THE ENERGY PATH OF LATIN AMERICA AND THE CARIBBEAN

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CONTENT

EXECUTIVE SUMMARY

2030 forecasts for the expansion of the electricity sector suggest that Latin America and the Caribbean are on the right path towards decarbonization. However, the pace needs to be accelerated to meet the 2050 net-zero emissions goal. Assuming that there is no substantial change in the trend, and based on expansion plans, the region's electricity sector will end the decade with an emissions gap of 273 megatons of CO_2 equivalent ($MtCO_2e$) needed to be reduced.

The impact of the pandemic at the beginning of 2020 led to economic and social stress worldwide. This created a 2.9% decrease in electricity demand from 2019 to 2020, which makes a green and sustainable recovery increasingly urgent. The results of the projection model predict that electricity demand in Latin America and the Caribbean will recover to pre-pandemic levels between 2022 and 2024. It is also estimated that it will grow around 3.9% on average per year for the remaining decade.

The recovery process will depend on various elements, including economic sectors, public entities, and international cooperation. Given the uncertainty regarding the recovery, several countries have updated their expansion plans. Based on those plans, coal is expected to be the generation source with the most significant reduction within the regional generation matrix, decreasing by 2030 at a 5.4% compound annual growth rate (CAGR). This is a big step toward sustainable development of the sector. Non-conventional renewables, such as solar and wind power, are expected to increase by 2030 at 10.4% and 9.1% CAGR, respectively. The total sum of these investments amounts to approximately USD 226 billion during 2020-2030 at the regional level. However, this amount may vary in the following years due to the price trend of different technologies, especially non-conventional renewables.

Two factors can contribute to emissions reduction: increasing energy efficiency and continuing efforts to electrify more sectors of the economy, particularly the transportation sector. An increase in energy efficiency would also generate savings in investment needs for the electricity system. Upon meeting these energy efficiency standards, a regional difference of 20% would be generated by 2030 compared to the original estimates; that is, the emissions gap would be 218.9 $MtCO_2e$.

The expansion of electromobility in the region would increase the investment needs in the electrical system. However, replacing internal combustion vehicles would reduce emissions by up to 170 $MtCO_2e$ by 2030. Our estimation results reveal that, in the most optimistic scenario, the region should have a fleet of 53 million electric vehicles by 2030.

The impact that this replacement will have on the emission reduction goals will depend on (1) how fast the adoption of electric vehicles is and (2) the pace of decarbonization of the energy matrix, given that its adoption would generate an increase in electricity demand. That is why electromobility without energy transition represents only half the journey and vice versa.

This document invites us to question the energy sector's path. The results presented here provide an updated overview of the electricity supply, the investment needs, and the sector's emissions. It also provides instruments for designing policies based on different scenarios and a vision of how to face the challenge of reducing carbon emissions.

1 INTRODUCTION

2020 was atypical for many sectors of the economy, including the electricity sector. The COVID-19 pandemic caused a significant loss of human life, as well as economic and social stress around the world. Following this global tragedy, a green recovery began to be seen as both an imperative and an opportunity. For this reason, the international community has underlined, in recent months, the need to double efforts to reach the goal of net-zero emissions by 2050 and prevent an increase in global temperature above 1.5 C.

This study responds to that call and provides a vision of the path that the electricity sector in Latin America and the Caribbean would follow during this decade, assuming no substantial change in its historical trends. This vision is based on the governments' plans published until the first quarter of 2021 since the main objective is to present an outlook rather than the potential of the energy matrix throughout this decade. Therefore, we note that the forecasts presented in the following chapters are based on countries' expansion plans and have as their primary assumption that there will be no change in trend.

The different sections of this report will attempt to answer the following questions: How far is the Latin American electricity sector from meeting the net-zero emissions goal by 2030? What type of energy matrix will supply the demand of the different subregions throughout the decade? How significant will the investment need to be? For this, the supply and demand prospects of the electricity sector in 26 Latin American and Caribbean (LAC) countries were analyzed until 2030. Taking this into account, we calculated the emissions gap that would need to be reduced between 2030 and 2050 to reach a net-zero emissions scenario. The demand projections are based on an econometric model that considers the historical series, and the supply projections are based on the expansion plans published by the countries.

The results suggest that the region is on its way to decarbonizing electricity generation; however, if the countries of Latin America and the Caribbean continue at the current rate until 2030, they will face a significant challenge to reach the goal of net-zero emissions by 2050. According to the estimates presented in section 2, there will be a gap of 273 megatons of CO_2 equivalent to be reduced by the end of the decade.

The impact of the pandemic was reflected in a 2.9% decrease in electricity demand from 2019 to 2020. There was no way to foresee an external shock of such magnitude. The results of the projection model suggest that the demand for electricity in Latin America and the Caribbean will recover between 2022 and 2024, growing around 3.9% on average per year for the remaining decade.

The recovery will depend on different factors, including economic sectors, public entities, and international cooperation. Given the uncertainty regarding the recovery, several countries have updated their expansion plans. Using these plans as a reference, the regional future generation source and investment needs for the next ten years were estimated.

Throughout these years, and based on those plans, coal is expected to be the energy source with the most significant reduction (5.4% on average per year). This is a big step toward the sustainable development of the sector. The second important finding is that non-conventional renewables, such as solar and wind power, are expected to increase by 2030 at 10.4% and 9.1% compound annual growth rate (CAGR), respectively. The region that will invest the most capacity throughout this decade is the Southern Cone with 79,617 MW; a large part of this investment will be in Brazil—followed by Central America with 45,678 MW and the Andean region with 19,313 MW. Finally, we estimate that the Caribbean countries will need to invest approximately 6,328 MW by 2030 to supply the electricity demand.

The total sum of these investment needs is approximately USD 226 billion by 2030 at the regional level. However, this amount may vary in the following years due to changes in the prices of the different technologies, especially non-conventional renewables. In the latest auctions, solar photovoltaic decreased its cost by 80%, while onshore wind has decreased by 54.7% in just 8 years (IEA, 2020). This price behavior draws attention to how investment needs could change if costs continue to fall in the years to come. At the end of section 2, a cost sensitivity analysis of renewables and their effect on regional investments is presented.

Two factors that can contribute to reducing emissions are the implementation of different energy efficiency policies and the electrification of more sectors of the economy, particularly the transport sector. Section 3 of this report estimates electricity demand if the region's countries implement energy efficiency policies that meet the standards estimated by the International Energy Agency (IEA) (2021), i.e., 4% by 2030. Estimates suggest that if the region's countries reach these energy efficiency standards, the regional electricity demand would be 25.9% lower in 2030 than our baseline scenario. The rise of electromobility – replacing internal combustion engine vehicles with electric vehicles – is another critical element for reducing carbon emissions. In 2019, 39% of CO_2 emissions in LAC came from the transport sector, followed by the electricity sector with 22%, which indicates the urgency of collaboration between both industries to decarbonize the economies.

Section 4 presents seven different scenarios for the adoption of electric vehicles to estimate the effect that an increase in electromobility would have on emissions at the regional level. The results reveal that, in the most optimistic scenario, it is expected that the region will have a fleet of 53 million electric vehicles in 2030. This scenario is based on the calculations of the IEA (2021) to reach the net-zero emissions scenario. Based on estimates for this scenario, we can forecast a reduction of 170 $MtCO_2e$ in 2030 compared to the baseline scenario. Finally, under this scenario, the cumulative decline in CO_2 - that is, all emissions avoided over 10 years - would be 616 $MtCO_2e$.

The level of impact that this replacement will have on the emission reduction goals will depend not only on how fast the adoption of electric vehicles will be but also on the pace of decarbonization of the energy matrix, given that its adoption would generate an increase in electricity demand. That is why electromobility without energy transition represents only half the journey and vice versa.

In summary, in the baseline scenario, the total emissions from the electricity sector in the region are estimated at 273 megatons of CO_2 equivalent by the end of the decade. In contrast, in the energy efficiency scenario, it will be reduced to 218.9 $MtCO_2e$ by 2030. If the expansion of electric vehicles is added to these scenarios, an additional reduction of 170 $MtCO_2e$ would be expected under the most optimistic setting, with the adoption of electric cars by 2030.

This report invites us to question the energy sector's path. The results presented here provide an updated overview of the electricity supply, the investment needs, and the sector's emissions. It also provides instruments for designing policies based on different scenarios and provides a vision of how to face the challenge of reducing carbon emissions.

2 THE NEXT CHALLENGE FOR LATIN AMERICA AND THE CARIBBEAN: HOW FAR IS IT FROM A NET-ZERO EMISSIONS SCENARIO?

International efforts in recent years have emphasized the goal of reaching a scenario of net-zero emissions by 2050 and preventing an increase in global temperature above 1.5 C. According to the latest IPCC report (2021), damage to the environment is irreversible, and if the pace of emissions continues, the point of no return will be even closer. This section is a first attempt to estimate how far Latin America and the Caribbean are from reaching the goal of net-zero emissions from the electricity sector point of view. In addition, this section seeks to know what the necessary investments will be throughout the decade for the baseline scenario if there is no change in trends.

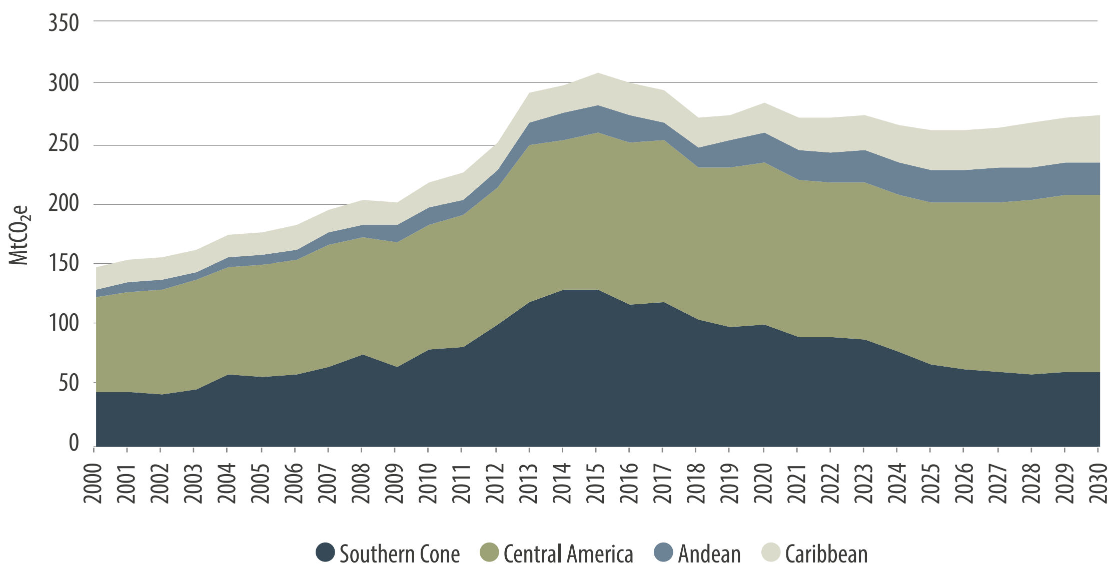
2.1 The Emissions Gap 2030-2050

The region is on the path toward the decarbonization of electricity generation. Since 2015, emissions from the electricity sector have been decreasing. However, if countries do not accelerate their decarbonization efforts, they will face an enormous challenge to reach the net-zero emissions goal by 2050. Figure 1 shows the emissions projection in $MtCO_2e$ of the electricity sector for the different subregions in Latin America and the Caribbean. It can be observed that, by the end of the decade, there will still be a gap of 273 $MtCO_2e$ in emissions, equivalent to the electricity system of 2012, with a decrease of around 11% compared to 2015. These projections are based on the expansion plans for the electricity sector of the countries in the region[1].

[1] As we will see, there are also other tools, in addition to the further incorporation of renewables into the matrix, that the different governments can implement to reduce emissions, such as energy efficiency policies and an increase in electromobility.

Central America and Mexico's subregion with the most significant carbon footprint since a large percentage of this subregion generates electricity using its thermal power plants fueled by natural gas. By 2030, 45% of the electricity produced in this subregion will come from this kind of generation plant. The subregion that reduces its carbon footprint more pronouncedly is the Southern Cone. This is because during the next few years, thermal power plants —fueled by all types of fuel— will have less participation in electricity generation. The countries of this subregion will also add a higher percentage of renewable sources to their generation sources. By 2030, solar and wind power will increase their participation in the generation source by 3.1 and 7.6 percentage points compared to 2020. The following section will describe in greater detail the changes in the generation sources of each subregion and what will be the investments in new capacity that the different countries will have to make to supply the electricity demand in the coming years.

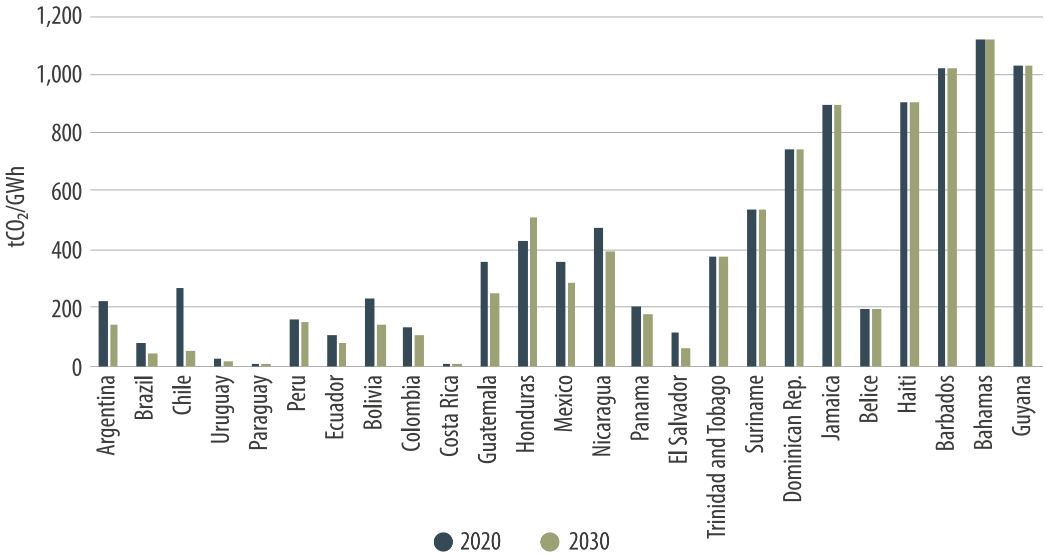
Figure 1. *Emissions trajectory ($MtCO_2e$) until 2030 in the baseline scenario. (Own elaboration)*



It is noteworthy that, despite there being a reduction in the carbon footprint at the regional level, in terms of country, significant heterogeneity is perceived. Let us look at emissions intensity per GWh generated by the country. For many economies in the region, the levels by 2030 will marginally decrease their intensity compared to 2020 (see Figure 2). This is because few countries will make a great effort to remove polluting sources during this period. The case of Chile stands out as a country with the most significant projection of a decrease in emissions intensity in the electricity sector. By 2030, the Chilean energy matrix will generate one GWh, with 82% less emissions than 2020. The cases of Argentina, Bolivia, Guatemala, Mexico, and Nicaragua also stand out. In these cases, there is a substantial reduction in the intensity of emissions from their electricity generation sources by 2030.

The emissions intensity for countries of the Caribbean region remains constant. One of the main assumptions of this study is that the generation sources of these countries will not experience substantial changes throughout the period of analysis, partly because, in most cases, there are no public expansion plans to indicate otherwise. On the other hand, there is an expected increase in the case of Honduras.

Figure 2. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



The following two sections will delve into these estimates. They will discuss other elements that led to these results, such as the investment decisions associated with the electricity supply and demand forecasts.

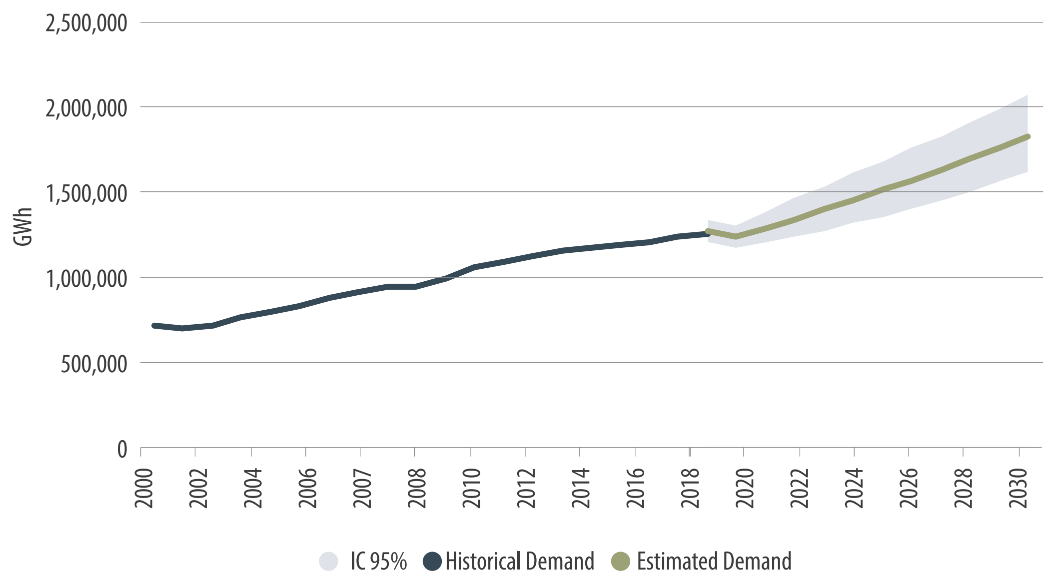
2.2 ELECTRICITY DEMAND 2020-2030

The first step in calculating the emissions gap was to estimate how much electricity the region's countries would demand throughout the decade. The projection model[2] predicts that the demand for electricity in Latin America and the Caribbean will increase 48% between 2020 and 2030, with an average annual growth rate of approximately 3.9%. This increase is higher than the previous decade's average (2010-2019), which was the annual average growth rate of 2.3% (see Figure 3).

The impact of the pandemic led to a 2.9% decrease in electricity demand from 2019 to 2020, and it is estimated that there will be a recovery in demand between 2022-2024. In other words, the demand for electricity in Latin America and the Caribbean is expected to return to pre-Covid levels in the next 4 years. That is partly due to the projections of the economic growth of the different countries in the region. This study's appendix describes the premises and methodology used in the estimates in greater detail.

2 For further reference on the data and methodology used to project electricity demand, please refer to Annex A.

Figure 3. *Projection of electricity demand in the region by 2030. (Own elaboration)*



2.3 GENERATION MATRIX 2020-2030

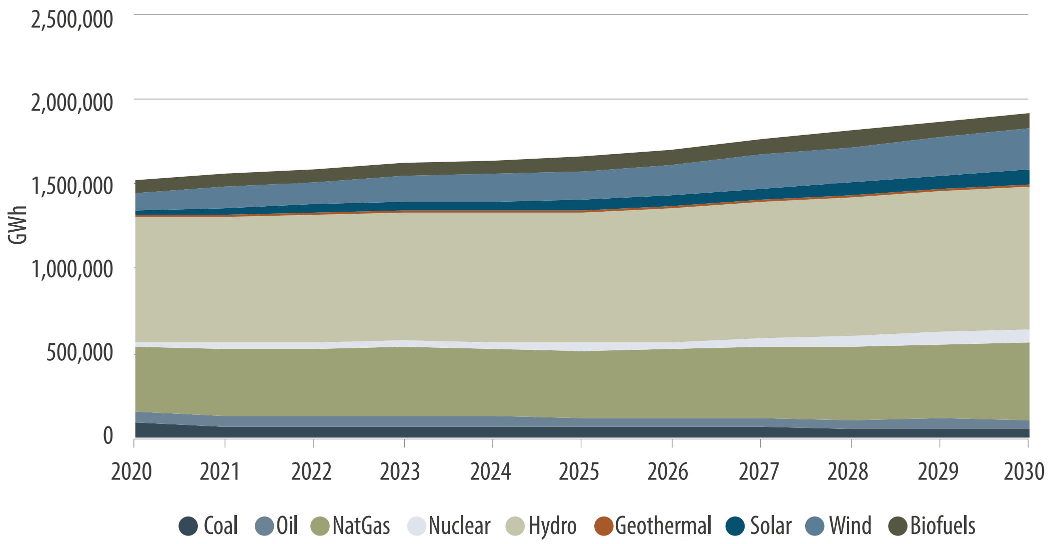
What sources will the region's different countries use to supply the demand throughout the decade? What kind of sources will be incorporated into the generation sources already in place? What role will non-conventional renewables play, and, above all, what will be the role of natural gas as a transition source? This section explores regional and subregional generation matrix changes in the coming years. It is divided into two parts, the first focusing on the region, and the second is dedicated to analyzing each generation matrix for the different subregions of Latin America and the Caribbean.

2.3.1 Regional Supply

The generation matrix of the region and that of each of the subregions were estimated using the methodology described in Yépez et al. (2018), which uses the latest expansion plans published by the countries as its primary source. Based on them, we forecasted the electricity matrix until 2030. When considering the expansion plans, the intentions of the different governments and the future vision for the energy sector of each one of them have been incorporated. For further reference, see Annex B.

Figure 4 shows this decade's generation matrix of Latin America and the Caribbean. Throughout these years, coal will be the source that will experience the most significant reduction (5.4% on average per year). This is an important step toward sustainable development for the sector. The second most important finding is that non-conventional renewables, such as solar and wind power, will increase by 10.4% and 9.1% compound annual growth rate (CAGR), respectively. This is the most significant increase they have had in recent decades and higher than any other generation source.

Figure 4. *Electricity generation matrix in LAC, 2020-2030. (Own elaboration)*



However, their participation remains relatively low. In terms of percentage points (pp.), solar power will increase by 2.3 p.p. towards 2030 while wind power will do so by 6 pp. A case of interest is the average annual increase in nuclear power. This source experiences an increase of 8.4% between 2020 and 2030. This is because Brazil and Mexico forecast expanding their generation in the middle of the decade. Geothermal energy is a limited source, and few countries have developed its use. Its average growth during the decade will be 6.6%. In regional terms, natural gas will experience a modest annual increase of 1.9%. However, this number does not reflect the heterogeneity at the subregional level, as we will see in the next section.

2.3.2 Subregional Supply

There is a variation in sources' supply across subregions in Latin America and the Caribbean. The following graphs show the electricity supply by type of source for each of the LAC subregions, based on the expansion plans for the coming years, assuming that there will be no substantial change in its trends. The main objective is to present an overview of the electricity sources throughout this decade. However, the reader should be advised that this is not a planning exercise, nor does it attempt to show the supply potential for the different LAC subregions.

In the Southern Cone, the average annual growth of the supply rate from 2020 to 2030 is 1.7% annual average. Of all sources, solar and wind power will report the most significant increase throughout this period, with an average annual growth of 11.3% and 8.9% compound annual growth rate (CAGR), respectively. It should be noted that this subregion is the one that presents a greater drop in the use of coal, with a decrease of 16.5% CAGR from 2020 to 2030, followed by fuel oil, with 16.7%. Figure 5 shows that, as of 2027, these two sources will no longer have a share in electricity generation.

