in the price of energy, either in a shorter or longer time horizon, since this would make the expansion of the electric power system itself, and access to electrical energy, impracticable. It should be noted that the same SDG 7 indicates that, in addition to an expansion of renewable sources in the energy mix, it is necessary to expand electricity access to populations, especially those who do not have access to energy or whose access is restricted. Therefore, it is necessary to adequately assess the attributes of each source, in addition to their environmental impacts, including the weighting of services needed for an adaptation of the grid (auxiliary services), and the back-up cost for the expansion of intermittent sources.

Due to this concern, this audit also had the objective of investigating if the countries consider the real price of energy, present and future, in their forecasts for the expansion of the electric power system. In particular, it was questioned whether the strategies adopted take into account the following criteria that can influence the price of energy, either in the present or in the future: evolution of costs and technologies in the national or world scene; costs of flexibility solutions to supply the high variation of intermittent renewable energy; local peculiarities and other factors that can influence the formation of the price. It was verified that only Chile and El Salvador consider all these factors in their system expansion strategies. In contrast, Colombia and Venezuela do not consider any of the factors mentioned. However, a large part of those countries - Brazil, Costa Rica, Cuba, Equador, Guatemala, Honduras, Mexico and Paraguay - consider only some of these criteria.

Finally, regarding the instruments for adaptation of the electric power sector to the characteristics of renewable sources, the audit findings listed in Box 7 were identified.

Box 7 – Operational challenges: findings and opportunities for improvement

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Failure to adequately consider the direct and indirect environmental impacts resulting from the expansion of renewable sources (Brazil, Colombia, Guatemala, Honduras, Mexico and Venezuela).	Improved evaluation of the advantages and disadvantages of the different energy sources, considering all their attributes, especially concerning direct and indirect environmental impacts considering the complete life cycle, both for expansion planning and socio-environmental licensing processes (Brazil, Colombia, Honduras, Mexico and Venezuela).
	Better use of geothermal energy potential (Guatemala, Honduras and Mexico).
Weaknesses in government instruments to ensure that the expansion of renewable sources is done in a way that guarantees the reliability and economy of the electric power system (Colombia, Costa Rica, Cuba, Equador, Honduras, Mexico and Venezuela).	Preparation of studies for the specific analysis of each technology to promote intermittent adaptation and increase distributed generation (Colombia and Equador).
	Establishment of standards and strategies to promote operational adaptations and control measures to guarantee the quality, supply and stability of the electric power system with the insertion of intermittent renewable sources (Colombia and Equador).
	Limit subsidies to fossil fuels and increase investments in renewable energy by opening up to private market participation (Venezuela).
	Development of an optimization model that considers the environmental and operational characteristics of renewable energy based on methodologies that include environmental externalities and operational costs associated with intermittency (Mexico and Venezuela).
	Improvement of planning strategies and tools to accelerate water pumping programs in **reversible hydroelectric power plants** and strategies for energy storage (Mexico).
	Development of instruments that measure the attributes of sources to prevent the expansion of electricity supply from negative consequences in energy prices (Cuba).
	Development of planning, operation and tariff instruments that respond to the strategy of optimizing the national electric power system (Costa Rica).

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Regulatory deficiencies for a higher increase of renewable sources (Brazil, Colombia, Costa Rica, Equador, El Salvador, Guatemala, Honduras, Mexico, Paraguay, and Venezuela).	Improving regulatory instruments so that hybrid plant or system projects can participate in energy auctions competitively (Brazil).
	Establishment or improvement of regulation that provides solutions for greater system flexibility, such as the implementation of intraday markets and auxiliary services (Colombia, Costa Rica, El Salvador, and Honduras).
	Review of the rules establishing the conditions for granting credit for renewable energy projects (Equador, Mexico, and Paraguay).
	Establishment of a new concession process without the need for a parliamentary approval and greater transparency in municipal taxes on renewable energy projects (El Salvador).
	Establishment of a new regulation that reduces the level of demand on prosumers as well as other adjustments to allow the expansion of distributed generation such as improved regulation of the requirements for self-production of energy and its injection into the grid (El Salvador and Guatemala).
	Review of regulations to address issues related to social conflicts over land use to facilitate the expansion of hydroelectric power plants (Guatemala).
	Implementation of regulation for greater openness to the private sector, including the possibility of updating prices to make investments in the electric power market more attractive (Honduras and Venezuela).
	Adjusting regulation to restrict subsidies for fossil fuels while creating incentives for renewable energy (Venezuela).
	Development of a tariff structure to adequately remunerate the different services and products that make up the operation of the electric power sector, especially new technologies that adapt the system to the increase in intermittent renewable energy and the expansion of distributed generation (Costa Rica).