Figure 5. *Electricity generation matrix for the Southern Cone region, 2020-2030. (Own elaboration)*

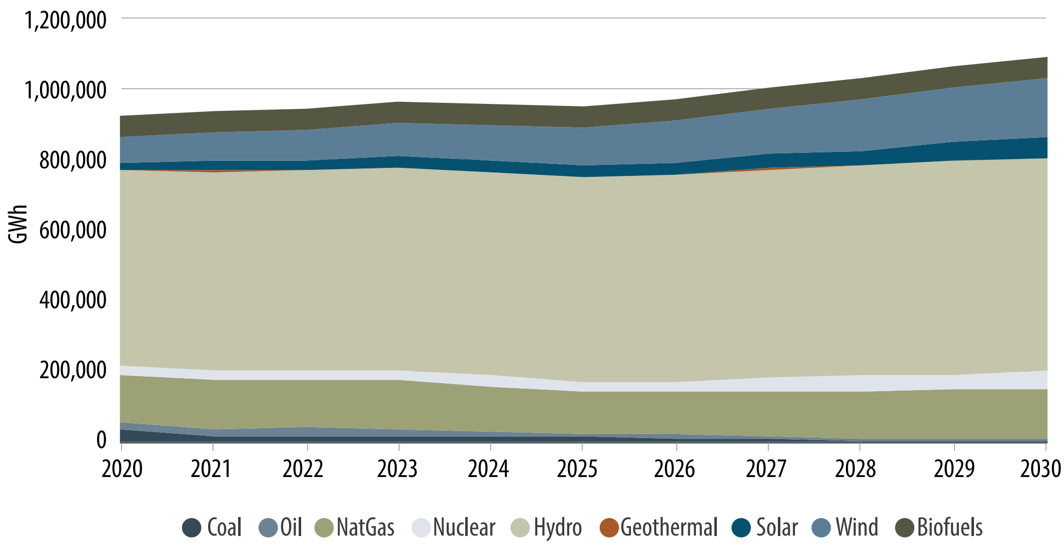
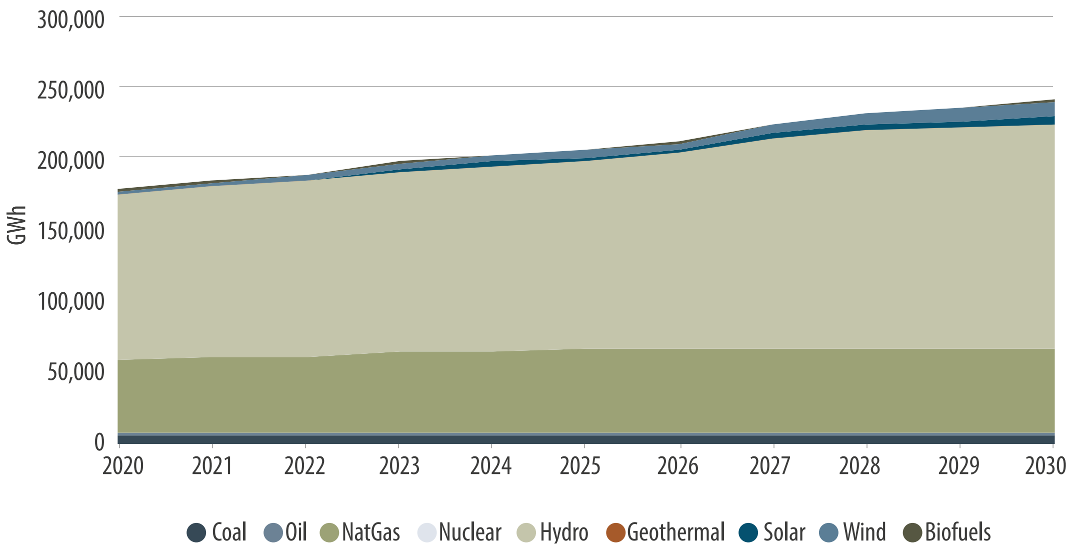


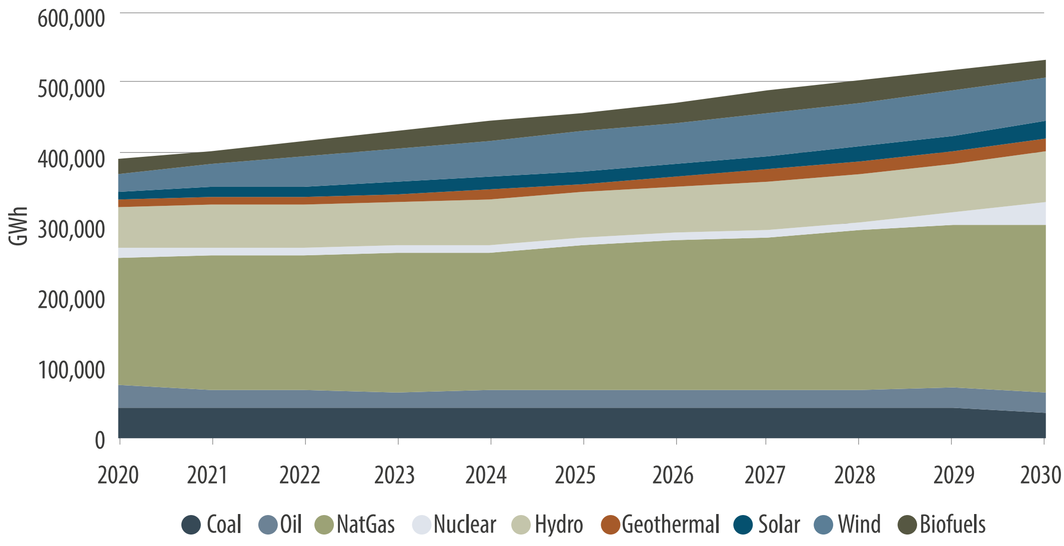
Figure 6 shows the generation matrix for the Andean region. The average supply growth in the Andean region is 3.09% per year from 2020 to 2030, ranking it as the region with the third highest growth, only behind the Caribbean and Central America and Mexico. In this region, solar and wind generation sources are the ones that report the highest increase, not only compared to all the other technologies but also in any region in LAC.

Figure 6. *Electricity generation matrix for the Andean region, 2020-2030. (Own elaboration)*



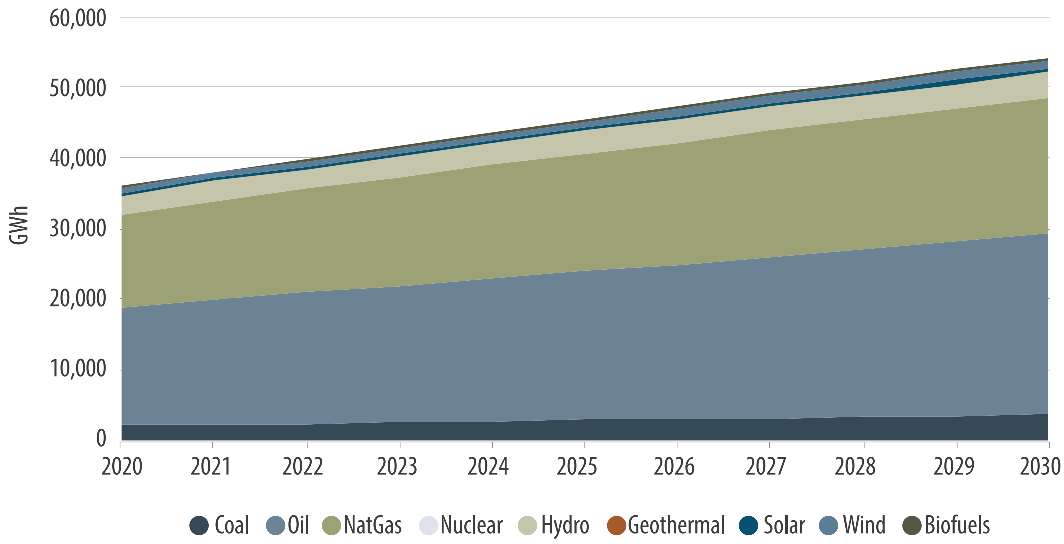
In Central America and Mexico, the electricity supply will grow by 3.14% annual average from 2020 to 2030, and Mexico will lead this increase. Historically, this region has been characterized by its high dependence on fossil sources. In 2020, 65% of the electricity was generated in thermal power plants. By 2030, this dependency will be reduced to 56%, one of the most significant results of the decade. Of all the fossil fuels, coal is the source that will have the most considerable reduction, going from 11% to 6% from 2020 to 2030, that is, a decrease of 4.3 percentage points (See Figure 7).

Figure 7. *Electricity generation matrix for Central America and Mexico, 2020-2030. (Own elaboration)*



The Caribbean is a unique case since few countries in this subregion have experience and tools for planning. For this reason, it was established as a premise that these countries will keep the generation rates of each source constant throughout the study period. This means that the participation of each of the sources is expected to increase proportionally to supply the electricity demand in the future (see Figure 8).

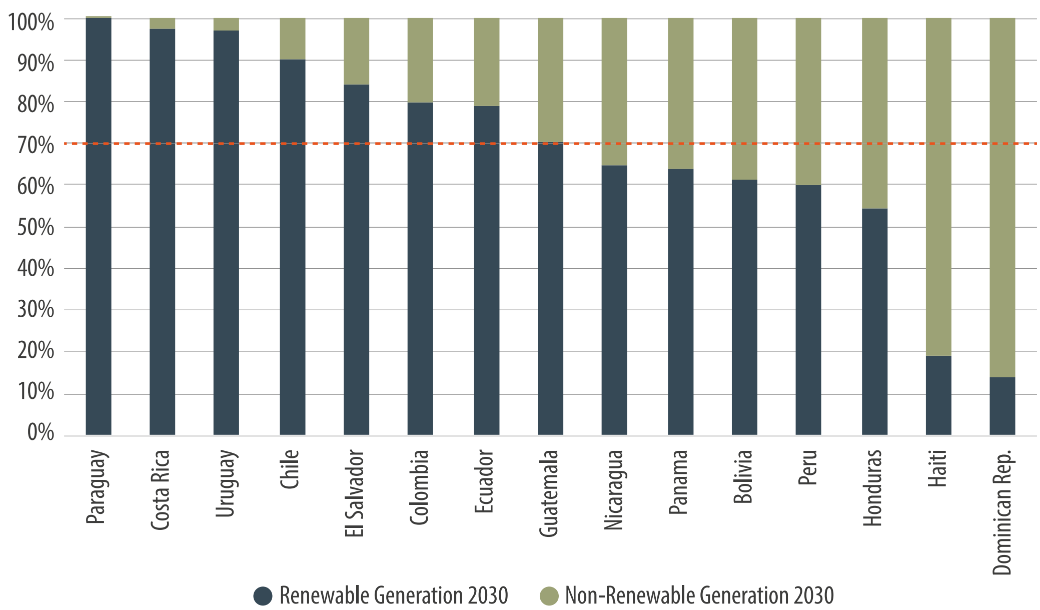
Figure 8. *Electricity generation source for the Caribbean region, 2020-2030. (Own elaboration)*



A transformation effort is taking place in the Caribbean, with important decarbonization initiatives and goals. Unfortunately, due to the lack of public information available and harmonized with that of other countries at the time we wrote this report, it was not possible to incorporate these initiatives into the analysis.

Furthermore, there are currently different regional initiatives to accelerate the incorporation of carbon neutrality in electricity systems. One is the Renewables in Latin America and the Caribbean initiative. This initiative was created during the 2019 UN Climate Action Summit. For the first time, a group of countries in the region voluntarily agreed to promote renewable energies with a concrete goal, operation and support structure, and a robust surveillance mechanism. Today, the RELAC initiative has 15 member countries. The common goal is to generate at least 70% of its electricity from renewable sources by 2030. Figure 9 shows the percentage of electricity generated by 2030 from renewable sources in each member country of this initiative. The orange dotted bar represents the goal of 70%.

Figure 9. *Generation source of member countries of the RELAC initiative by 2030. (Own elaboration)*



The above results show each subregion's different efforts in terms of the energy transition. The following sections will detail the investment needs that each of these subregions will have in the future, as well as a sensitivity analysis to show the impact that the cost of non-conventional renewables will have on investment amounts.

2.4 INVESTMENT NEEDS 2020-2030

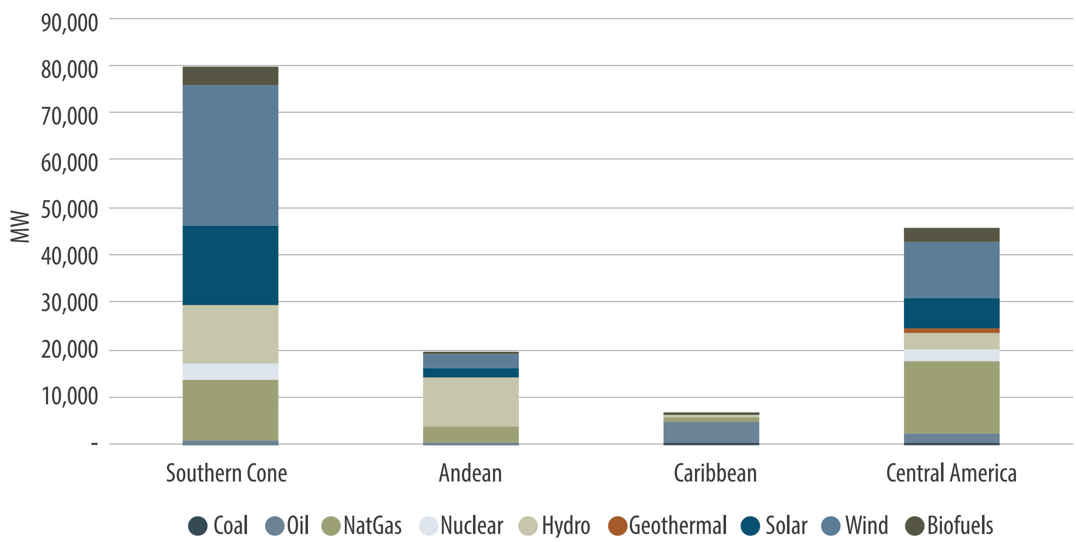
The previous two sections detailed the changes in electricity demand and supply in the different LAC subregions. This section will focus on answering the following questions: What will be the investment requirements in capacity in the different LAC subregions for this decade? What sources will receive more investments in each country? Will they depreciate over these 10 years?

To estimate the different investments by technology, we follow the methodology suggested by Yépez et al. (2018), which we describe in greater detail in Annex B. Figure 10 shows the totals in new capacity by subregion and technology. The region that will invest the most capacity in this decade is the Southern

Cone, with 79,617 MW (a large part of this investment is located in Brazil), followed by Central America with 45,678 MW and the Andean region with 19,313 MW. Finally, we estimate that to supply the electricity demand, the Caribbean countries will need to invest approximately 6,328 MW in new capacity. Regarding technologies, non-conventional renewables —solar PV and onshore wind— will be the focus of attention throughout this decade. By 2030, approximately 46% of the new capacity added by the region will be distributed between solar and wind power. Wind power will have 44,112 MW in new capacity, while solar PV will have 25,061 MW. The two regions with the highest investment in these two sources are the Southern Cone and Central America.

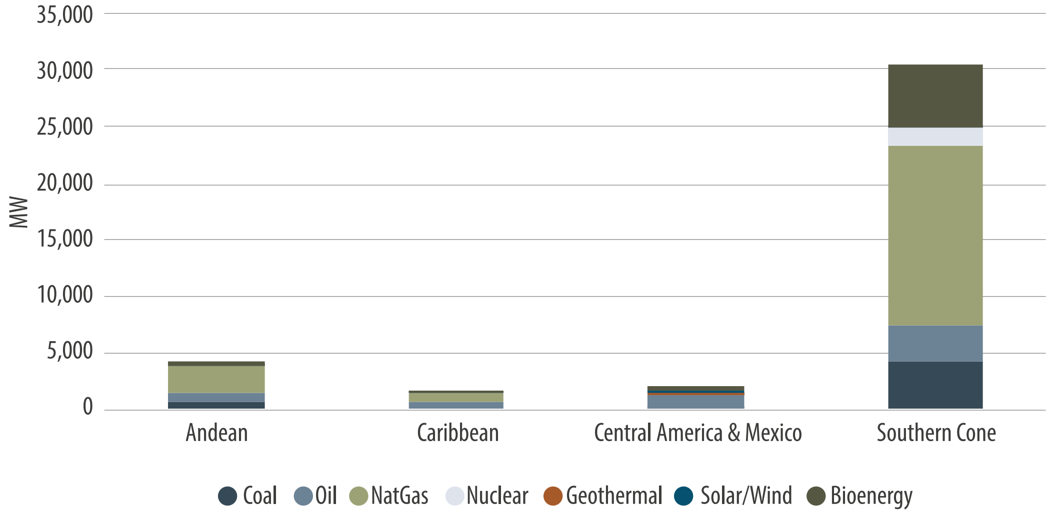
The region will require an investment of approximately USD 226 billion by 2030 to meet these goals. However, this amount may vary in the following years for various reasons, one of which is the trajectory of the price of non-conventional renewables in the future. For this reason, the authors make a sensitivity analysis at the end of this section, and the effect that different cost scenarios for solar PV and wind power would have on investment needs in the different LAC subregions is identified.

Figure 10. *Investment in new capacity by subregion and technology, 2020-2030. (Own elaboration)*



In the coming years, governments will need to invest in new capacity and transmission lines and replace outdated infrastructure. Throughout this decade, many generation plants will reach the end of their lifespan. To estimate this type of investment, we assume that the countries will not invest in maintenance to prolong the lifespan of these plants and instead replace them in fixed terms with a plant of the same size and technology. We call this type of investment discontinuous depreciation. In fact, the countries do not replace the same capacity at the end of the depreciation period. Many seize the plants beforehand to incorporate new, more efficient, less polluting capacity. However, this approach allows us to see what kind of technologies will require attention during this decade (see Figure 11).

Figure 11. *Discontinuous depreciation by subregion and technology. (Own elaboration)*

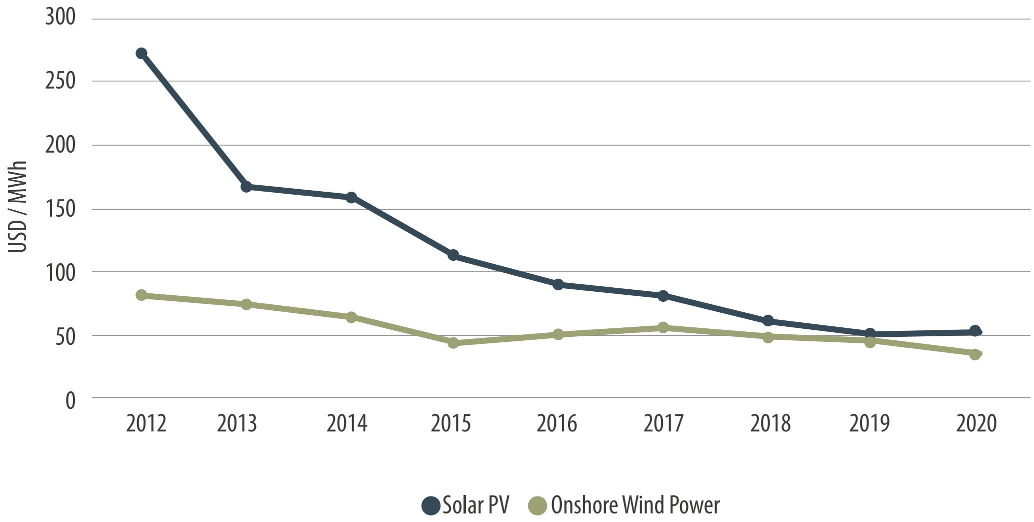


Our estimates suggest that a large percentage of combined cycle plants fueled by natural gas will reach the end of their useful life over this decade (see Figure 11). Many of these plants are located in Chile, Brazil, and Argentina, which opens a space of opportunity for essential changes in CO_2 emissions

2.4.1 Sensitivity Analysis: Renewables Cost Scenario

One of the most important results of the previous section is the significant investment that the region's countries will make in new solar and wind power capacity. One factor behind this optimism is the reduction in costs that these two technologies have had in recent years, in addition to their increased efficiency and the adaptation of regulatory frameworks for their use. In recent auctions, solar photovoltaic power has decreased in price by 80.2%, while onshore wind power has decreased by 54.7% in just 8 years (see figure 12). This price behavior draws attention and invites us to wonder how investment needs would change if costs continued to fall in the years to come.

Figure 12. *The average price of announced wind and solar photovoltaic energy auctions by the date of commissioning. (Own elaboration with data from the International Energy Agency.)*



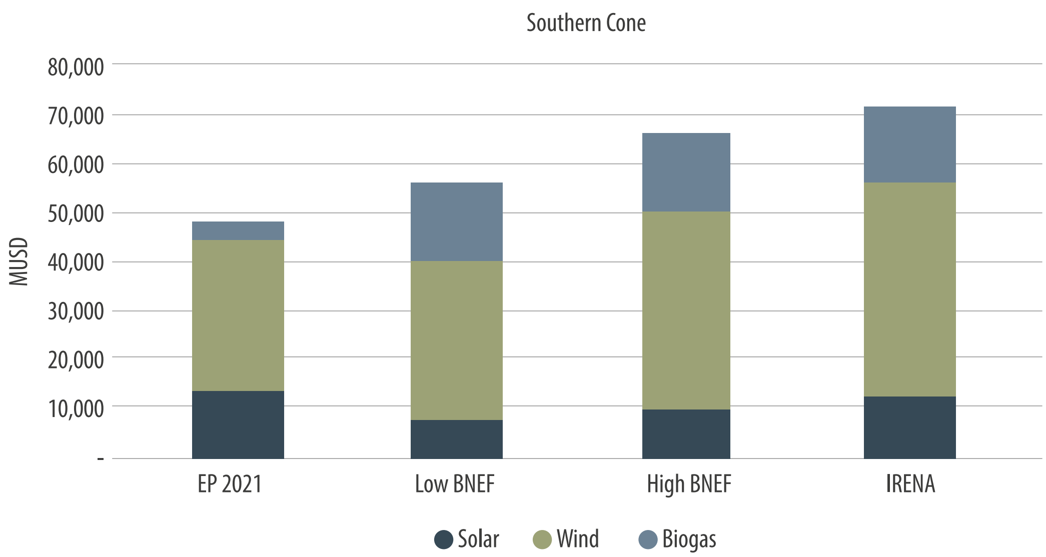
Note: The highest values for onshore wind power in 2017-2018 result from the UK Contracts for Difference (CfD) auction.

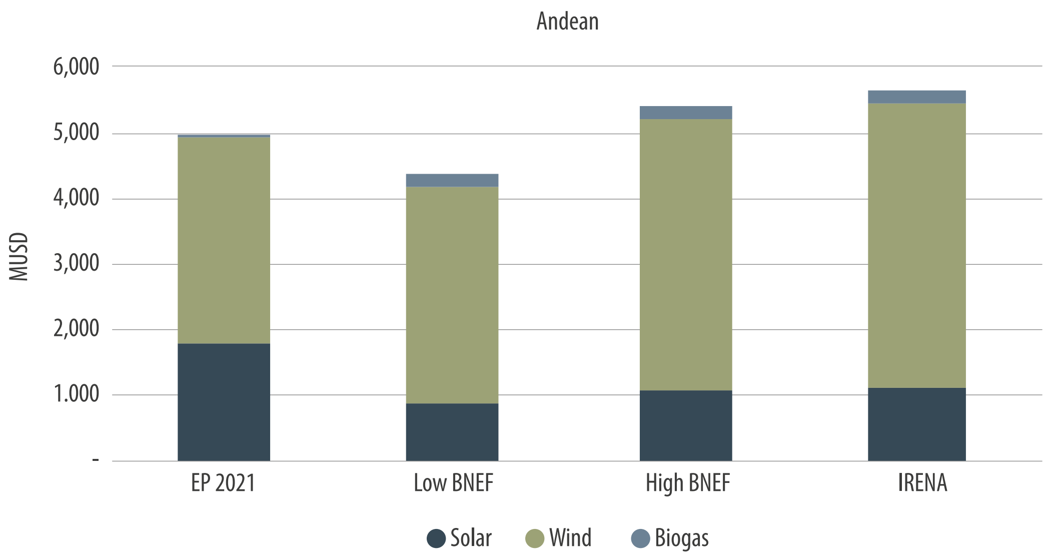
This section presents a sensitivity analysis that considers 4 possible price scenarios for solar and wind technology. Each scenario is distinguished by the premises made from the prices of these two technologies, leaving the amount of new capacity constant across scenarios. The main goal is to compare the investment amounts that different subregions would have made in the next ten years. The premises that characterize each of the four price scenarios are as follows:

Scenario	Description
Scenario *Energy Path* 2021	The baseline scenario is considered, and the results are presented in section 3.4. See Annex B for further reference.
Scenario BNEF low	This scenario assumes the cost of capital for solar and wind power generation plants made by Bloomberg New Energy Finance (BNEF) in its low scenario.
Scenario BNEF high	This scenario assumes the cost of capital for solar and wind power generation plants made by Bloomberg New Energy Finance (BNEF) in its high scenario.
Scenario IRENA	The cost of renewable energies follows the average trend for the last 5 years. Data source: IRENA.

The graphs below show the accumulated investment amounts in millions of dollars (MUSD) for each subregion under each scenario. For example, figure 13 shows the results for the Southern Cone and the Andean subregions. The first aspect we observe is the size of the investment. In the four different price scenarios, the countries of the Southern Cone will invest nearly ten times the value of the investment in the Andean zone. The IRENA price scenario is the highest in the two regions, followed by the high and low BNEF scenarios. Regarding technology, the two subregions will allocate a large percentage of their investments to wind power projects, followed by solar power projects in the Andean region and biogas in the Southern Cone.

Figure 13. *Sensitivity analysis for the Southern Cone and Andean regions. (Own elaboration)*

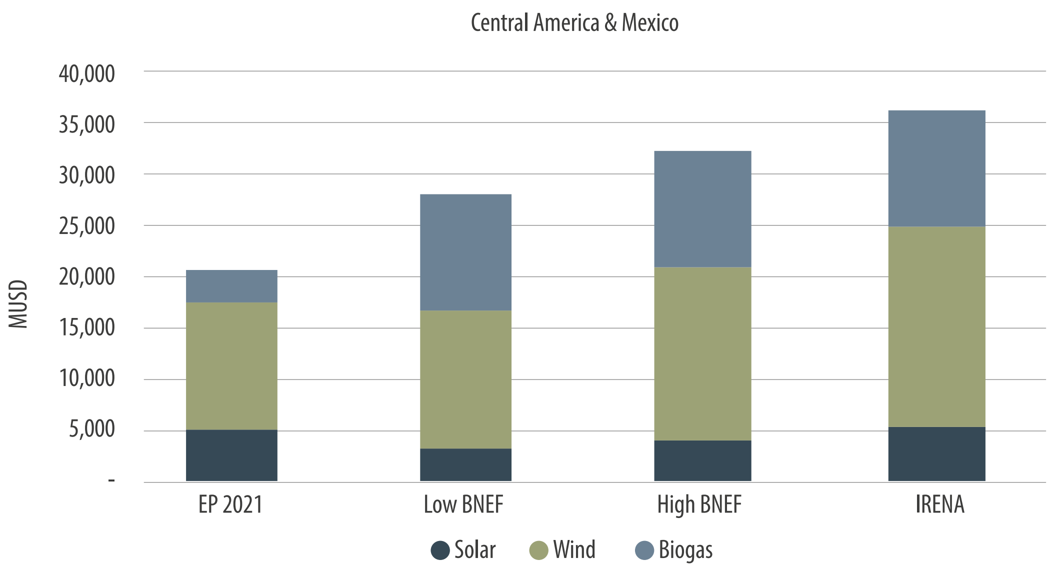


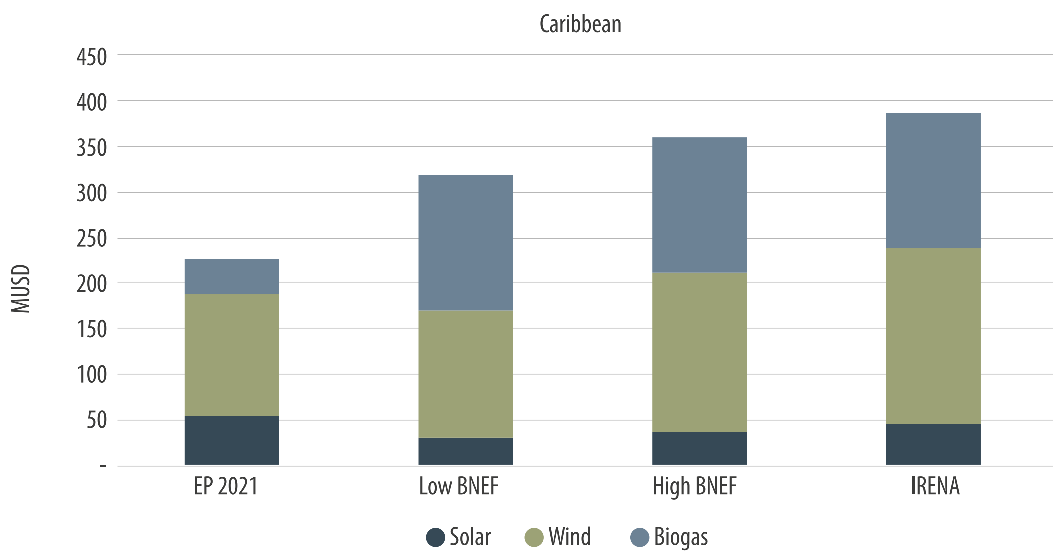


The Caribbean and Central America and Mexico subregions were analyzed similarly. This overviews the investment dimension and the efforts the different subregions must make during the decade.

Figure 14 shows the amounts of investments according to the different price scenarios. The size of the scales is highlighted, as the Caribbean countries (graph on the right) will invest about 100 times less in wind, solar, and biogas energy compared to the countries of Central America and Mexico.

Figure 14. *Sensitivity analysis for Central America and Mexico and the Caribbean regions. (Own elaboration)*





In most subregions, the baseline scenario named Energy Path 2021 is the most optimistic. This scenario references Latin America's prices for solar and wind power, reflecting the region's experience with non-conventional renewable energies. Another interesting sensitivity analysis result is the range between the different investment amounts. The results of the various subregions indicate that between the baseline scenario —from which the investment amounts of this report are estimated— and the most conservative scenario, the IRENA scenario, there is a difference of 63% on average. This indicates the future saving possibilities that the region's different economies may have.

3 ENERGY EFFICIENCY: THE ALLY OF ENERGY TRANSITION

In the electricity sector, energy efficiency indicates the energy needed to carry out domestic tasks, industrial production, or supply services. An efficient power system allows significant energy savings, directly impacting the short-term supply and the need for long-term investments. In addition, in systems with a substantial dependence on fossil fuels, greater electrical efficiency allows for a decrease in the use of this type of power plant and, therefore, a reduction in emissions. Thus, electrical efficiency is an ally of the energy transition, helping the country to achieve its sustainable development goals.

According to the IEA (2020), from a global perspective, energy efficiency—from all sources and for all uses—has changed on average by 2.05% per year, between 2010 and 2019, with a cumulative increase of 20% during that period. This implies that the same good, service, or task carried out in 2010 consumed 20% less energy when carried out in 2019. It also reports that to achieve the sustainable development goals, countries must increase their energy efficiency by 4.0% annually between 2020 and 2040, two times what was achieved in the previous decade (2010-2019).

Today, the world's nations are in very different positions on their path to long-term sustainable development. As for the LAC countries, Ravillard et al. (2019) highlight that the low quality of electrical services, limited access to new and more efficient electrical devices, and the precarious affordability of energy services by the most vulnerable population are gaps that could be closed with policies that improve energy efficiency standards. For this reason, this study adds a new scenario to analyze the effect that redoubling energy efficiency efforts will have on investments in the electricity sector and the reduction of emissions.

In this section, electricity demand is estimated under the assumption that the region's countries will implement energy efficiency policies that meet the IEA (2021) standards, i.e., 4% until 2030. With the new demand estimates, we calculate the needed supply and investments by type of technology to maintain the generation portfolio planned for 2030. At the end of this section, we present the emissions savings associated with this scenario.

3.1 EVOLUTION OF DEMAND BY 2030 WITH ENERGY EFFICIENCY

If the countries of the region achieve the energy efficiency standards estimated by the International Energy Agency, the regional electricity demand would be 25.9% lower than our baseline scenario calculated in the previous sections.

Figure 15. *Electricity demand in LAC in the energy efficiency scenario. (Own elaboration)*

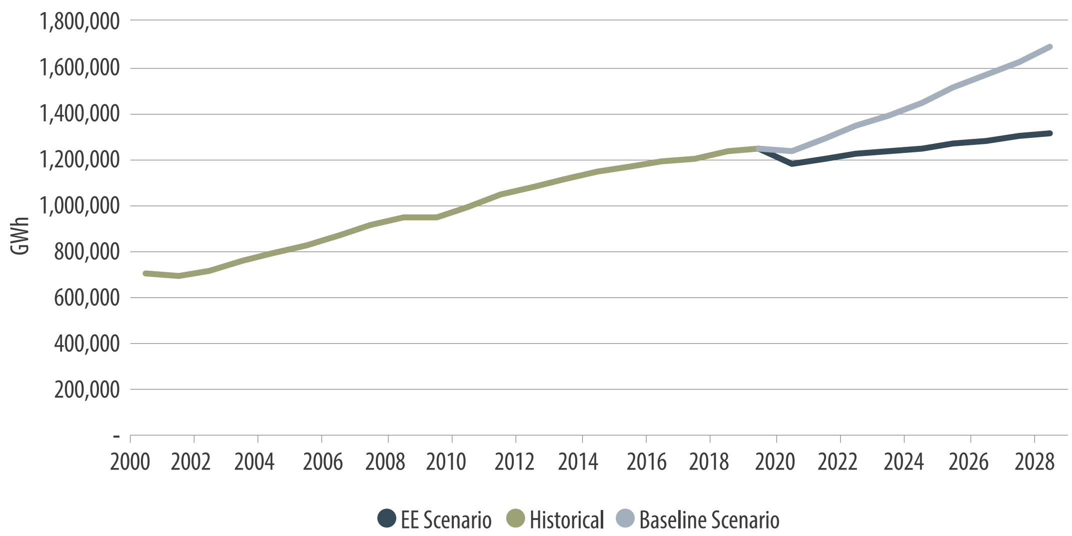
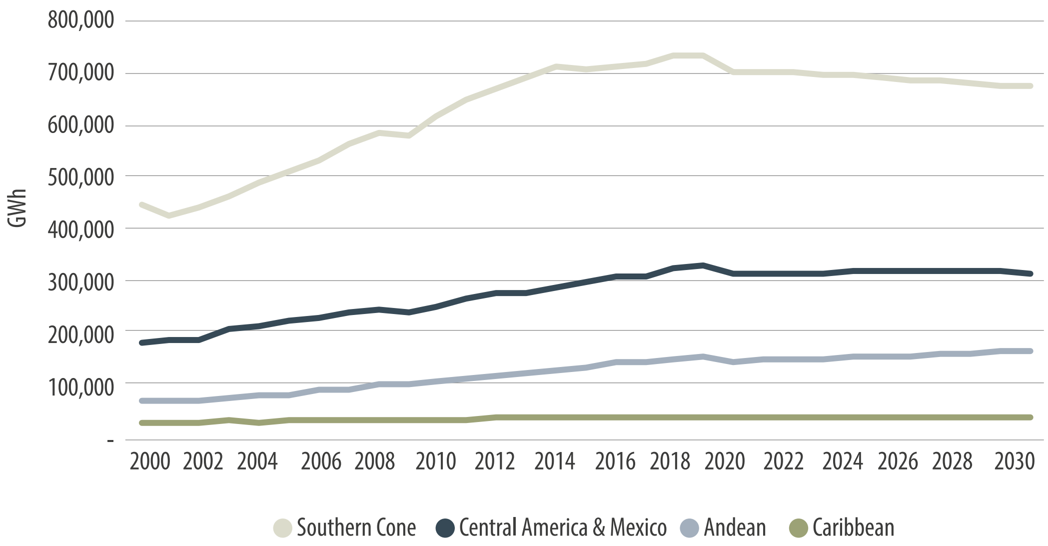


Figure 15 shows the results of the demand estimation. The navy blue line indicates the new trajectory of the demand under the energy efficiency scenario (EE), while the sky blue line represents the baseline scenario previously calculated. At the end of 2030, the regional electricity demand under the EE scenario is 25.9% lower than that estimated for the baseline scenario. Figure 16 replicates the analysis for each subregion.

Figure 16. *Electricity demand by subregion in an energy efficiency scenario. (Own elaboration)*



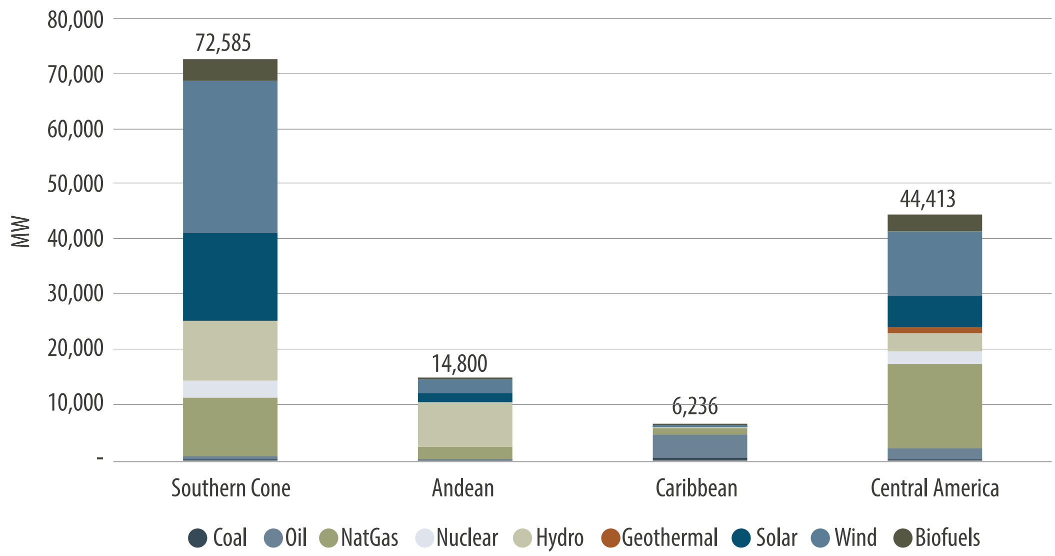
In all the subregions, except for the Southern Cone region, it is observed that the demand increases at a lower rate compared to our baseline scenario, see Figure 16. The electricity demand in the Southern Cone is the only one that experiences a contraction in absolute values compared to 2020 due to the potential increase in electrical efficiency.

3.2 INVESTMENT IN NEW CAPACITY

To obtain the investment requirements, we carried out the same procedure as in section 2, considering the new demand estimates obtained previously. The results indicate that, due to the increase in energy efficiency, all regions will have savings in their investment needs compared to the forecasts of our baseline scenario. Figures 17 and 18 show the estimates of investments in new capacity by subregion.

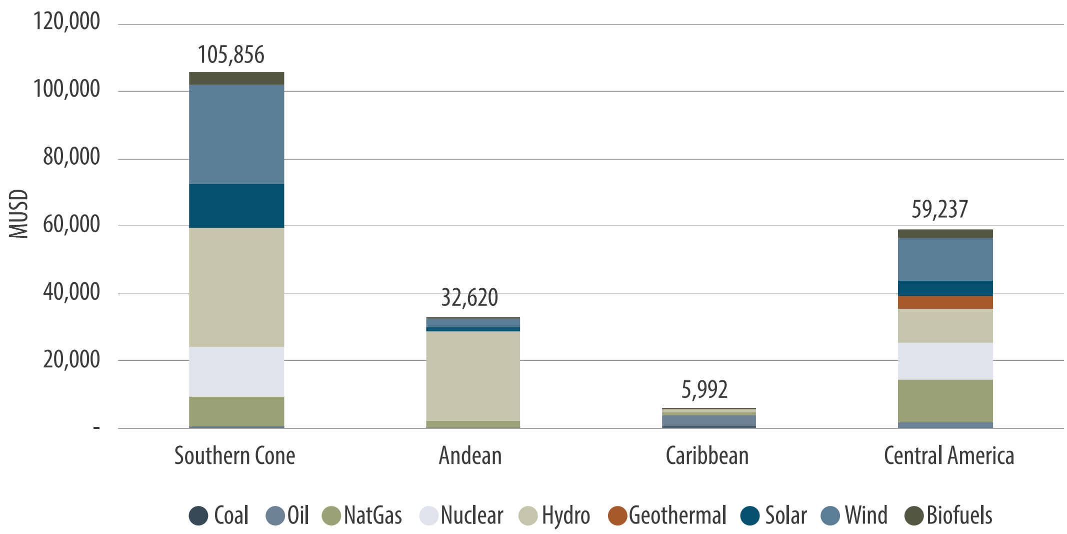
Regarding the results of the baseline scenario, see Figure 10. A reduction in investment requirements is observed in all subregions. The region experiencing the most significant decrease is the Southern Cone, which went from investing 79.6 thousand MW to 72.5 thousand MW (a reduction of 8.8%). Among all energy sources, the most significant decrease is in new thermal power plants powered by fuel oil (47.7%). With this increase in efficiency, we estimate savings of USD 10.8 billion (9.3%).

Figure 17. *Investments in new capacity in the energy efficiency scenario, 2020-2030. (Own elaboration)*



In its turn, the Andean region experienced a reduction from 19.3 thousand MW to 14.8 thousand MW (23.4%), with a significant reduction in thermal power plants fueled by fuel oil (49.9%) and natural gas (34.3%). With this increase in efficiency, it is estimated that this region would achieve savings of USD 9 billion (-21.8%). In Central America and Mexico, a reduction of 45.8 thousand MW to 44.4 thousand MW (0.7%) is estimated. With this increase in efficiency, we estimate savings of USD 531 million (0.9%). In the case of the Caribbean, there is not enough information to estimate the results of electrical efficiency.

Figure 18. *Investments in new capacity in the energy efficiency scenario, 2020-2030. (Own elaboration)*



3.3 EMISSIONS REDUCTION

Energy efficiency translates into monetary and emission savings. We estimate the emissions generated by new generation sources, and the results suggest a regional difference of 20% by the end of 2030 compared to the baseline scenario.

Figure 19. *Estimated emissions (MtCO2e) in the energy efficiency scenario, 2000-2030. (Own elaboration)*

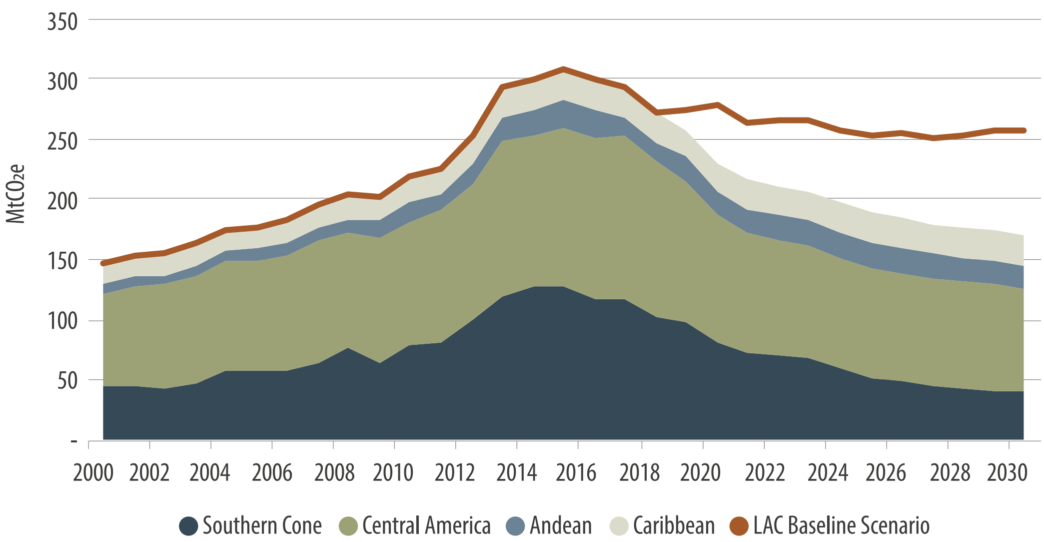


Figure 19 shows this reduction, going from 273 $MtCO_2e$ in the baseline scenario to 218.9 $MtCO_2e$ in the scenario where the countries achieve the energy efficiency goals. The emission savings are observable in all regions, starting with the Southern Cone, with a reduction of 33.7%; the Andean Region, with 14.62%; Central America and Mexico, with 9.7%; and the Caribbean, with 4.0%.

4 BENEFITS OF ELECTROMOBILITY IN LAC

According to data from the *Energy Hub* (IDB, 2020), in 2019, 39% of CO_2 emissions in LAC were from the transport sector, followed by the electricity sector with 22%, which indicates how urgent collaboration between both industries is to decarbonize the economies. An important component to accelerate emissions reduction in both industries is the battery, particularly those that allow greater efficiency of electric vehicles. The rise of electromobility -- the replacement of internal combustion engine vehicles with electric vehicles -- is an important step toward reducing carbon emissions. The countries' energy transitions on their different electrical sources and the electrification of the vehicle fleet will allow reaching the net-zero emissions goal.

The level of impact that this replacement will have on the energy transition goals will depend not only on the speed of adoption of electric vehicles but also on the rate of decarbonization of the electrical matrix once its adoption generates an exceptional demand for electricity. This section analyzes the effect that the adoption of electric vehicles has on electricity demand, in addition to the direct and indirect effects that this adoption has on the transport sector's emissions in LAC.

To estimate these effects, different rates of replacement of traditional vehicles with internal combustion engines by electric vehicles were evaluated. For each of these scenarios, a Bass adoption curve (these curves are known to be S-shaped) is estimated assuming a fixed rate of adopters equal to that calibrated in Mejdalani et al. (2019) for photovoltaic solar panels, while the mathematical model itself calculates the imitation rate (bandwagon effect).

Although this methodology is not characterized by its predictive power, it allows us to conduct a sensitivity analysis between different scenarios. For example, from the most conservative scenario, one without significant adoption of electric vehicles, to a more optimistic scenario, where economies are about to reach the goal of net-zero emissions in 2050 (IEA, 2021). For data reasons, we performed the sensitivity analysis on a representative sample of 14 LAC countries.

Southern Cone	Andean Region	Central America and the Caribbean
Argentina	Bolivia	Costa Rica
Brazil	Colombia	Guatemala
Chile	Ecuador	Mexico
Paraguay	Peru	Panama
Uruguay		Dominican Republic

For each country, we collected the following information:

i. Light vehicle fleet size in 2020 (or 2019 when more up-to-date data was unavailable) (Global Fleet, 2021).

ii. The average growth rate of the light vehicle fleet in the last 5 years (Global Fleet, 2021).

iii. The emissions intensity of CO_2 equivalent from the transport sector per million vehicles (Climate Watch, 2021).

iV. The emissions intensity of the electrical source that was previously presented in section 2.

Finally, we assume that the growth rate of the light vehicle fleet and the emissions intensity of CO_2 per million vehicles will remain constant across countries until 2030. In practice, this implies that: (1) reported revenues from light vehicle sales are inelastic, but more importantly, this assumes that (2) there will be no significant technological gain in internal combustion engines that reduce the emissions intensity of the fleet. Furthermore, we assume that an electric vehicle consumes an average of 0.15 kWh per kilometer and that each vehicle travels an average of 15,000 kilometers in a year.