SITUATION (AUDIT FINDING)	OPPORTUNITIES FOR IMPROVEMENT
Technical deficiencies for the increase of renewable energy (Brazil, Chile, Equador, Guatemala, Honduras, Mexico, Paraguay and Venezuela).	Investments to adapt the electrical grids to the bidirectional flow necessary for the operation of mini and micro distributed generation (Brazil and Equador).
	Investments to improve the infrastructure needed for the development of energy projects, such as the expansion of roads and equipment storage facilities at ports and airports to enable the growth of wind energy (Guatemala).
	Introducing the necessary adaptations to the grid to further integrate non-dispatchable renewable energy, such as solutions to mitigate power differences to ensure system stability (Honduras and Venezuela).
	Increase the interconnection between the different systems to allow a greater input of intermittent sources by taking advantage of the complementarity between them (Chile, Honduras, Mexico, Paraguay, and Venezuela).

The following were also identified as good practices:

BRAZIL: a government procurement for the development of tools to assist the construction of a model that considers the various attributes of sources to support the planning of the expansion of the national electric power sector, taking into account, mainly, the expected progress of wind and solar sources, as well as distributed generation.

Specific auctions for wind energy generation, previously **contracted by availability**, now **by quantity**, which help in the more precise identification of real costs of this source.

CHILE: improvement in the legislation dealing with auxiliary (complimentary) services for adapting the operation of the electric power system to the increase in renewable sources, such as active power generation or injection capacity and reactive power injection or absorption capacity and connected power of users.

The following were also identified as good practices:

CHILE: a bill in progress by parliament that aims to allow safe, efficient and sustainable integration of variable renewable energy. The main measures foreseen in the project are related to the recognition of what each agent contributes to the flexibility required by the system and to the development of new technological solutions and business models so that the electric power system can integrate a large volume of clean energy.

COSTA RICA: the construction of an electric power system through the diversification of energy sources for generation by taking advantage of the various existing resources in the country, which has allowed the use of its complementary attributes. Another exemplary practice is the periodic creation of a generation expansion plan based on studies that simulate the effects of different renewable energy and verify compliance with reliability criteria using computer models.

The adoption of various projects for the technological update of electric power system operation in strategic planning, such as short-term forecasting studies of variable renewable generation; the digital transformation process of the entity operating the system; and the integrated management of resources distributed in the electric power system demand.

EL SALVADOR: monitoring of the process of expansion of the electricity supply to mitigate, prevent or compensate for the environmental impacts of activities, works or projects aimed to introducing renewable sources by the ministerial body responsible for the environment.

MÉXICO: the existence of indicators for the increase of energy storage with batteries to minimize the effects of intermittency in the national strategy for the expansion of the electricity supply.

PART 4

4. FINAL CONSIDERATIONS

This coordinated audit made the exchange of data and information between the participating SAIs possible, allowing for a diagnosis of the evolutionary picture of the expansion of renewable sources in the electric power sector. This evaluation led to the compilation of various lessons, opportunities for improvement and good practices which, when disseminated, can help the governments of each country to make decisions that are more appropriate to their respective realities, with the intention of making public policies for the increase in clean energy more effective. The success of the energy transition can contribute not only to the reduction of GHG emissions, but also to the expansion of the electrical energy supply for the populations of the countries involved, considering the decreasing cost of clean energy and the possibility of decentralized generation make access to electrical energy feasible, even in locations distant from the transmission and distribution grid.

It is noted that the results of this audit can also be used for other countries that did not participate in the audit, including other regions of the world, since the challenges for the expansion of renewable sources are often similar. The action of OLACEFS countries may also serve as an example for other coordinated audits for other SAIs, since the mitigation of the effects of climate change is a transnational issue that needs the joint effort of the international community.

Finally, it is highlighted that the action of SAIs for the increase of renewable sources in the electric power sector, related to the realization of the already mentioned SDG 7 - "Ensure access to affordable, reliable, sustainable and modern energy for all;" 11 - "Make cities and human settlements inclusive, secure, resilient and sustainable; and 13 - "Take urgent action to combat climate change and its impacts," also connects to the implementation of SDG 16 - "Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels," and 17 - "Strengthen the means of implementation and revitalize the global partnership for sustainable development."

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The effort of the Comptroller General of the Republic of Equador for the organization of the Results Consolidation Workshop in Quito is also highlighted.

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The participation of the Economic Commission for Latin America and the Caribbean (ECLAC), represented by the energy specialist Rubén Contreras Lisperguer, should be also emphasized. In the workshop held in Santiago, he presented the challenges for the expansion of renewable sources in the electricity generation mix in order to guarantee a reliable electricity supply at low prices.

The contribution of the Government Accountability Office (GAO), SAI of the United States of America, is highlighted by the participation of the specialist Alfredo Gómez, Director of Natural Resources of this entity, who spoke about the experience of the GAO in audits on issues concerning the increase of renewable sources in the energy mix at the workshop held in Quito.