4.1 ELECTRIC VEHICLE ADOPTION SCENARIOS

The expected impact on emissions can be divided into two effects with opposite signs: i) direct effect (-) in reducing carbon emissions from the transport sector; and ii) indirect effect (+) due to the increase in carbon emissions from the electricity sector due to increased demand. Therefore, the total impact is the sum of the direct (-) and indirect (+) effects on carbon emissions. The higher the emissions intensity (CO_2/KWh) of the electric source projected into the future, the lower the expected decarbonization gain with introducing electric vehicles into the fleet. That is why electromobility without energy transition is only a halfway journey and vice versa.

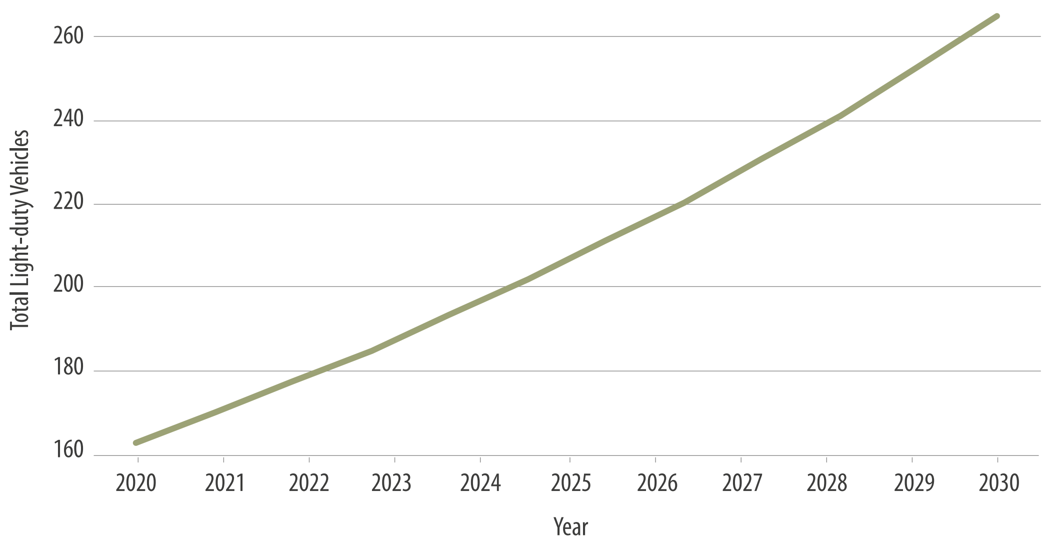
The following two sections present the regional and country results of the 7 different electric vehicle adoption scenarios defined below. The scenarios go from the most conservative to the most optimistic context.

Scenario	Characteristics
Business as Usual (BAU)	There will be no significant participation of electric vehicles until 2030, keeping the market share at levels close to 0%.
Conservative	The market share of electric vehicles will reach 1% by 2030.
Moderated	The market share of electric vehicles will reach 5% by 2030.
IEA-Sustainable development	The market share of electric vehicles will reach 8.2% in 2030. This scenario is based on the IEA's *Global Electric Vehicles Outlook* (2020).
Optimistic	The market share of electric vehicles will reach 10% in 2030.
IEA-State policies	The market share of electric vehicles will reach 12.2% in 2030. This scenario is based on the IEA's *Global Electric Vehicles Outlook* (2020).
IEA-Net-zero emissions (NZE)	The market share for electric vehicles will reach 18.8% in 2030. This scenario is based on the IEA's Net-Zero Emissions publication (2021), which predicts that, by 2030, electric vehicles will account for 60% of the sales of new light vehicles.

4.2 REGIONAL RESULTS

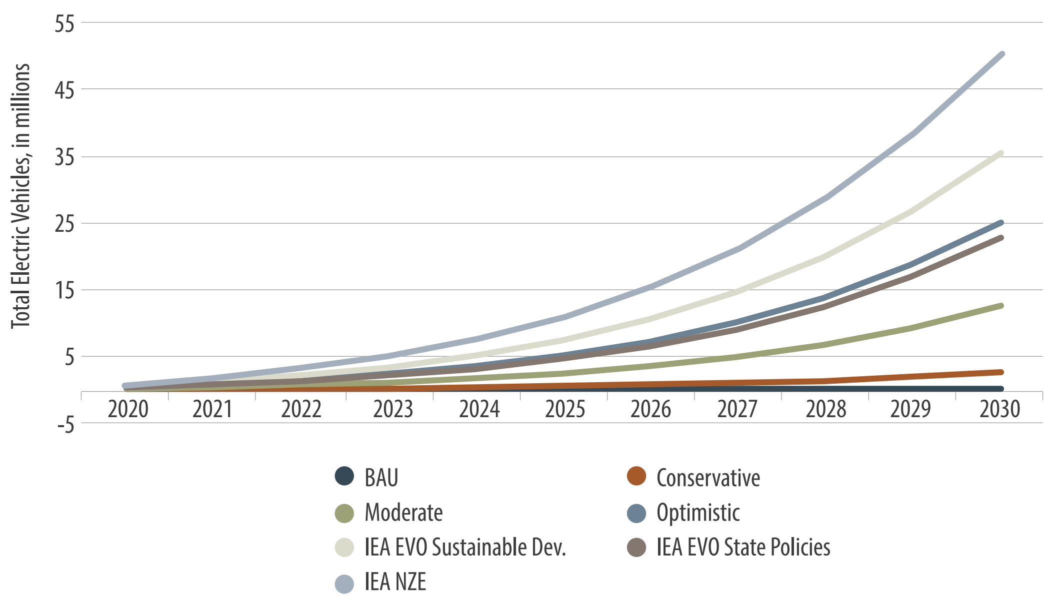
The estimation strategy was as follows: first, in order to obtain the regional results, we projected the increase, by 2030, in the light weight vehicle fleet for the whole sample of 14 LAC countries. Figure 20 shows that, by 2030, the light vehicle fleet will reach nearly 265 million units in circulation, which translates into an average annual increase of 5% between 2020 and 2030.

Figure 20. *The fleet of light weight vehicles in Latin America and the Caribbean. (Own elaboration)*



Once the light weight vehicle fleet had been estimated, we proceeded to estimate the seven scenarios according to the premises of adoption assumed in each of them. Figure 21 shows the total electric vehicle fleet in millions of units per year. The results reveal that, in the most optimistic case, the IEA-NZE scenario, a fleet of 53 million electric vehicles is expected by 2030. It is important to remember that this scenario is based on the IEA (2021) calculations to reach the net-zero emissions scenario. It is also observed that the growth trend accelerates at the end of the decade, indicating that there is room for even greater adoption in the following years. It highlights that, in 4 scenarios, it is expected the adoption of over 20 million units of electric vehicles in the region, which happens when the market share of electric vehicles reaches at least 12.2% in 2030 (state policy scenario).

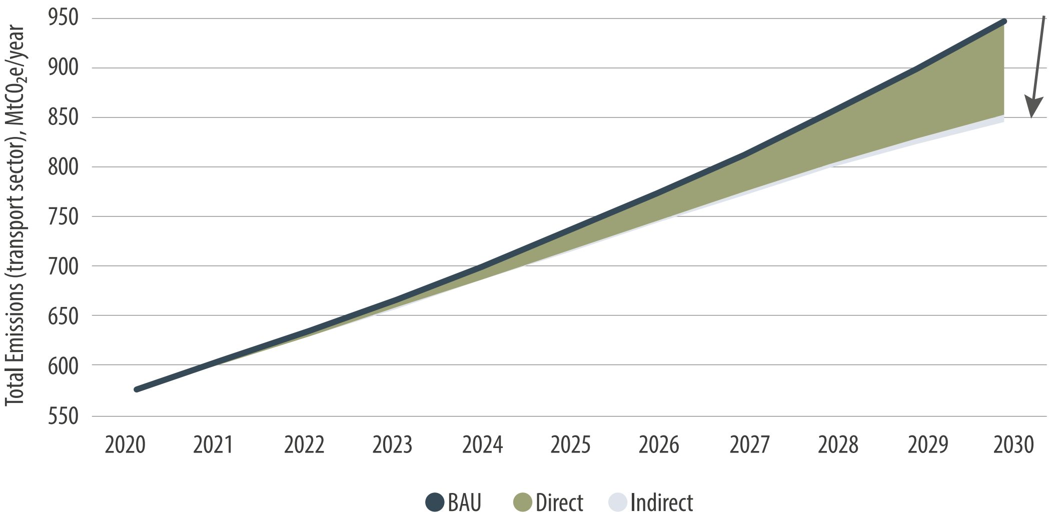
Figure 21. *The electric vehicle fleet in Latin America and the Caribbean according to different adoption scenarios. (Own elaboration)*



As previously mentioned, the full impact of electric vehicle adoption on emissions would depend on two effects in opposite directions. Therefore, after estimating the electric vehicle fleet, the next step was calculating transportation sector emissions. Figure 22 compares the emissions of two scenarios, one where there is no adoption of electric vehicles (BAU, market share is close to 0%) against the optimistic scenario, in which 10% of the light vehicle fleet with internal combustion engines are replaced by electric vehicles until 2030. We can see that the emissions of the BAU scenario have a 45-degree line, while in the optimistic one, it is more curved. The distance between these two emissions trends can be broken down into direct and indirect effects. On average, the indirect effect (+8.27 $MtCO_2e$) generated by the increase in electricity demand is small compared to the direct substitution effect (-93.75 $MtCO_2e$), promoting a negative balance in CO_2 emissions of 85,48 $MtCO_2e$, or 9.1%.

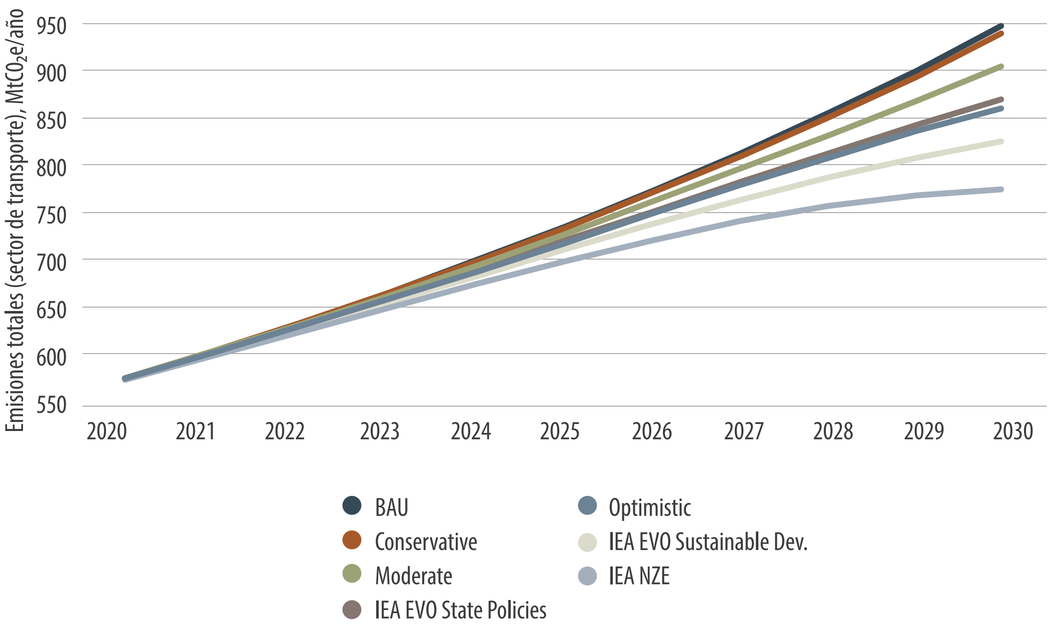
Figure 22 offers another perspective. Throughout these 10 years, the cumulative reduction in CO_2 emissions amounts to 297 $MtCO_2e$. This cumulative reduction, represented by the arrow pointing down, exceeds the sum of the annual emissions of Mexico (193 $MtCO_2e$ in 2018) and Brazil (88 $MtCO_2e$ in 2018) in electricity production or for heating purposes.

Figure 22. *Emissions of the transport sector in Latin America and the Caribbean; BAU scenario vs. optimistic scenario. (Own elaboration)*



Similarly, the other scenarios also reveal a significant reduction in CO_2 emissions from replacing internal combustion engine vehicles with electric vehicles. In the scenario with the most significant decrease, IEA-NZE (gray line), a reduction of 170 $MtCO_2e$ is expected by 2030, compared to the BAU scenario (navy blue line). In this scenario, the cumulative reduction of CO_2 over 10 years amounts to 616 $MtCO_2e$ (see figure 23).

Figure 23. *Emissions of the transport sector in LAC according to each adoption scenario. (Own elaboration)*



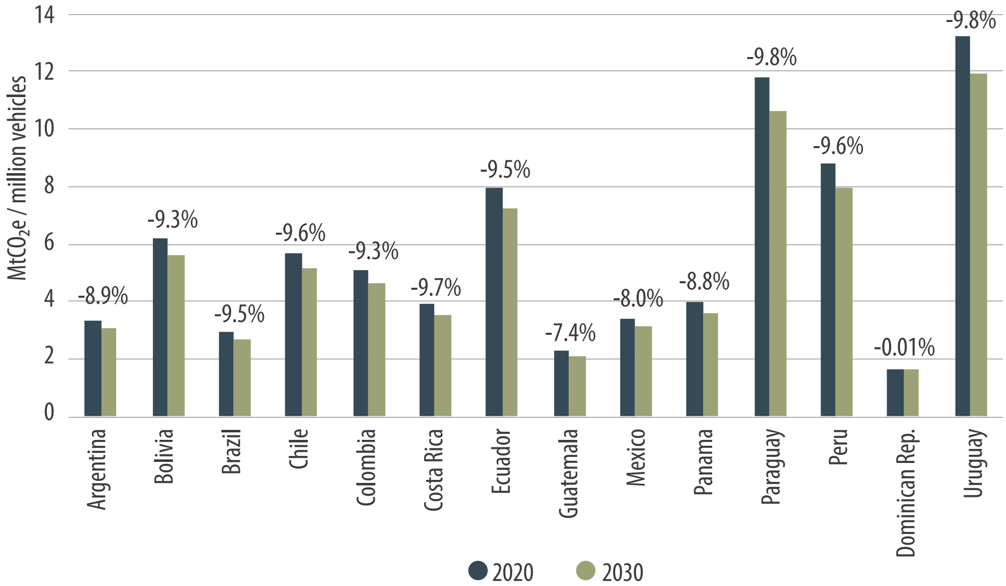
The purpose of modeling these scenarios is to show the space that governments have in the design of policies for the adoption of electric vehicles; however, the probability that these results materialize will depend, to a greater or lesser extent, on its execution and, clearly, on the rate of replacement and adoption by households and businesses.

4.3 RESULTS BY COUNTRY

In this section, information from 14 Latin American countries is used to model the adoption of electric vehicles, comparing the emissions intensity of the light vehicle fleet ($MtCO_2e$/million vehicles) between 2020 and 2030 for each of these countries. The indicator in 2030 compares the 10% fleet replacement scenario.

Figure 24 shows that the change in emissions intensity is directly related to the difference between the direct and indirect effects of replacement. The indirect effect derives from the emissions trajectory of the country's technological matrix. The greater the effort to decarbonize the electricity generation sources, the less onerous will be the inclusion of excess demand caused by the adoption of electric vehicles. Emissions intensity is significantly and heterogeneously reduced in the different countries, except for the Dominican Republic, which had a significant effect depending on the characteristics of its electricity source.

Figure 24. *The intensity of vehicle fleet emissions by country, 2020 vs. 2030. (Own elaboration)*



In summary, in the baseline scenario, the emissions gap is calculated at 256 megatons of CO_2 equivalent by the decade's end. In contrast, in the energy efficiency scenario, it will be reduced to 218.9 $MtCO_2e$ by 2030. If the expansion of electric vehicles is added to these scenarios, by 2030, an additional reduction of 170 $MtCO_2e$ would be expected under the most optimistic scenario of the adoption of electric cars.

5 CONCLUSION

In recent decades, the electricity sector in Latin America and the Caribbean has been in constant expansion, driven by the growth of the countries in the region, the development of industrial activity, and the implementation of public policies that promote universal access to electricity. However, the beginning of the 2020s raised the question of how far we are from reaching the emission reduction goals, especially when the countries suffered economic stress caused by the COVID-19 pandemic.

This report invites discussion on the direction that the different electricity sectors of the countries are taking. Using the methodology of the study *¡A Todas las Luces!* (Yépez et al. 2018), electricity demand projections were updated, and, based on the expansion plans of the countries, the different generation sources were estimated. The results of this exercise suggest that by 2030 there would still be a gap of 273 megatons of CO_2 equivalent to be reduced to reach the goal of zero-net emissions in the electricity sector by 2050. Among the main findings, coal will be the source that will experience the most significant reduction in participation throughout this decade, and non-conventional renewable generation sources will have a boom, certainly driven by the fall in their costs.

In terms of investment, the subregion that will invest the most capacity throughout this decade is the Southern Cone, with 79,617 MW, and a large part of this investment will be located in Brazil. The Southern Cone is followed by Central America with 45,678 MW and the Andean region with 19,313 MW. Finally, we estimate that to supply the electricity demand, the Caribbean countries will need to invest approximately 6,328 MW by 2030. The sum of investment needs amounts to approximately USD 226 billion distributed throughout the decade.

The results presented provide an updated overview of the sector's electricity supply, investment needs, and emissions. But they also provide instruments for the design of policies based on different scenarios. It was shown that if the region's countries reached the energy efficiency standards of 4%, estimated by the International Energy Agency, the regional electricity demand by 2030 would be 25.9% lower than our baseline scenario. The estimates suggest a decrease of 20% in emissions compared to the initial scenario, thereby reducing the emissions gap by 2030. The fourth section of the report was dedicated to exploring the expected impact of an expansion of electromobility over emissions. It is observed that, among the estimated cases, the most optimistic scenario predicted that, by 2030, approximately 53 million electric vehicles would be circulating in the region. Under this scenario, a cumulative reduction of 616 $MtCO_2e$ is expected over 10 years.

When the first *¡A Todas las Luces!* was published in 2018, there was no way to foresee the magnitude of an external shock like the one that the pandemic had on the region, capable of paralyzing sectors of the economy, delaying projects, and demanding that large sums of public funds were canalized for poverty alleviation and economic recovery. However, the economic recovery opens the opportunity to accelerate the transition process, going beyond what the expansion plans had foreseen. However, the speed of the recovery will depend on a range of factors that include economic sectors, public entities, and international cooperation. The countries of Latin America and the Caribbean must make use of all the tools at their disposal and continue on the path of decarbonizing their economies and thus reduce the emissions gap by 2050.

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7 ANNEXES

7.1 ANNEX A: DATA AND METHODOLOGY FOR ESTIMATING ELECTRICITY DEMAND

This section presents the methodology and data used to estimate the electricity demand projection for LAC. According to the economic literature, there are different methods to estimate long-term electricity demand. Bhattacharya (2011) lists the methods for calculating the future demand for electrical energy most used by researchers and policy makers. According to the author, these methods can be grouped into 7 different categories: (i) based on economic indicators; (ii) historical trend analysis; (iii) household and business surveys; (iv) input-output models; (v) evaluation of energy scenarios; and, (vi) artificial neural networks.

Analyzing the estimation methods most used by LAC agencies and policy makers, the publication ¡A Todas las Luces! (published in English as The Energy Path, Yépez, et al. in 2018) found that the categories (i) and (ii) were the most commonly used. In addition to being more practical and understandable, market agents widely approve of these methods. Furthermore, they require a smaller amount of data for their estimation and have a low implementation cost compared to other alternative methods.

In this report, we opt for a combined estimate, including historical indicators and their projections, such as the historical trend of electricity demand. For the selection of variables, the variables whose relationship with electricity demand has extensive empirical evidence recognized in the economic literature were chosen. The estimation of the long-term projection model is also inspired by the projection made by Yépez et al. (2018). They estimated the electricity demand of 26 countries in Latin America and the Caribbean for 2018-2040. The demand estimate was made using 3 different data sources: (i) the Latin American Energy Organization (OLADE) to obtain total final consumption from 1971 to 2019;

(ii) the macroeconomic indicators of the World Bank; (iii) the data available on electricity rates on the Energy Hub platform of the Inter-American Development Bank.

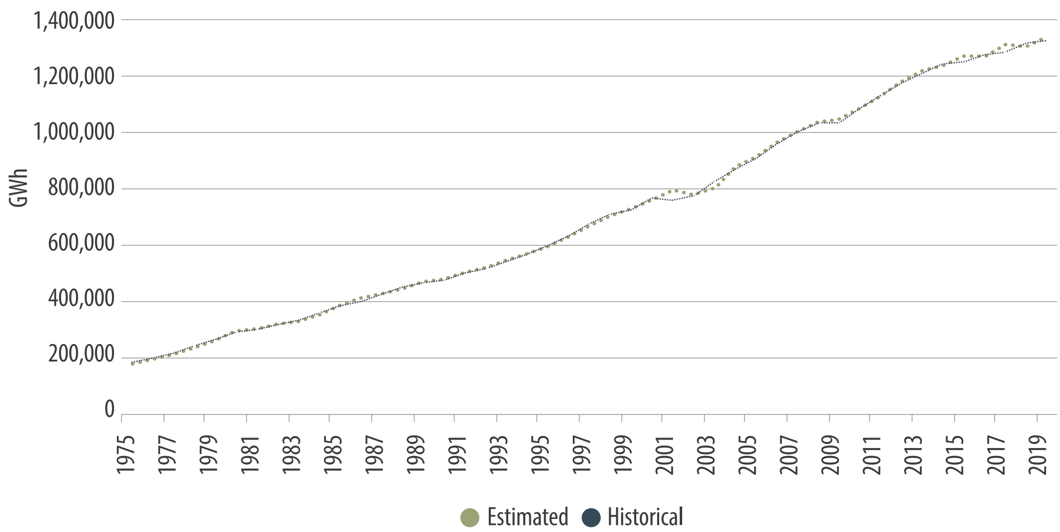
Specifically, the model used to estimate the demand projections was an ARIMAX, an autoregressive integrated moving average model with exogenous variables. This econometric model is a generalization of the ARIMA class of models that allows analyzing and projecting time series using past behavior and exogenous variables. The model consists of 4 parts. Each part corresponds to (i) integration or differentiation (generally referred to by the letter d), a (ii) autoregressive element (the letter p), to which is added a (iii) moving average (the letter q), and controls referred to (iv) exogenous variables (letter x). Each part performs an important function in the estimation, integration, or differentiation and ensures that the time series is described as a stationary process. A stationary process is one in which there is a stochastic process with a fixed probability distribution for all time instants. This implies that the mean and variance of the time series are constant over time. The autoregressive part takes into account the past values of the study variable, capturing, in a way, its trend. The moving average, in turn, is the value of the q past estimation errors. Exogenous variables help explain the path of the dependent variable. This study includes the GDP projection and the utility rate as exogenous variables. Some examples of the relationship between electricity demand and economic activity can be found in the following articles: Magazzino (2014); Chen and Kuo (2007); Jiménez and Mercado (2014); Al-mulali, Fereidouni, and Lee (2014). The article by Fan and Hyndman (2011) is a good starting point regarding the relationship between demand and prices.

The reference equation used to estimate electricity demand is presented below. The model is a linear combination of the 4 parts mentioned above, where TFC is the Total Final Consumption and is the study variable that is sought to be projected. Finally, for the correct specification of the equation (values of *d, p, q*), we use a very recurrent method in the time series literature, that is, the Box-Jenkins method (Box and Jenkins, 1970):

$$\underbrace{y'(TFC)_t}_{\text{differenced time series}} = \underbrace{\sum_{i=1}^{p} \beta_i y'(TFC)_{t-p}}_{AR(p)} + \underbrace{\sum_{j=1}^{q} \Theta_j \varepsilon_{t-q}}_{MA(q)} + \underbrace{\sum_{m=1}^{k} \alpha_m x_m}_{\text{Exogenous variables}}$$

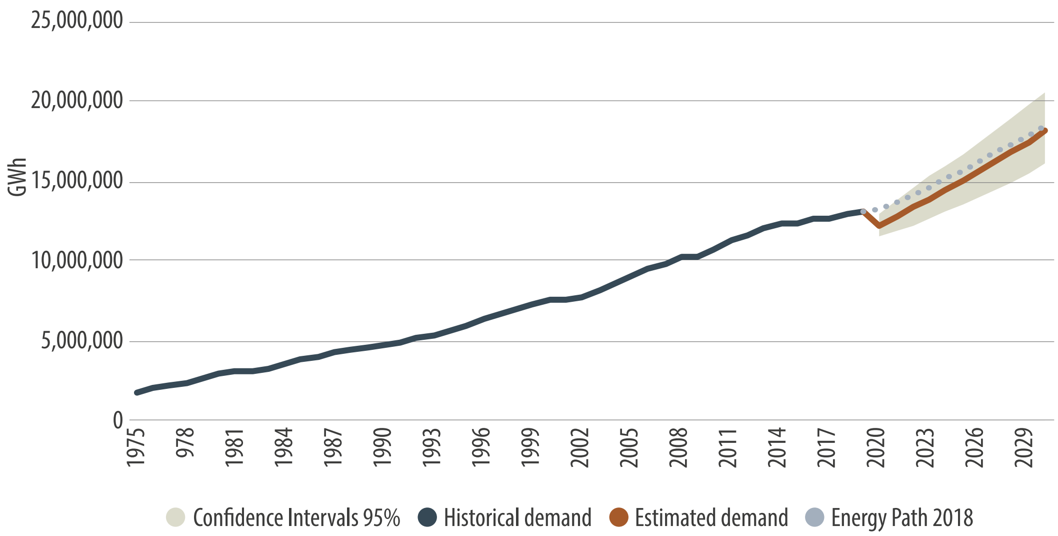
The prediction model must be able to explain the past at any given time. That is, the selected econometric model must have a good historical fit to project the future. Below, in figure A.1., two lines are depicted: the dotted green line is the electricity demand estimate resulting from the ARIMAX model, and the solid navy blue line represents the regional historical electricity demand from 1975 to 2019. We can observe that both curves are superimposed, which is a good sign of the model's fit in historical terms. In terms of premises, we assume that all generation goes directly to final consumption, so we do not discount electrical losses.

Figure A.1. *Historical demand and ARIMAX projection, 1975-2019. (Own elaboration)*



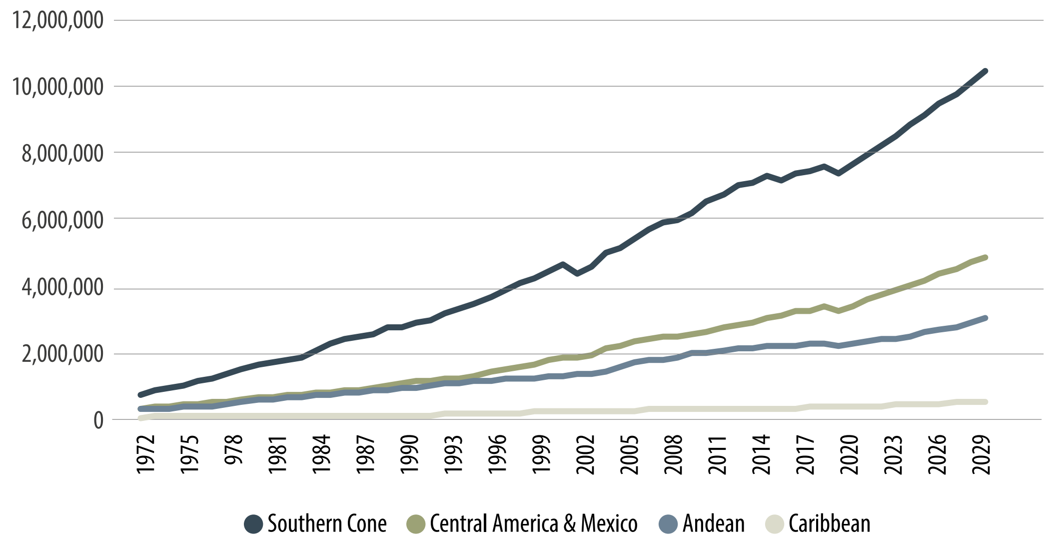
Furthermore, like any other statistical method of projection of temporal data, the error is cumulative and increases with subsequent periods. That is, although the estimated error for the first year of the projection is small, the estimated errors for the last years of the projection are likely significant. That is why it is necessary to calculate the confidence intervals of the estimates. Figure A.2. shows the confidence intervals of future demand estimates. It can be observed that the electricity demand projection (orange line) is within the confidence interval (lime green space). The two figures above show that the model fits in historical terms and is a useful tool for forecasting regional electricity demand.

Figure A.2. *Projection of regional electricity demand by 2030. (Own elaboration)*



The exercise was replicated for each subregion of Latin America and the Caribbean. The results indicate that the demand for electricity in the Southern Cone will grow at a growth rate of 3.3% on average per year during the decade. The region comprised of Mexico and Central America will do so at 3.7%, the countries of the Andean region will do so at a growth rate of 3.1%, and the Caribbean at 3.9%. Figure A.3 below shows each subregion's historical electricity demand and projections.

Figure A.3. *Historical and regional electricity demand projection, 1972-2030. (Own elaboration)*



7.2 ANNEX B: ELECTRICITY SUPPLY AND INVESTMENTS

7.2.1 Electricity Provision

To estimate the generation source of each country and calculate the investment needs, we follow the methodology described in Yépez et al. (2018). This methodology uses the electricity generation expansion plans of the different countries in the region as the primary source of information. When incorporating the projections of the various expansion plans into the analysis, the intentions of the governments and their different planning exercises are taken into account.

However, the region still has obstacles to making the planning exercise a regular practice. In many cases, we faced the challenge of not finding an update for the plan with projections that reach the year 2030. In these cases, we assume that the last matrix projected by the plan remains constant until the end of the decade. In cases where there is no expansion plan to be used as a reference, we also assume that the country will maintain the same composition of its generation sources in the coming years. These premises are conservative since it is assumed that, throughout the decade, the country will not make any changes in the type of technologies that supply electricity. The following table shows the expansion plans considered in the analysis and their expansion period. In the case of the Caribbean countries and those where it was not possible to obtain a public and updated expansion plan, we assume that there will be no changes in the composition of their generation sources. This premise was called the perpetuity premise. In the case of Venezuela, its projections were not included due to the lack of updated, public and official information that could be harmonized with the rest of the regions.

Table B.1. *Electrical expansion plans for Latin America and the Caribbean countries. (Own elaboration)*

Country	Region	Title (in Spanish)	Planning Period
Chile	Southern Cone	Planificación Energética de Largo Plazo	2023-2027
Brazil	Southern Cone	Plano Decenal de Expansão de Energia 2030	2030
Uruguay	Southern Cone	Plan Quinquenal 2019-2023	2019-2023
Argentina	Southern Cone	Escenarios Energéticos 2040	2040
Argentina	Southern Cone	Escenarios Energéticos 2030	2040
Argentina	Southern Cone	Programa Federal Quinquenal de expansión de obras de Infraestructura Energética	2030
Paraguay	Southern Cone	Plan Maestro de Generación y Transmisión	2025
Bolivia	Andean	Plan Eléctrico	2025
Peru	Andean	Plan Energético Nacional 2014-2025	2014-2025
Ecuador	Andean	Plan Maestro de Electrificación	2019-2027
Colombia	Andean	Plan de Expansión de Transmisión 2019-2033	2019-2033
Colombia	Andean	Plan de Expansión de Generación 2017-2031	2017-2031
Colombia	Andean	Plan Energético Nacional 2020-2050	2020-2050
Venezuela	Andean	Plan de la Patria 2019-2025	2019-2025
Mexico	Central America and Mexico	Programa de Desarrollo del Sistema Eléctrico Nacional 2018-2032	2018-2032
Guatemala	Central America and Mexico	Plan Indicativo de Expansión del Sistema de Generación 2020-2050	2020-2050
Nicaragua	Central America and Mexico	Plan de Expansión de la Generación Eléctrica 2019-2033	2019-2033
El Salvador	Central America and Mexico	Plan Indicativo de la Expansión de la Generación Eléctrica de El Salvador 2019-2028	2019-2028
Honduras	Central America and Mexico	Plan Indicativo de Expansión de la Generación del Sistema Interconectado Nacional	2019-2029
Honduras	Central America and Mexico	Análisis del Impacto de la Emergencia Nacional COVID-19 en la Planificación Operativa de Mediano Plazo	2020-2029
Costa Rica	Central America and Mexico	Plan De Expansión de la Generación Eléctrica 2018-2034	2018-2034
Panama	Central America and Mexico	Plan de Expansión del Sistema Interconectado Nacional 2019-2033	2019-2033

Country	Region	Title (in Spanish)	Planning Period
Belize	Central America and Mexico	Assessment of the Electricity Generation System	2020-2035
Haiti	Caribbean	Assumption of perpetuity	
Dominican Republic	Caribbean	Planificación de Inversiones en Generación Eléctrica	2020-2040
Barbados	Caribbean	Assumption of perpetuity	
Bahamas	Caribbean	Assumption of perpetuity	
Surinam	Caribbean	Assumption of perpetuity	
Guyana	Caribbean	Assumption of perpetuity	
Trinidad and Tobago	Caribbean	Assumption of perpetuity	
Jamaica	Caribbean	Assumption of perpetuity	

The next step was to homogenize the electricity generation data of all the available expansion plans with the historical generation data published in the *Energy Hub* of the Inter-American Development Bank. This created a unique time series for each energy source in each country: coal, oil, natural gas, geothermal, hydroelectric, biomass, wind, solar, and nuclear. All the country's sources were added, and with this, the generation sources for Latin America and the Caribbean were built for 2020-2030.

7.2.2 Estimated Investment in New Capacity, Transmission, and Discontinuous Depreciation

As the electricity supply estimates, the methodology used to estimate investment needs comes from the report *¡A Todas las Luces!* by Yépez et al. (2018). The investment requirements are mainly divided into three sources: (i) new capacity —all capacity related to the expansion plans of the countries and the additional capacity to cover projected future demand—; (ii) discontinuous depreciation —the capacity that will reach its useful life and will need to be replaced—; and, (iii) expansion of electrical grids necessary to meet the growing demand.

The procedure for estimating the first category is based on taking what is projected by the government and adding the gap between the demand projection and the amount of energy estimated according to the government's expansion plan. Therefore, the category of new capacity focuses on the generation plants necessary to meet the growth in demand. If the projected demand is greater than the supply described in the plan, this gap is calculated in GWh and distributed among the different types of sources according to the generation source of each country. It is then converted to MW using plant-level data, and finally, the capacity is multiplied by the unit cost of capital. The following table shows the costs applied for each of the technologies.

Table B.2. *Average cost of capital. (Own elaboration with data from IPCC, EIA, and NREL)*

Type	Overnight Capex (USD/kW)	Optimal Utilization Factor
Coal	1880.0	4730.4
Oil	800.0	2102.4
Natural gas	831.0	4758.1
Nuclear	4700.0	8 103.0
Hydroelectric	3263.0	5535.5
Geothermal	3173.0	7884.0
Solar	820.5	2694.6
Wind	1065.5	3560.5
Bio fuels	980.5	5308.6

To estimate the investment requirements associated with discontinuous depreciation, we first calculate the age of the installed capacity and define the replacement date or useful life by type of technology. As with the new capacity estimates, the GWh generated since 1971 was converted to MW. Once converted to MW, the replacement dates for each technology were calculated based on the useful life cycle of each type of plant according to data from the World Bank's META model. For example, coal-fired power plants have a useful life of 30 years, so some of the capacity installed in 1980 will need to be replaced in 2010. Using this correlation, we assume that once the technology reaches the end of its useful life, it will be replaced entirely, resulting in a discontinuity. We also note that this calculation is not associated with a maintenance cost and is intended to be more of an approximation to the replacement cost of installed capacity and an approach to the level of investment that countries will have to make to maintain current levels of generation in good condition.

Finally, investment in electrical grids is associated with the following equation:

$$Redes_{t,k} = \pi_k * (G_{t,k} - G_{t-1,k}) * C_k$$

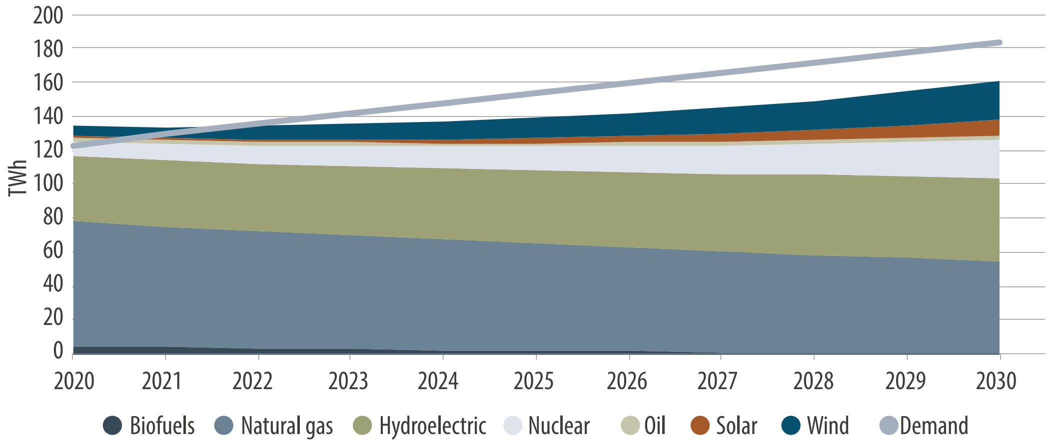
Where π_k is the additional length of the transmission grid required for each additional generation unit (km/GWh), the term in parentheses is the increase in electricity demand from one year to the next (t) in the k-th country, and C_k is the unit cost of grid assets (USD/km).

7.3 ANNEX C: RESULTS BY COUNTRY

7.3.1 Argentina

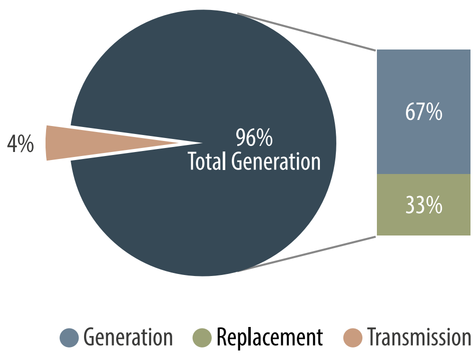
It is estimated that the demand for electricity in Argentina will increase by 4.1% on average per year until 2030. The country will demand 184 TWh by 2030. The estimated generation sources in 2030 will be composed of: 33.6% natural gas; 30.8% from hydroelectric power plants; 14.3% wind power; 14% nuclear power; 5.5% solar power, 1.4% oil, and 0.4% biofuels. It is estimated that the participation of wind power in 2030 will increase by 10 percentage points (pp.) compared to its participation in 2020, nuclear energy by 8 pp., solar energy by 5 pp., and hydroelectric energy by 3 pp. The share of natural gas will decrease by 21 pp. and that of biofuels by 3 pp.

Figure C.1. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



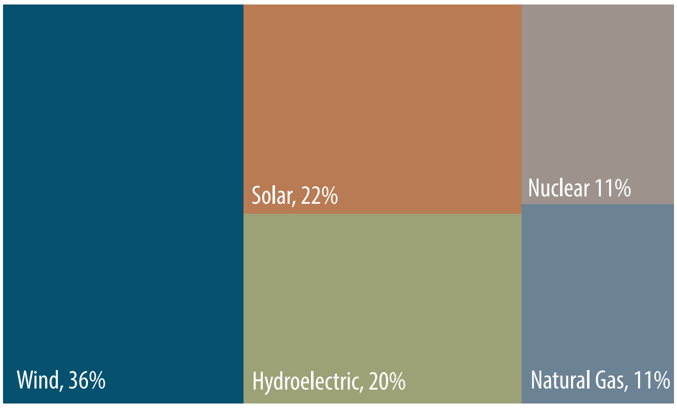
It is estimated that Argentina will invest a total of USD 54 billion by 2030. Of that amount, USD 51.6 billion will be invested in generation (67% in new plants and 33% in replacement of existing ones) and USD 2.4 billion in transmission lines.

Figure C.2. *Total investment: USD 54 billion, 2020-2030. (Own elaboration)*



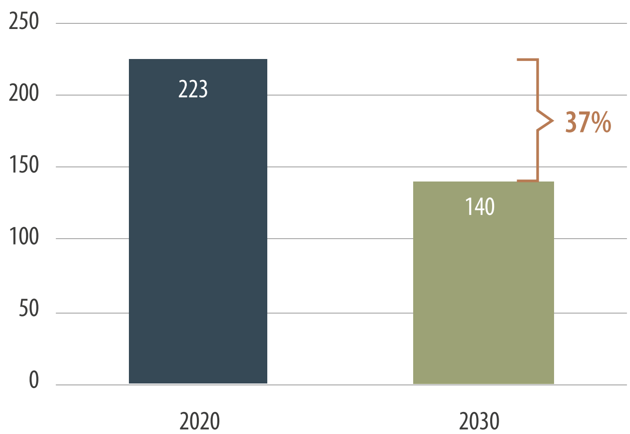
Of the total investment in new generation plants, it is estimated that the country will invest approximately USD 12 billion in hydroelectric power plants, USD 9.9 billion in nuclear plants, USD 7 billion in wind power plants, USD 3.3 billion in solar, USD 1.7 billion in thermal power plants fueled by natural gas, USD 357 million in thermal power plants fueled by oil, USD 21 million thermal power plants fueled by biofuel. In terms of capacity, for Argentina, this means 19 GW in new capacity throughout 2020-2030.

Figure C.3. *Investment in new capacity: 19 GW, 2020-2030. (Own elaboration)*



It is estimated that Argentina will reduce its emissions intensity by 37%, measured as tCO_2/GWh, by 2030.

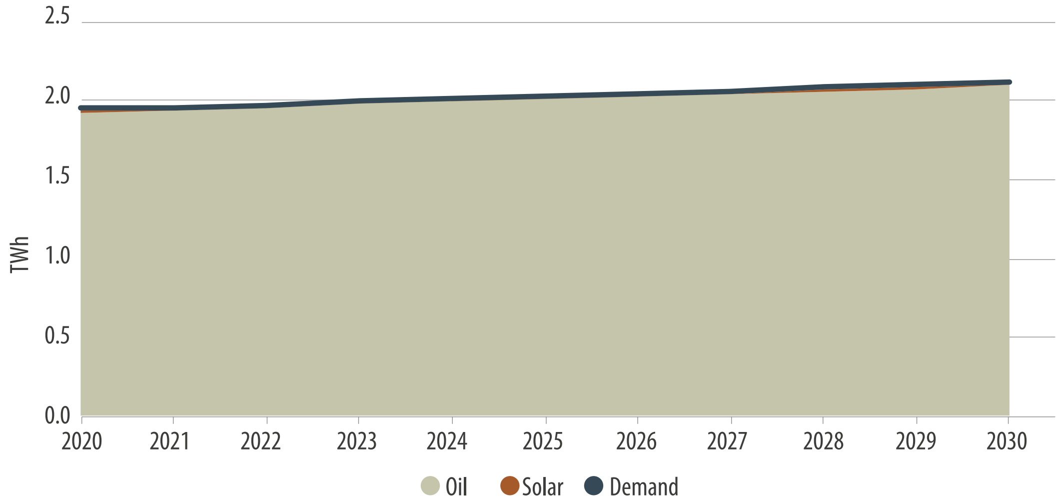
Figure C.4. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.2 Bahamas

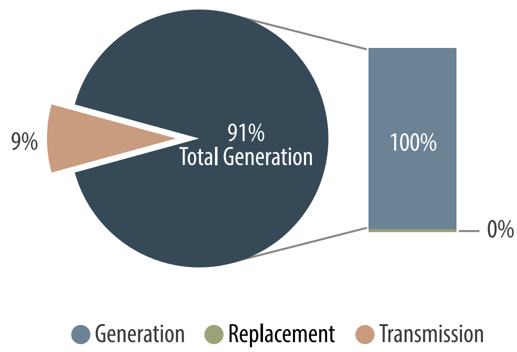
It is estimated that the demand for electricity in the Bahamas will increase 0.8% on average per year until 2030. The country will demand 2.1 TWh in 2030. The generation sources in 2030 will be composed of 99.9% oil and 0.01% solar. Initiatives to transform the electricity source and announced capacity goals by source of electricity generation that did not have available official and public data at the time the study was conducted are not considered here (for further methodology details and data, see Annex A and B.)

Figure C.5. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



The Bahamas will invest a total of USD 71.2 million by 2030. Of that amount, USD 64.6 million will be invested in generation (100% in new plants and 0% in replacement of existing ones) and USD 6.6 million in transmission lines.

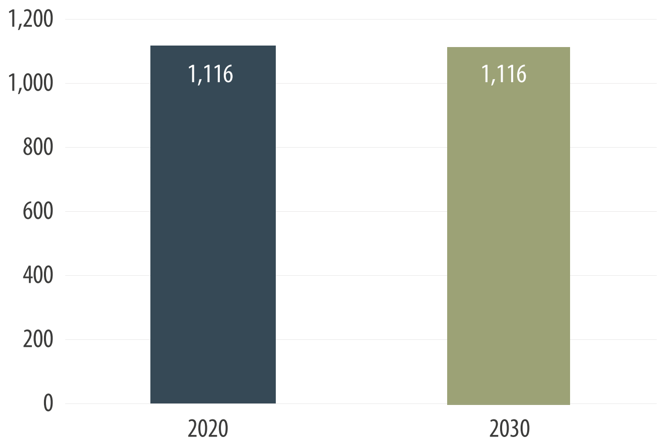
Figure C.6. *Total investment: USD 71.2 million, 2020-2030. (Own elaboration)*



Of the total investment in new generation plants, it is estimated that the country will invest approximately USD 64.5 million in thermal power plants fueled by oil and USD 0.1 million in solar power plants. In terms of capacity, this means an investment of 81 MW in new capacity throughout the decade of 2020-2030.

Given the characteristics of the models, which assume no change in the composition of the electricity sources, it is estimated that the Bahamas will maintain its emissions intensity of 1,116 tCO_2/GWh by 2030.