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GLOSSARY

Auxiliary (complimentary) services: technical services whose purpose is to maintain a permanent balance between generation and load. These services are mainly used for tasks such as maintaining the frequency of the system within certain limits; controlling the voltage profile of the system; maintaining the stability of the system; preventing overloads in the transmission line and restoring the system or part of it after a electricity supply failure. Performing these tasks increases the reliability and stability of grid operation. However, it entails an additional cost for the system, which must be properly measured when introducing new energy sources.

Cogenerations: simultaneous production of two or more forms of energy, from a single fuel or by-products of generation, maximizing the use of energy potential.

Conventional renewable energy: renewable sources used for decades and, therefore, have already reached a high level of technological maturity as the case of hydroelectric power plants. So the trend is that there will be no significant reduction in their cost over time.

Dispatchable energy sources: energy sources that allow more precise control of the moment of energy production due to the possibility of storing the source of generation. Examples: hydroelectric with storage reservoir; thermoelectric power plants in general; geothermal plants.

Distributed generation: electric power generation carried out in the vicinity of consumers, regardless of energy, technology and source. Compared to centralized generation, distributed generation has the advantage of reducing investments in transmission lines and losses in the transmission of energy over long distances.

Greenhouse effect: a natural phenomenon of global warming that makes it possible to maintain the temperature of the planet in ideal conditions for the survival of beings. Greenhouse gases (GHGs) - such as carbon dioxide (CO2), methane (CH4) and water vapor (H2O) - act as a barrier that prevents the solar energy absorbed by the Earth during the day from being emitted back into space. In doing so, some of the heat is retained close to the planet, whose average temperature is about 15° C. Without the greenhouse effect, the earth would be cold enough to make the development of most animal and plant species unfeasible. However, the excess of greenhouse gases is also harmful. Increased emissions of these gases as a result of activities such as burning, logging and polluting industrial activities have raised the temperature of the earth threatening the survival of several species of fauna and flora, including human health.

Hybrid power plants (hybrid power systems): power plants that use more than one type of source for electricity production to take advantage of their complementary attributes.

Intermittent energy power plant: energy power plant that does not allow control of the moment in which the generation of energy will take place, which can vary considerably depending on the climatic conditions and the period of the day since the storage of the source is not possible. Examples: solar photovoltaic and wind power plants.

Intraday electricity markets: electricity markets that measure the price of electricity at various times during the same day. A more efficient measurement is sought through higher time granularity. The development of intraday electricity markets makes the resulting prices more closely related to generation characteristics.

Net metering / net billing: this is a system that allows prosumers (agents who, depending on the availability of the source, are either producers or consumers of electricity) to export surplus energy to the grid, and there may be compensation at the due values. In this case, the electrical grid acts as a battery for the prosumers. This strategy is intrinsically related to the expansion of distributed generation, which favors greater use of renewable energy, especially solar photovoltaic and wind energy.

Non-conventional renewable energy: energy sources that have had their technological development recently and still have a great potential for expansion, especially biomass, wind and solar photovoltaic sources, which have been presenting increasingly lower costs. Other non-conventional sources that can be mentioned are geothermal and tidal.

Non-renewable energy: sources of energy that cannot be replaced within a period compatible with its use by humans (such as fossil sources, mineral coal, oil and natural gas derivatives and nuclear fuel).

Public consultation: opportunity given to the general public to contribute to a technical discussion so that the government and society can formulate public policy together. Citizens, businesses, movements and civil society organizations can access the consultations available on government portals and make contributions.

Public hearing: opportunity given to the general public to contribute in an open, transparent and widely discussed meeting, allowing communication between the various sectors of society and public authorities. Its objective is to debate or present, orally, a topic of relevant interest.

Public procurement by availability: in this public procurement modality, energy generating agents are paid according to their guaranteed (or potential) energy quantity and not based on the energy generated. Buying agents assume the risks and consumers assume possible positive or negative exposures in the short-term market.

Public procurement by quantity: in this public procurement modality, the energy-generating agents are paid according to the energy generated. The generators assume the risks integrally, which presupposes a more precise knowledge of the amount of electricity that will be produced according to the technical and climatic conditions.

Prosumers: agents who, depending on the availability of the energy source, are either producers or consumers of electricity. In general, prosumers, even when producing their own electricity, have an interest in remaining connected to the grid because of the guarantee of supply.

Renewable energy: energy in which the source (or fuel) for its production is replaced by nature in periods consistent with its energy demand (such as water, tidal, solar, wind and geothermal sources) or whose management by man can be carried out in a compatible manner with the needs of their energy use (as in the case of biomass: sugarcane, energy forests, and animal, human and industrial waste).