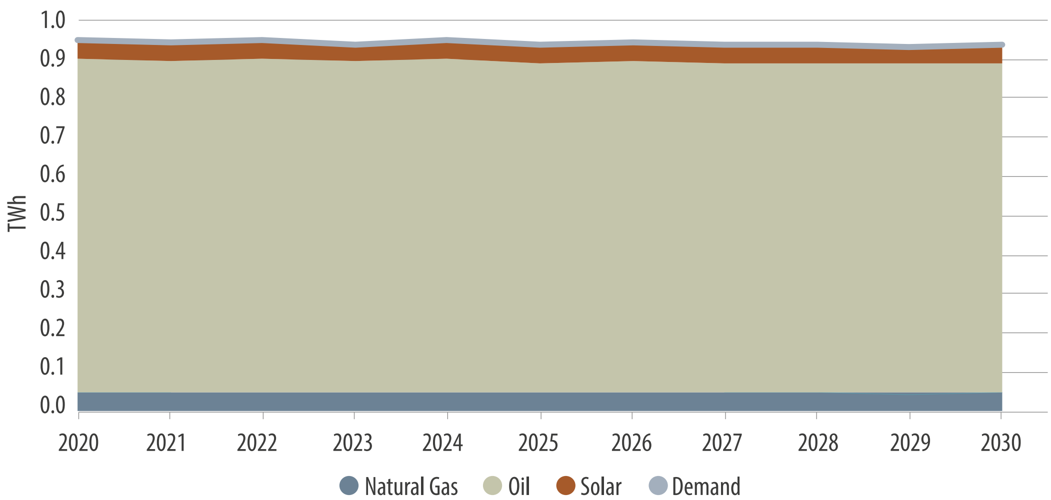
Figure C.7. *Emissions intensity (tCO2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.3 Barbados

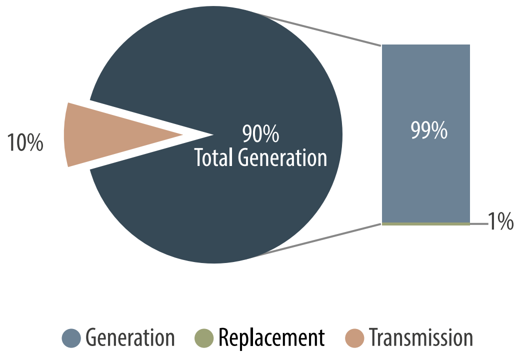
It is estimated that the demand for electricity in Barbados will decrease by 0.2% on average per year until 2030. The country will demand 934 GWh in 2030. The generation sources in 2030 will be composed of 90% oil, 5% solar, and 5% natural gas. Initiatives to transform the electricity source and announced capacity goals by source of electricity generation that did not have available official and public data at the time the study was conducted are not considered here (for further methodology details and data, see Annex A and B.)

Figure C.8. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



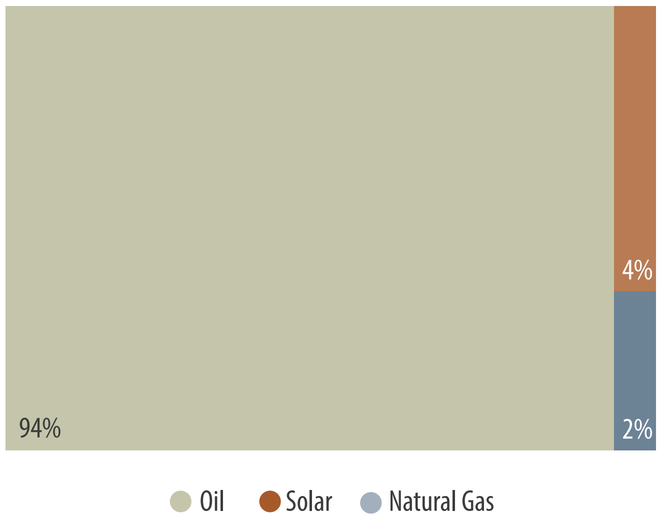
It is estimated that Barbados will invest a total of USD 9.6 million by 2030. Of that amount, USD 8.7 million will be invested in generation (99% in new plants and 1% in replacement of existing ones) and USD 0.9 million in transmission lines.

Figure C.9. *Total investment: USD 9.6 million, 2020-2030. (Own elaboration)*



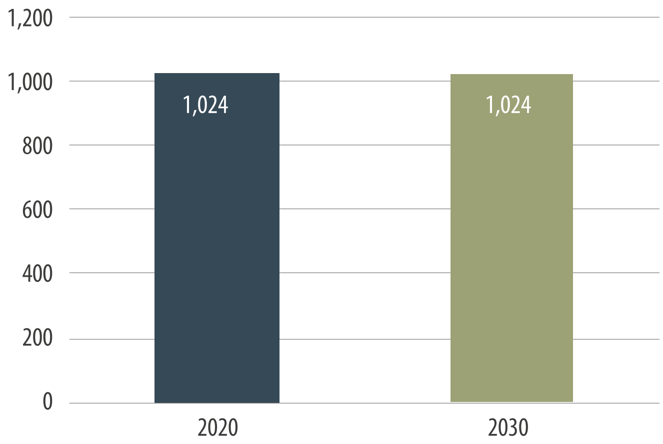
Of the total investment in new generation plants, the country will invest approximately USD 8 million in thermal power plants fueled by oil, USD 0.4 million in solar power plants, and USD 0.2 million in thermal power plants fueled by natural gas. Barbados will invest 11 MW in new capacity throughout 2020-2030.

Figure C.10. *Investment in new capacity: 11 MW, 2020-2030. (Own elaboration)*



Regarding its emissions, and based on the characteristics of the model, Barbados will maintain the composition of its electricity sources at 1024 tCO_2/GWh by 2030.

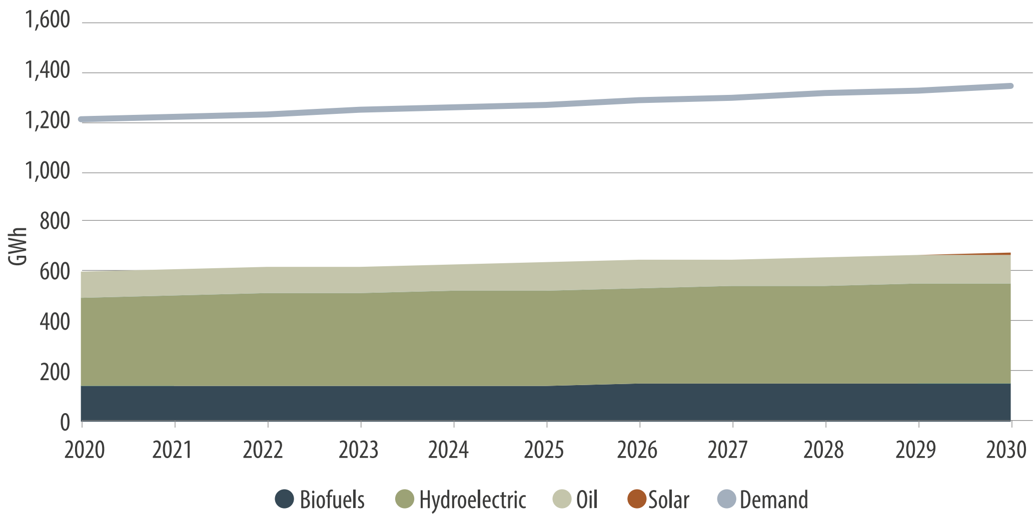
Figure C.11. *Emissions intensity (tCO₂/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.4 Belize

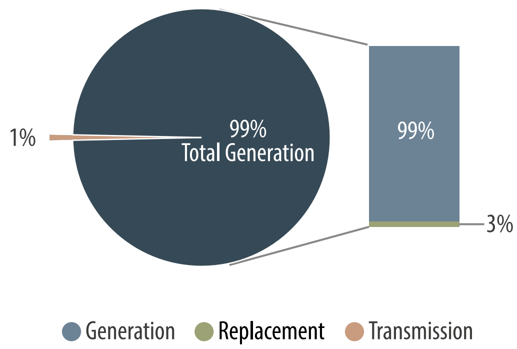
It is estimated that the demand for electricity in Belize will increase by 1.1% on average per year until 2030. The country will demand 1.3 TWh by 2030. The generation source in 2030 will be composed of 60% hydroelectric, 23% biofuels, and 17% oil.

Figure C.12. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



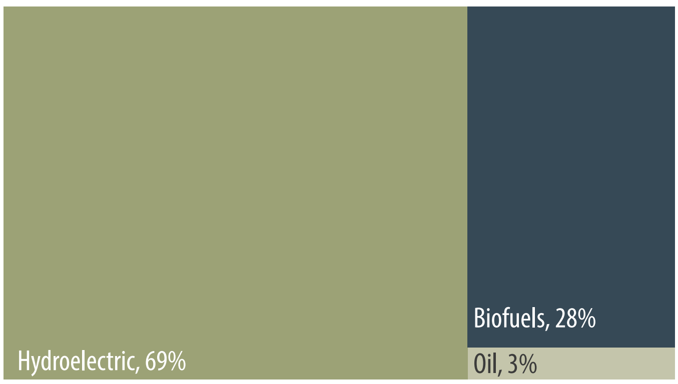
Belize will invest a total of USD 779 million by 2030. Of that amount, USD 774 million will be invested in generation (97% in new plants and 3% in replacement of existing ones) and USD 5 million in transmission lines.

Figure C.13. *Total investment: USD 779 million, 2020-2030. (Own elaboration)*



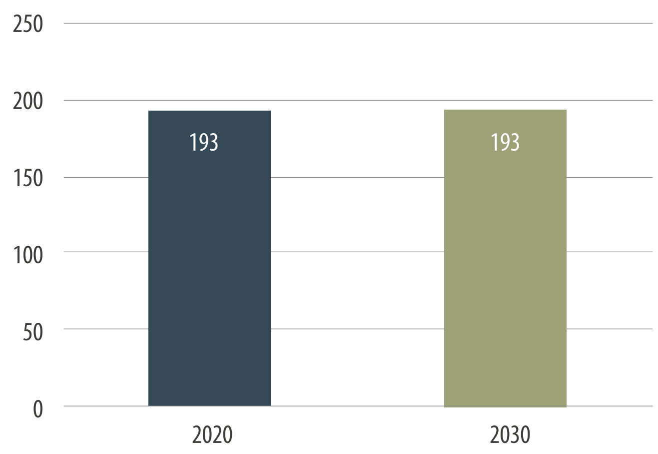
Of the total investment in new generation plants, the country will invest approximately USD 472 million in hydroelectric power plants, USD 223 million in thermal power plants fueled by oil, USD 58 million in thermal power plants fueled by biofuel, and USD 1 million in solar power plants. In terms of capacity, Belize will invest 210 MW in new capacity throughout 2020-2030.

Figure C.14. *Investment in new capacity: 210MW, 2020-2030. (Own elaboration)*



Belize will maintain its emissions intensity, measured as tCO_2/GWh, by 2030.

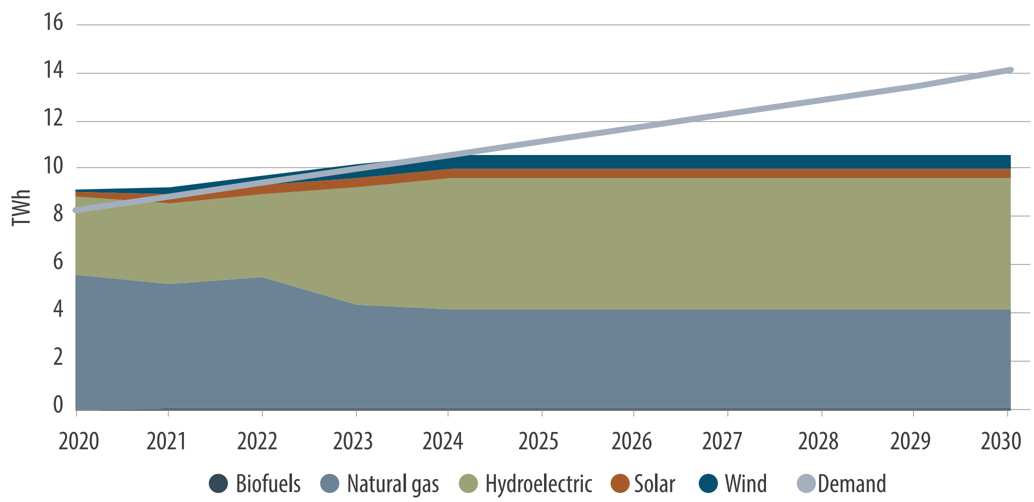
Figure C.15. *Emissions intensity (tCO₂/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.5 Bolivia

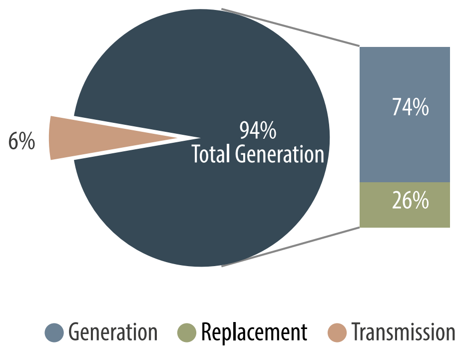
The demand for electricity in Bolivia will increase 5.4% on average per year until 2030. The country will demand 14 TWh by 2030. The generation source in 2030 will be composed of: 51.6% hydroelectric; 38.6% natural gas; 5.2% wind power; 3.7% solar power; and 0.9% biofuels. The participation of hydroelectric energy in 2030 will increase by 17 percentage points (pp.) compared to its participation in 2020, wind power by 5 pp., solar power by 1 pp., and energy from biofuels by 1 pp. The share of natural gas will decrease by 23 pp.

Figure C.16. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



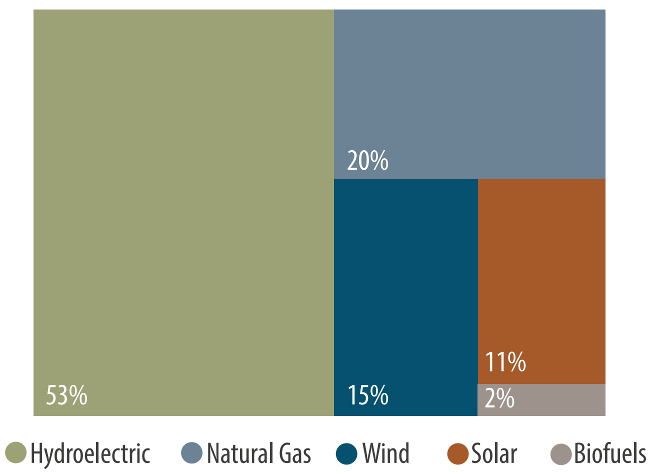
Bolivia will invest a total of USD 3.9 billion by 2030. Of that amount, USD 3.7 billion will be invested in generation (74% in new plants and 26% in replacement of existing ones) and USD 225 million in transmission lines.

Figure C.17. *Total investment: USD 3.9 billion, 2020-2030. (Own elaboration)*



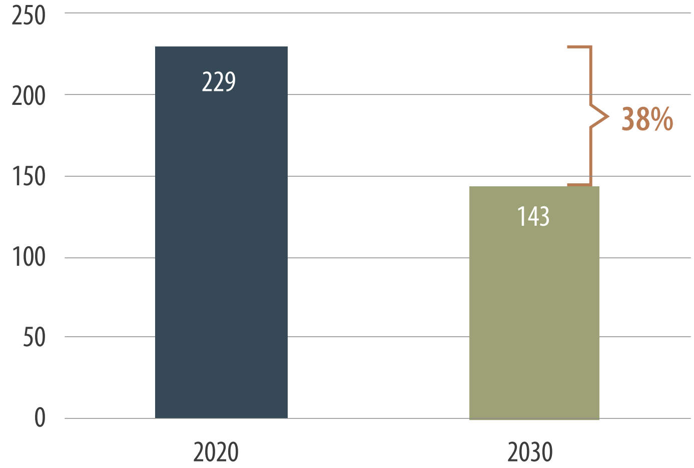
Of the total investment in new generation plants, the country will invest approximately USD 2 billion in hydroelectric power plants, USD 210 million in thermal power plants fueled by natural gas, USD 200 million in wind power plants, USD 117 million in solar power plants and USD 21 million in thermal power plants fueled by biofuel. Bolivia will invest 1.3 GW in new capacity throughout 2020-2030.

Figure C.18. *Investment in new capacity: 1.3 GW, 2020-2030. (Own elaboration)*



Bolivia will reduce its emissions intensity by 38%, measured as tCO_2/GWh, by 2030.

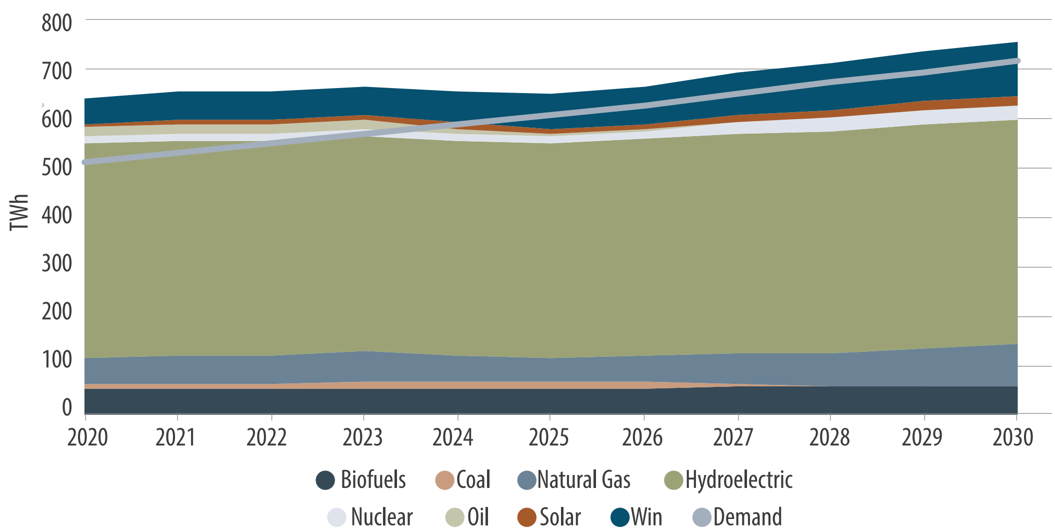
Figure C.19. *Emissions intensity (tCO₂/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.6 Brazil

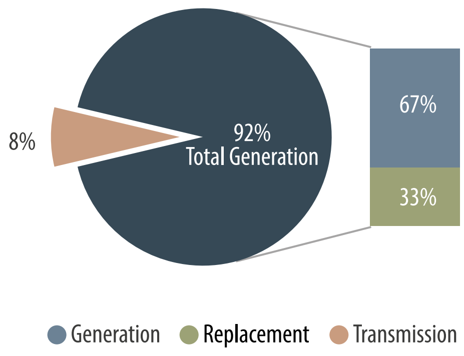
It is estimated that the demand for electricity in Brazil will increase by 3.5% on average per year until 2030. The country will demand 716 TWh by 2030. The generation source in 2030 will be composed of: 60.6% hydroelectric; 14.4% wind power; 10.9% natural gas; 7.4% biofuels; 3.4% nuclear; 2.7% solar; 0.3% carbon; and 0.1% oil. The participation of wind power in 2030 will increase by 6 percentage points (pp.) compared to its participation in 2020, natural gas by 3 pp., solar power by 2 pp., and nuclear power by 1 pp. The share of hydroelectric power plants will decrease by 7 pp, oil by 2 pp., coal by 1 pp., and biofuels by 1 pp.

Figure C.20. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



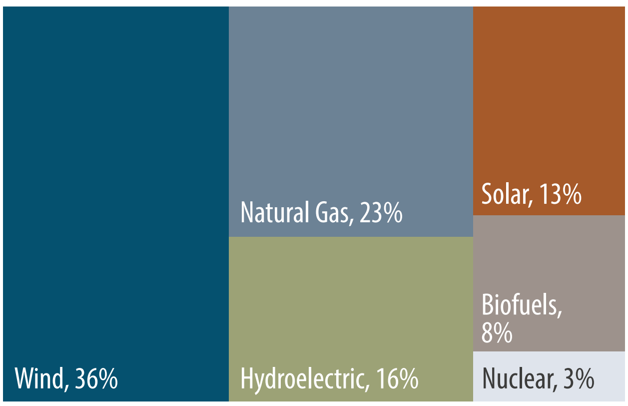
Brazil will invest a total of USD 100.5 billion by 2030. Of that amount, USD 92.5 billion will be invested in generation (67% in new plants and 33% in replacement of existing ones) and USD 8 billion in transmission lines.

Figure C.21. *Total investment: USD 100.5 billion, 2020-2030. (Own elaboration)*



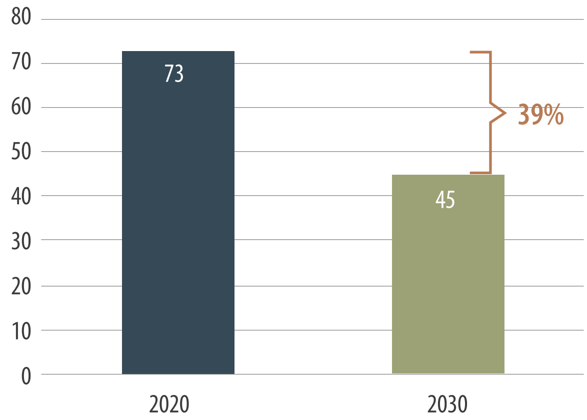
Of the total investment in new generation plants, it is estimated that the country will invest approximately USD 22 billion in hydroelectric power plants, USD 16 billion in wind power plants, USD 8 billion in thermal power plants fueled by natural gas, USD 6 billion in nuclear power plants, USD 5 billion in solar power plants, USD 4 billion in thermal power plants fueled by biofuel and USD 230 million in thermal power plants fueled by oil. Brazil will invest 43 GW in new capacity throughout 2020-2030.

Figure C.22. *Investment in new capacity: 43 GW, 2020-2030. (Own elaboration)*



Brazil will reduce its emissions intensity by 39%, measured as tCO_2/GWh, by 2030.

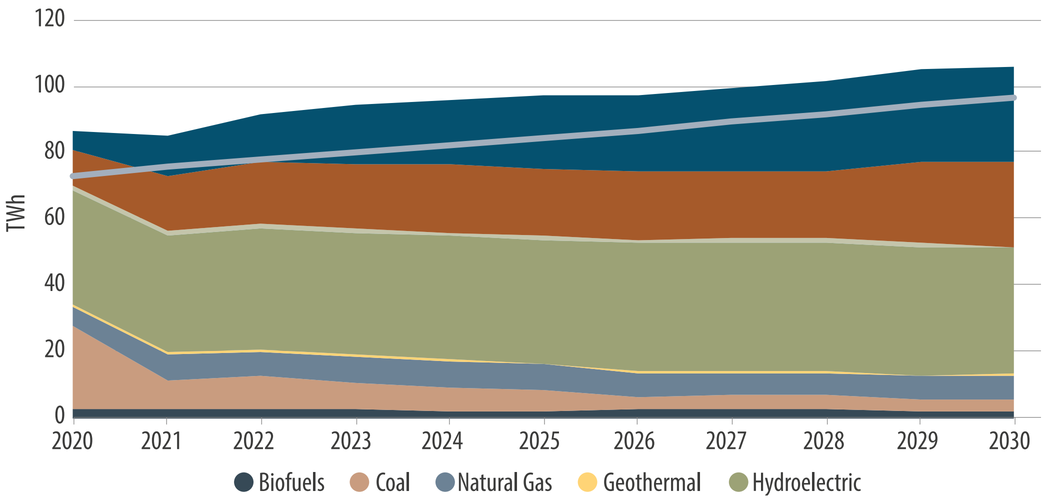
Figure C.23. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.7 Chile

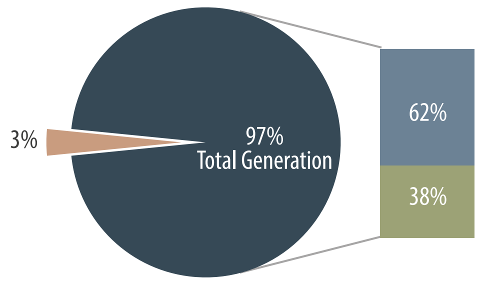
Chile is the country that has the greatest expectation of reducing CO_2 emissions from its electricity sources. It is estimated that the demand for electricity in Chile will increase by 2.9% on average per year until 2030. The country will demand 97 TWh by 2030. The generation source in 2030 will be composed of: 36% hydroelectric; 27% wind; 24% solar; 7% natural gas; 3% carbon; 2% biofuels; and 1% geothermal. The participation of wind power by 2030 will increase by 20 percentage points (pp.) compared to its participation in 2020, and solar power, by 12 pp. The share of coal will decrease by 26 pp., hydroelectricity by 3 pp., oil by 2 pp., and biofuels by 1 pp.