Reversible hydroelectric power plants: hydroelectric power plants whose generation potential comes from the prior pumping of water to a high-level storage reservoir. Pumping can be carried out, for example, at the moment of excess production of non-disposable sources to optimize the available resources. Technological developments in this type of enterprise and appropriate regulatory incentives can encourage the use of these plants.

GLOSSARY

Self-producers: natural persons or legal entities or companies gathered in a consortium that receive a concession or authorization to produce electrical energy for their own and exclusive use.

Smart grids: systems that allow optimizing the management of the network and its energy supply. These smart grids can be used for various purposes, such as reducing technical and commercial losses; improving the quality of service provided; reducing operational costs; improving network expansion planning; and promoting energy efficiency.

Time granularity: this is the time interval for the evaluation of electricity supply or demand. The higher the granularity, the shorter the time interval for this measurement. Because storage technologies remain very expensive, scheduling based on the higher granularity of energy supply and consumption ensures greater adherence to actual generation costs (or the respective price).

Datasheet

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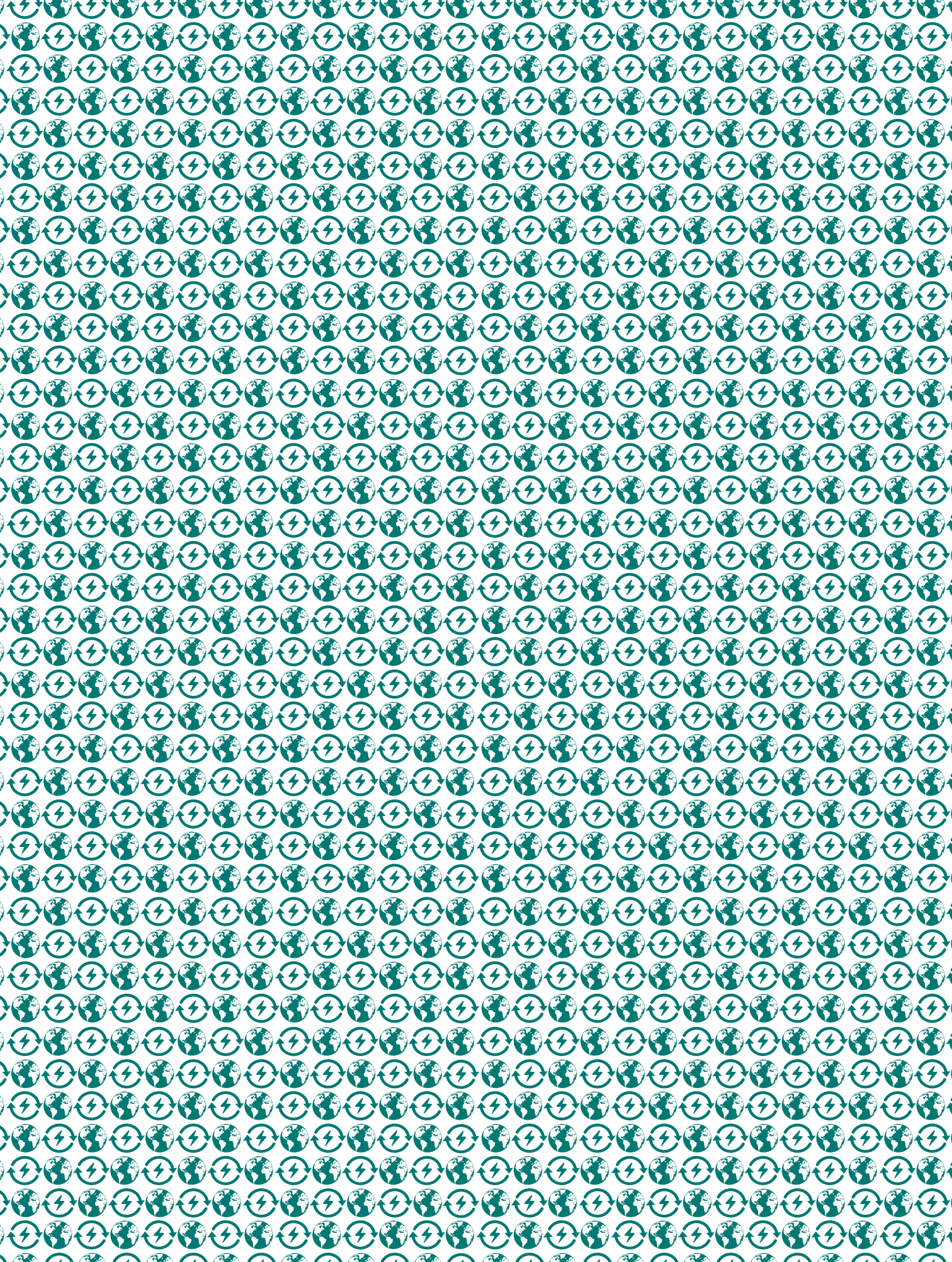

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