Figure C.24. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



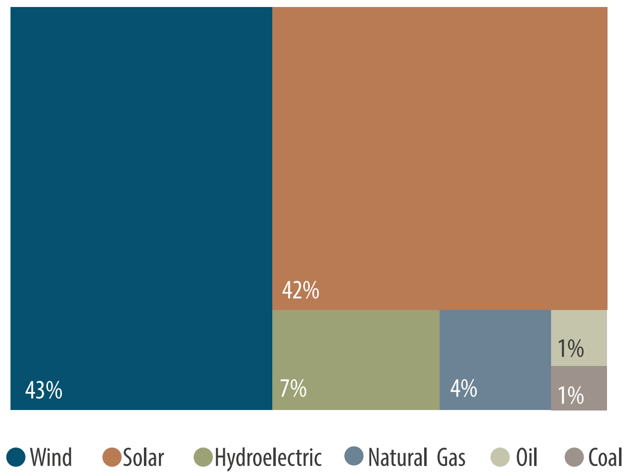
Chile will invest a total of USD 29 billion by 2030. Of that amount, USD 28 billion will be invested in generation (62% in new plants and 38% in replacement of existing ones) and USD 1 billion in transmission lines.

Figure C. 25. *Total investment: USD 29 billion, 2020-2030. (Own elaboration)*



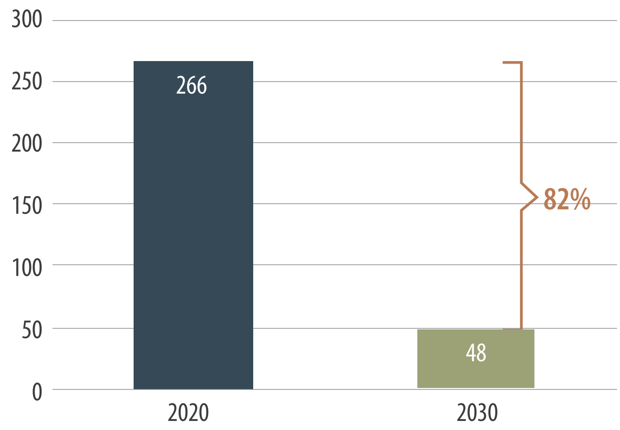
Of the total investment in new generation plants, the country will invest approximately USD 7.1 billion in wind power plants, USD 5.4 billion in solar power plants, USD 3.5 billion in hydroelectric power plants, USD 570 million in thermal power plants natural fueled by gas, USD 300 million in thermal power plants fueled by coal, USD 161 million in thermal power plants fueled by oil, USD 108 million in geothermal power plants and USD 67 million in thermal power plants fueled by biofuels. Chile will invest 15.5 GW in new capacity throughout 2020-2030.

Figure C.26. *Investment in new capacity: 15.5 GW, 2020-2030. (Own elaboration)*



It is estimated that Chile will reduce its emissions intensity by 82%, measured as tCO_2/GWh, by 2030.

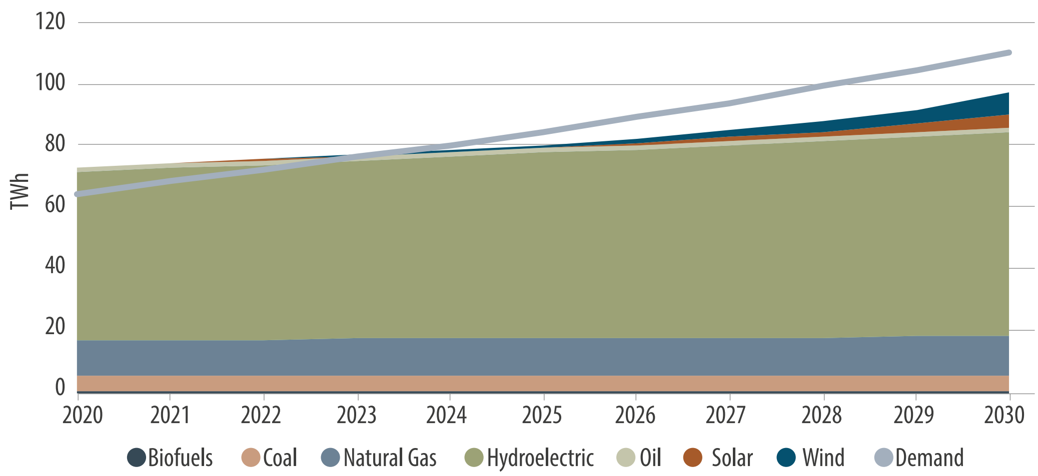
Figure C.27. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.8 Colombia

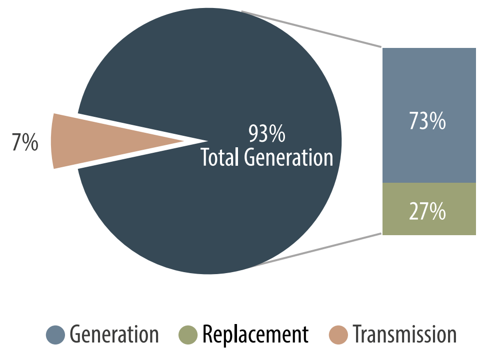
The demand for electricity in Colombia will increase by 5.5% on average per year until 2030. The country will demand 110 TWh by 2030. The generation source in 2030 will be composed of: 68% hydroelectric; 13.4% natural gas; 7.5% wind power; 5.1% carbon; 4% solar power; and, 1.8% oil. The participation of wind power in 2030 will increase by 7 percentage points (pp.) compared to its participation in 2020, and solar power will increase by 4 pp. The share of hydroelectric power plants will decrease by 7 pp., natural gas by 3 pp. and coal by 2 pp.

Figure C.28. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



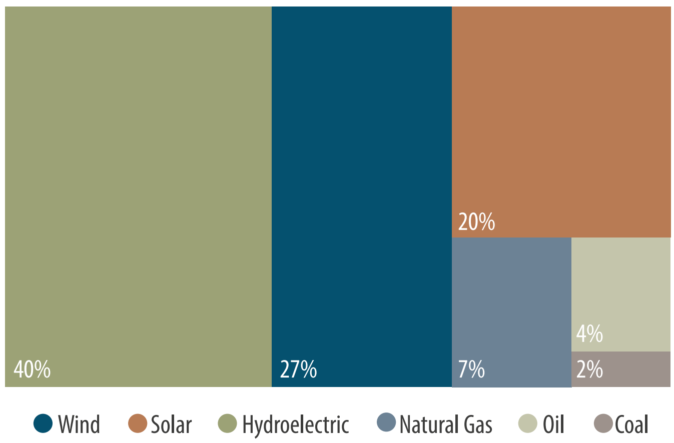
Colombia will invest a total of USD 24.8 billion by 2030. Of that amount, USD 23 billion will be invested in generation (73% in new plants and 27% in replacement of existing ones) and USD 1.8 billion in transmission lines.

Figure C.29. *Total investment: USD 24.8 billion, 2020-2030. (Own elaboration)*



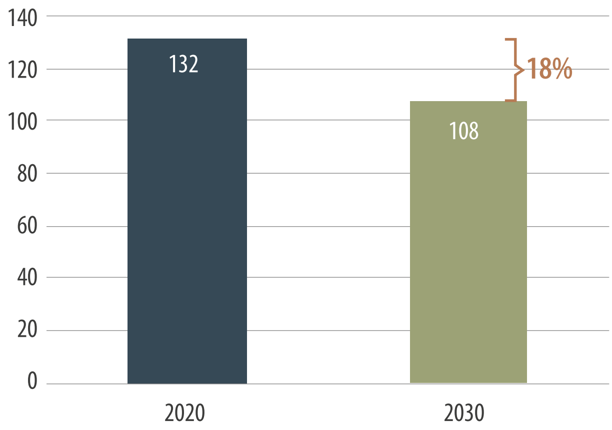
Of the total investment in new generation plants, the country will invest approximately USD 11.5 billion in hydroelectric power plants, USD 2.5 billion in wind power plants, USD 1.4 billion in solar power plants, USD 516 million in thermal power plants natural fueled by gas, USD 397 million in thermal power plants fueled by oil, USD 253 million in thermal power plants fueled by coal and USD 22 million in thermal power plants fueled by biofuels. Colombia will invest 9 GW in new capacity throughout 2020-2030.

Figure C.30. *Investment in new capacity: 9 GW, 2020-2030. (Own elaboration)*



Colombia will reduce its emissions intensity by 18%, measured as tCO_2/GWh, by 2030.

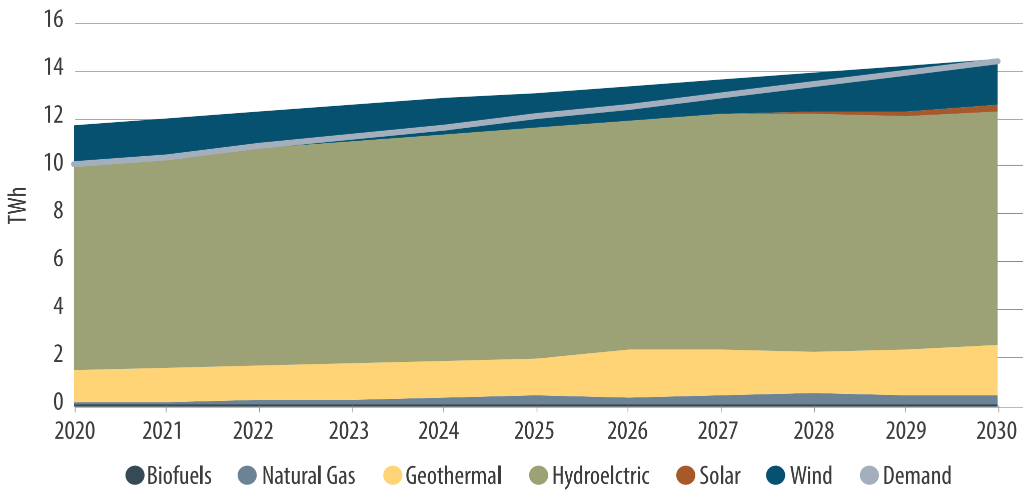
Figure C.31. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.9 Costa Rica

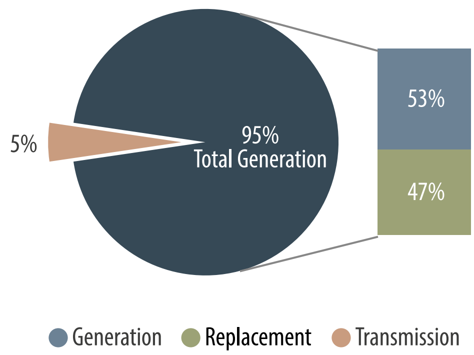
The demand for electricity in Costa Rica will increase by 3.6% on average per year until 2030. The country will demand 14 TWh by 2030. The generation source in 2030 will be composed of: 67.6% hydroelectric; 14% geothermal; 13.4% wind power; 2.5% natural gas; 1.8% solar power; and, 0.6% biofuels. The share of geothermal energy in 2030 will increase by 2.2 percentage points (pp.) compared to its participation in 2020, natural gas by 2.1 pp., solar energy by 1.6 pp., and wind energy by 0.6pp. The share of hydroelectric power plants will decrease by 6.3 pp.

Figure C.32. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



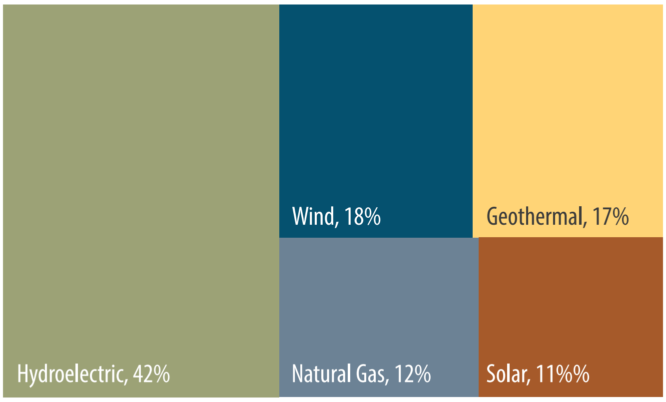
Costa Rica will invest a total of USD 3.5 billion by 2030. Of that amount, USD 3.3 billion will be invested in generation (53% in new plants and 47% in replacement of existing ones) and USD 0.2 billion in transmission lines.

Figure C.33. *Total investment: USD 3.5 billion, 2020-2030. (Own elaboration)*



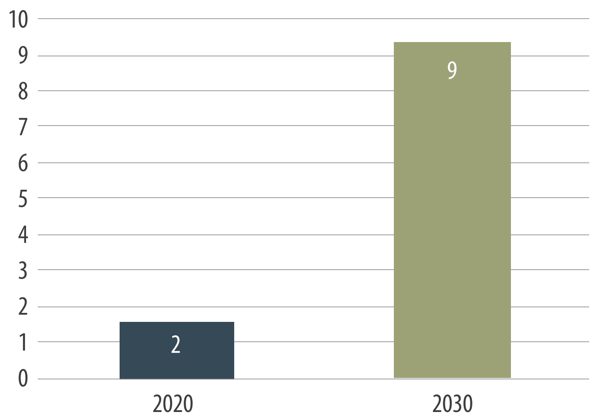
Of the total investment in new generation plants, the country will invest approximately USD 1 billion in hydroelectric power plants, USD 416 million in geothermal power plants, USD 145 million in wind power plants, USD 79 million in thermal power plants fueled by natural gas, USD 73 million in solar power plants and USD 1.3 million in thermal power plants fueled by biofuels. Costa Rica will invest 773 MW in new capacity throughout 2020-2030.

Figure C.34. *Investment in new capacity: 773 MW, 2020-2030. (Own elaboration)*



Costa Rica will increase its emissions intensity by 505%, measured as tCO_2/GWh, by 2030.

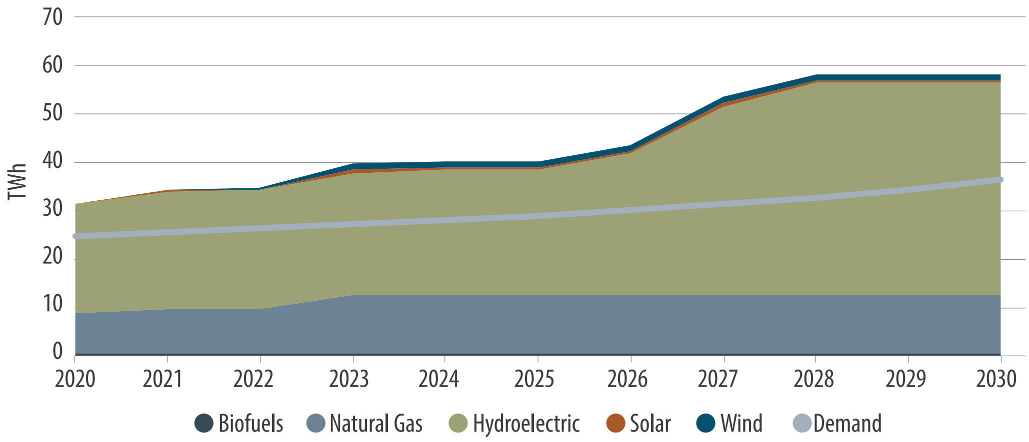
Figure C.35. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.10 Ecuador

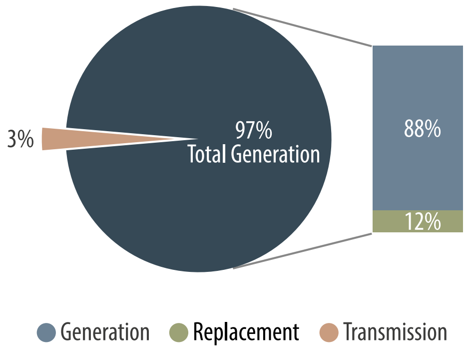
The demand for electricity in Ecuador will increase by 3.9% on average per year until 2030. The country will demand 36 TWh by 2030. The generation source in 2030 will be composed of 75% hydroelectric, 21% natural gas, 2% wind, 1% solar, and 1% biofuels. The participation of hydroelectric power in 2030 will increase by 4 percentage points (pp.) compared to its participation in 2020, wind energy by 2 pp., and solar energy by 1 pp. The share of natural gas will decrease by 6 pp. and biofuels by 1 pp.

Figure C.36. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



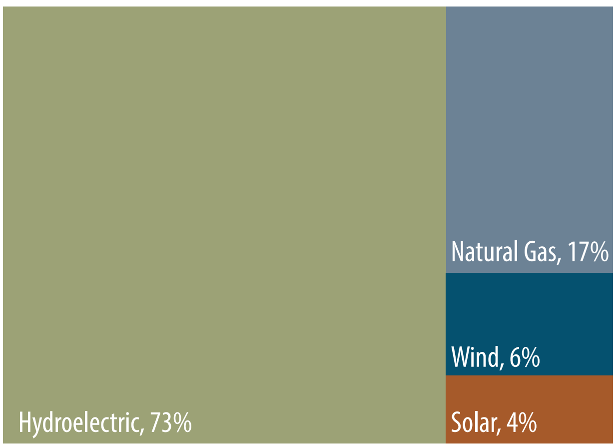
Ecuador will invest a total of USD 16.3 billion by 2030. Of that amount, USD 15.8 billion will be invested in generation (88% in new plants and 12% in replacement of existing ones) and USD 0.5 billion in transmission lines.

Figure C.37. *Total investment: USD 16.3 billion, 2020-2030. (Own elaboration)*



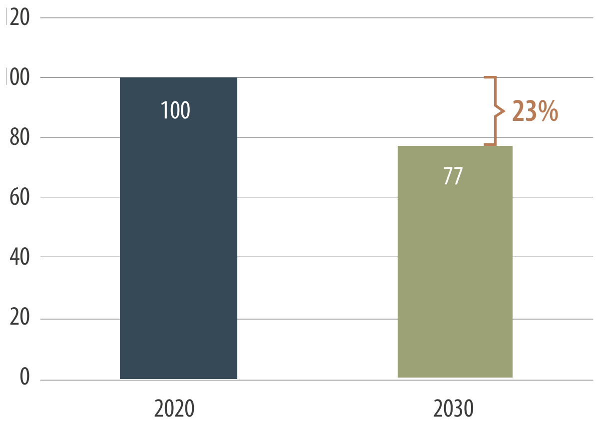
Of the total investment in new generation plants, the country will invest approximately USD 13 billion in hydroelectric power plants, USD 734 million in thermal power plants fueled by natural gas, USD 367 million in wind power plants, and USD 180 million in solar power plants. Ecuador will invest 5 GW in new capacity throughout 2020-2030.

Figure C.38. *Investment in new capacity: 5 GW, 2020-2030. (Own elaboration)*



Ecuador will reduce its emissions intensity by 23%, measured as tCO_2/GWh, by 2030.

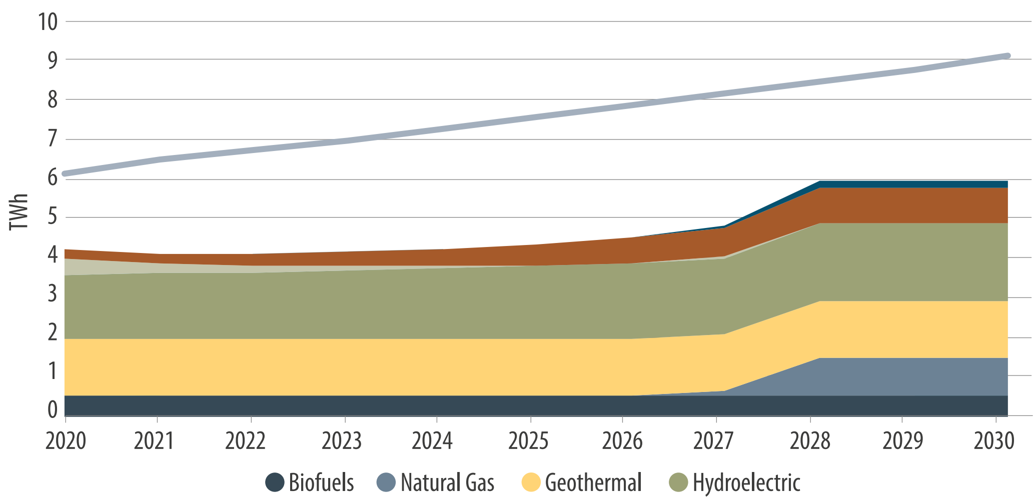
Figure C.39. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.11 El Salvador

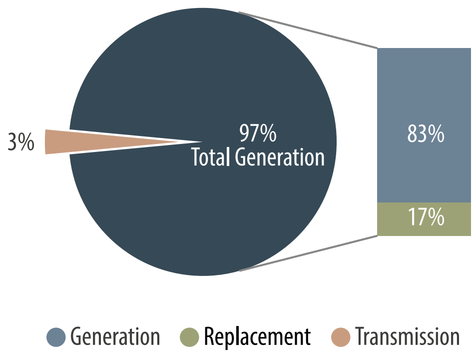
The demand for electricity in El Salvador will increase by 4% on average per year until 2030. The country will demand 9 TWh by 2030. The generation source in 2030 will be composed of: 34% hydroelectric; 24% geothermal; 16% natural gas; 15% solar; 9% biofuels; and, 3% wind power. The participation of natural gas in 2030 will increase by 16 percentage points (pp.) compared to its participation in 2020, solar power by 10 pp., and wind energy by 3 pp. The share of oil will decrease by 10 pp., geothermal by 10 pp., hydroelectric by 5 pp., and biofuels by 3 pp.

Figure C.40. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



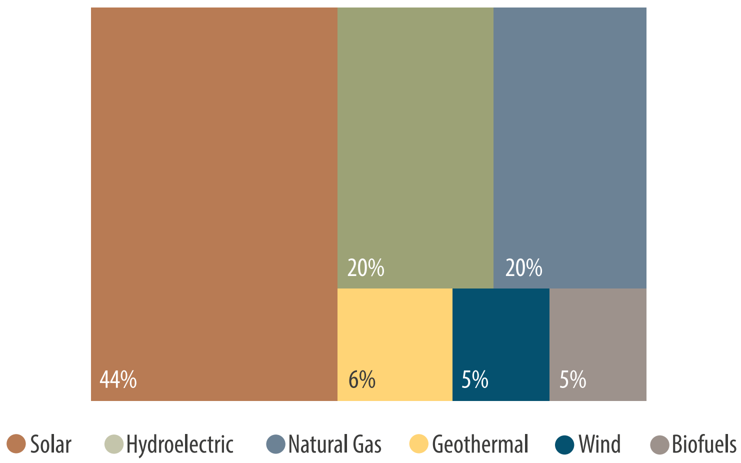
El Salvador will invest a total of USD 3.8 billion by 2030. Of that amount, USD 3.7 billion will be invested in generation (83% in new plants and 17% in replacement of existing ones) and USD 0.1 billion in transmission lines.

Figure C.41. *Total investment: USD 3.8 billion, 2020-2030. (Own elaboration)*



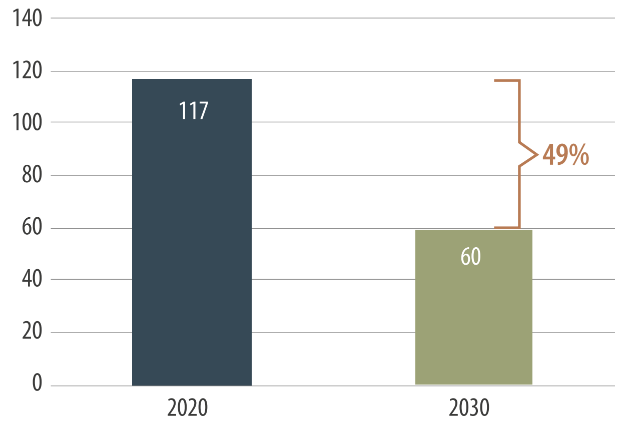
Of the total investment in new generation plants, the country will invest approximately USD 1.4 billion in hydroelectric power plants, USD 755 million in solar power plants, USD 383 million in geothermal power plants, USD 342 million in thermal power plants fueled by natural gas, USD 112 million in wind power plants, USD 100 million in thermal power plants fueled by biofuels and USD 8 million in thermal power plants fueled by oil. El Salvador will invest 2 GW in new capacity throughout 2020-2030.

Figure C.42. *Investment in new capacity: 2 GW, 2020-2030. (Own elaboration)*



El Salvador will reduce its emissions intensity by 49%, measured as tCO_2/GWh, by 2030.

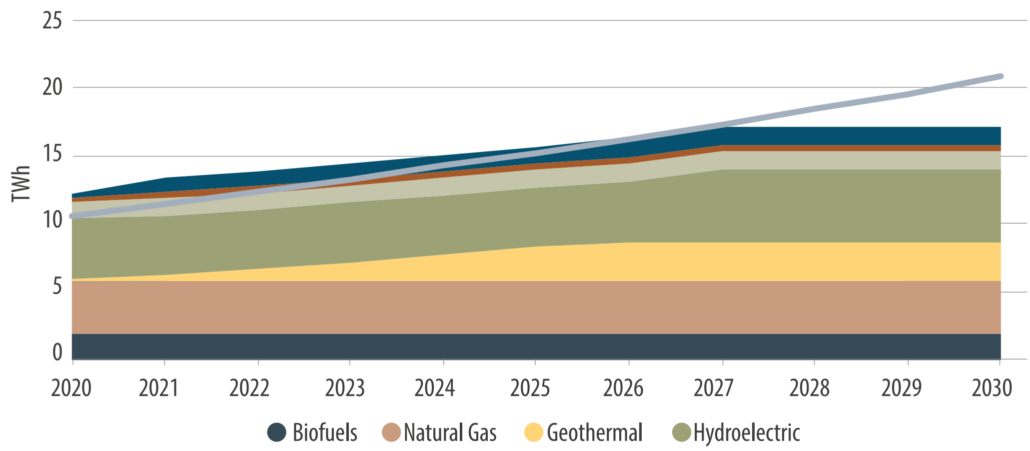
Figure C.43. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.12 Guatemala

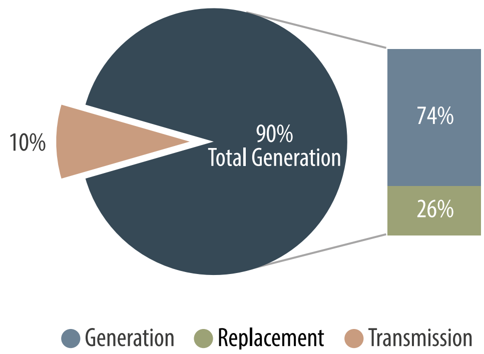
The demand for electricity in Guatemala will increase by 6.9% on average per year until 2030. The country will demand 21 TWh by 2030. The generation source in 2030 will be composed of: 31.2% hydroelectric; 22.4% carbon; 16.8% geothermal; 11% biofuels; 8.5% wind power; 7.4% oil; and 2.6% solar. The participation of geothermal power in 2030 will increase 15 percentage points (pp.) compared to its participation in 2020, wind power by 6 pp., and solar power by 1 pp. The share of coal will decrease by 9 pp., hydroelectric power by 5%, biofuels by 4%, and oil by 3 pp.

Figure C.44. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



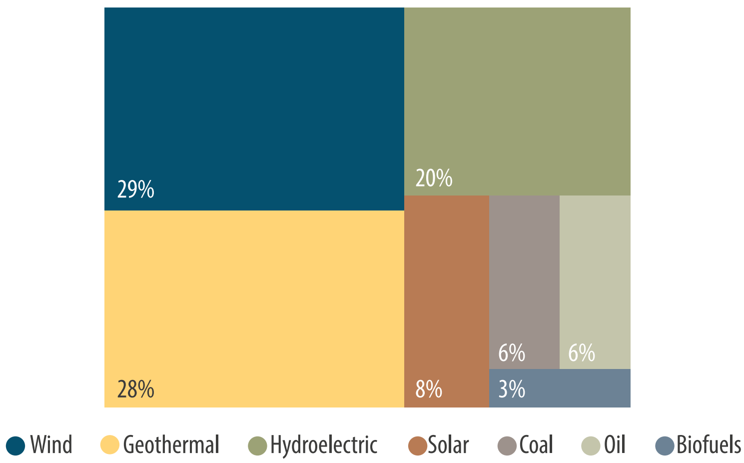
Guatemala will invest a total of USD 4 billion by 2030. Of that amount, USD 3.6 billion will be invested in generation (74% in new plants and 26% in replacement of existing ones) and USD 0.4 billion in transmission lines.

Figure C.45. *Total investment: USD 4 billion, 2020-2030. (Own elaboration)*



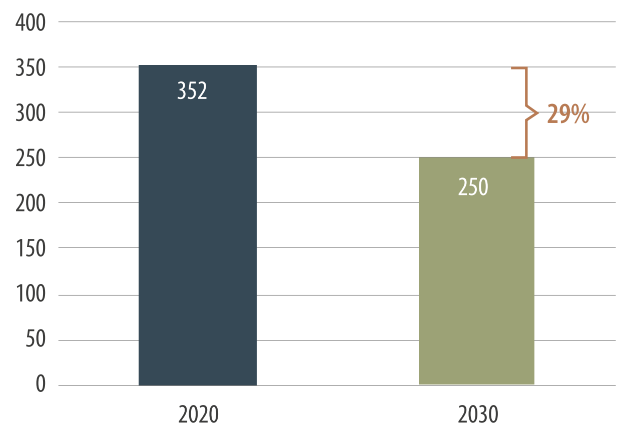
Of the total investment in new generation plants, the country will invest approximately USD 1.1 billion in geothermal power plants, USD 826 million in hydroelectric power plants, USD 390 million in wind power plants, USD 139 million in thermal power plants fueled by coal, USD 99 million in thermal power plants fueled by oil, USD 88 million in solar power plants and USD 31 million in thermal power plants fueled by biofuels. Guatemala will invest 1.3 GW in new capacity throughout 2020-2030.

Figure C.46. *Investment in new capacity: 1.3 GW, 2020-2030. (Own elaboration)*



Guatemala will reduce its emissions intensity by 29%, measured as tCO_2/GWh, by 2030.

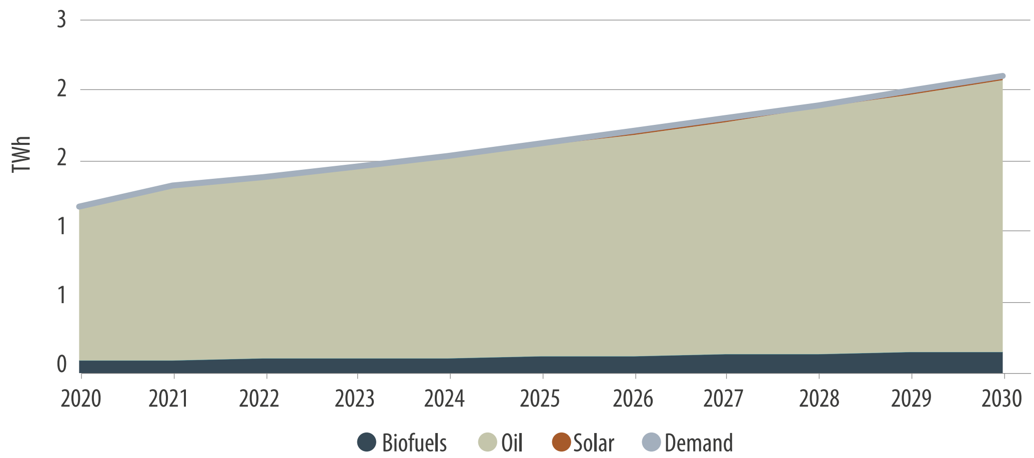
Figure C.47. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.13 Guyana

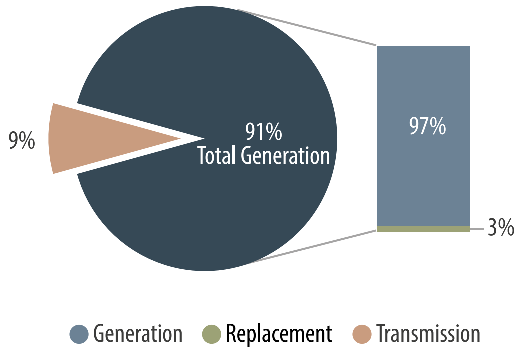
Electricity demand in Guyana will increase by 5.9% on average per year until 2030. The country will demand 2.1 TWh by 2030. The generation source in 2030 will be composed of 92% oil, 7% biofuels, and 1% solar.

Figure C.48. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



Guyana will invest a total of USD 378 million by 2030. Of that amount, USD 342 million will be invested in generation (97% in new plants and 3% in replacement of existing ones) and USD 36 million in transmission lines.

Figure C.49. *Total investment: USD 378 million, 2020-2030. (Own elaboration)*

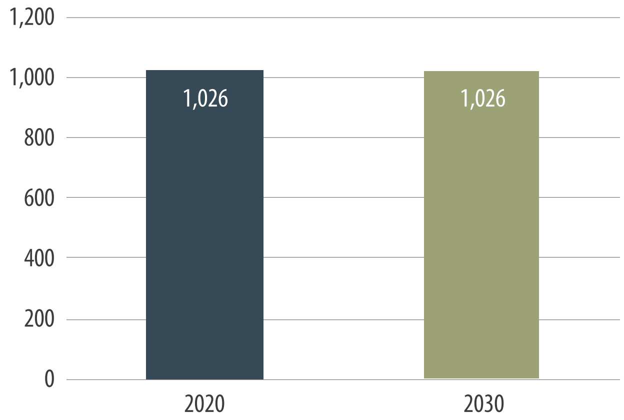


Of the total investment in new generation plants, the country will invest approximately USD 319 million in thermal power plants fueled by oil, USD 12 million in thermal power plants fueled by biofuels, and USD 3 million in solar power plants. Guyana will invest 414 MW in new capacity throughout 2020-2030.

Figure C.50. *Investment in new capacity: 414 MW, 2020-2030. (Own elaboration)*

Guyana will not reduce its emissions intensity, measured as tCO_2/GWh, by 2030.

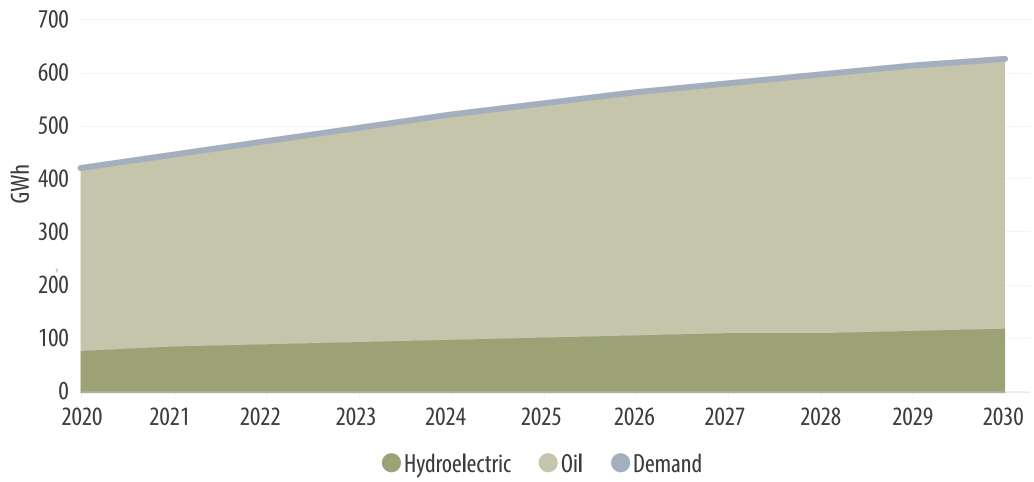
Figure C.51. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.14 Haiti

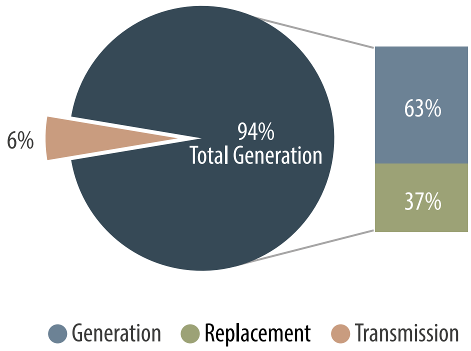
The demand for electricity in Haiti will increase by 4% on average per year until 2030. The country will demand 627 GWh by 2030. The generation source in 2030 will be composed of 81% oil and 19% hydroelectric.

Figure C.52. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



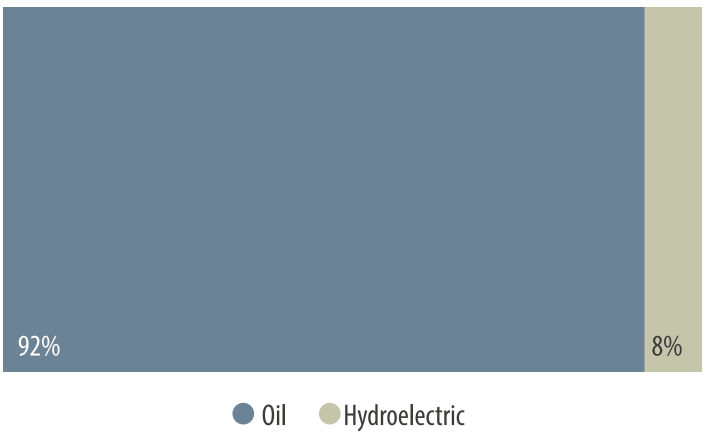
Haiti will invest a total of USD 144 million by 2030. Of that amount, USD 136 million will be invested in generation (63% in new plants and 37% in replacement of existing ones) and USD 8 million in transmission lines.

Figure C.53. *Total investment: USD 144 million, 2020-2030. (Own elaboration)*



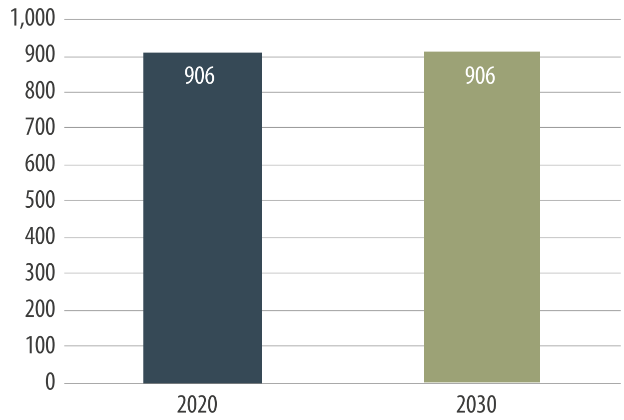
Of the total investment in new generation plants, the country will invest approximately USD 63 million in thermal power plants fueled by oil and USD 23 million in hydroelectric power plants. Haiti will invest 86 MW in new capacity throughout 2020-2030.

Figure C.54. *Investment in new capacity: 86 MW, 2020-2030. (Own elaboration)*



Haiti will maintain its emissions intensity, measured as tCO_2/GWh, by 2030.

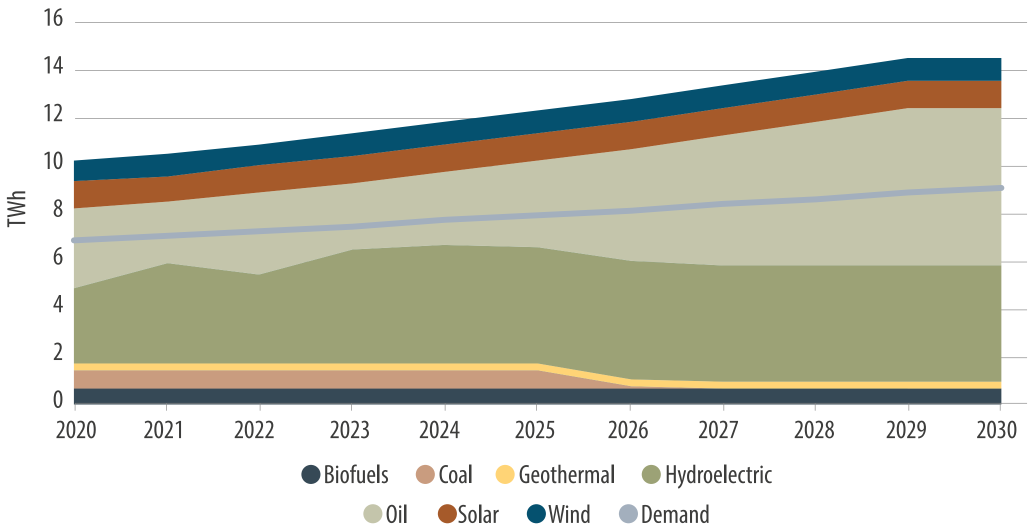
Figure C.55. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.15 Honduras

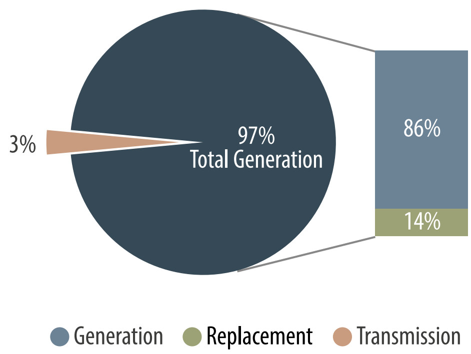
The demand for electricity in Honduras will increase by 2.8% on average per year until 2030. The country will demand 9 TWh by 2030. The generation source in 2030 will be composed of: 45.6% oil, 33.6% from hydroelectric power plants, 7.88% solar; 6.4% wind power; 4.6% biofuels; and 2.1% geothermal. The participation of oil in 2030 will increase 13 percentage points (pp.) compared to its participation in 2020, and hydroelectric energy by 3 pp. The share of coal will decrease by 8 pp., solar, wind and solar by 3%, biofuels by 2% and geothermal by 1 pp.

Figure C.56. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



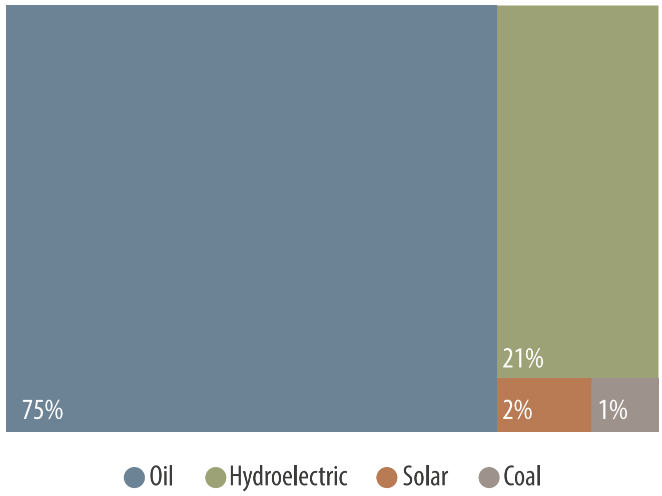
Honduras will invest a total of USD 2.83 billion by 2030. Of that amount, USD 2.75 billion will be invested in generation (86% in new plants and 14% in replacement of existing ones) and USD 86 million in transmission lines.

Figure C.57. *Total investment: USD 2.83 billion, 2020-2030. (Own elaboration)*



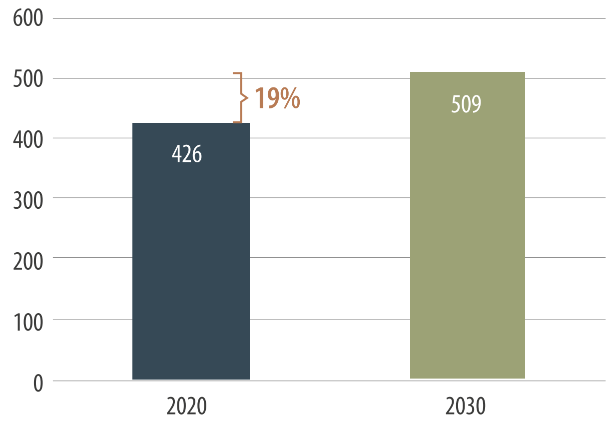
Of the total investment in new generation plants, the country will invest approximately USD 1.2 billion in hydroelectric power plants, USD 1 billion in thermal power plants fueled by oil, USD 43 million in thermal power plants fueled by coal, USD 26 million in solar power plants, and USD 12 million in thermal power plants fueled by biofuel., Honduras will invest 1.8 GW in new capacity throughout 2020-2030.

Figure C.58. *Investment in new capacity: 1.8 GW, 2020-2030. (Own elaboration)*



Honduras will increase its emissions intensity by 19%, measured as tCO_2/GWh, by 2030.

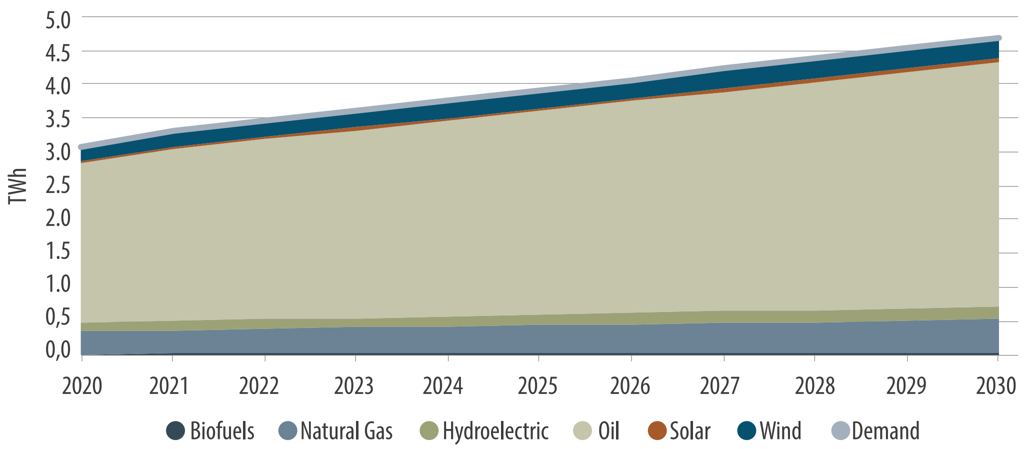
Figure C.59. *Emissions intensity (tCO2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.16 Jamaica

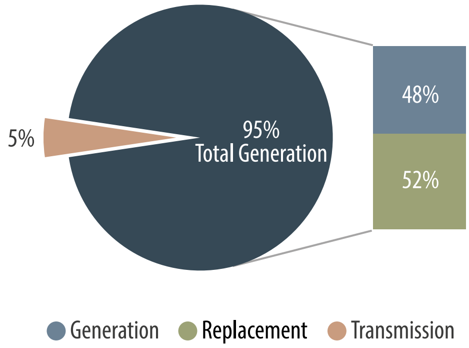
The demand for electricity in Jamaica will increase 4.3% on average per year until 2030. The country will demand 4.7 TWh by 2030. The generation source in 2030 will be composed of: 77% oil, 11% natural gas, 7% wind, 4% hydroelectric, and 1% solar.

Figure C.60. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



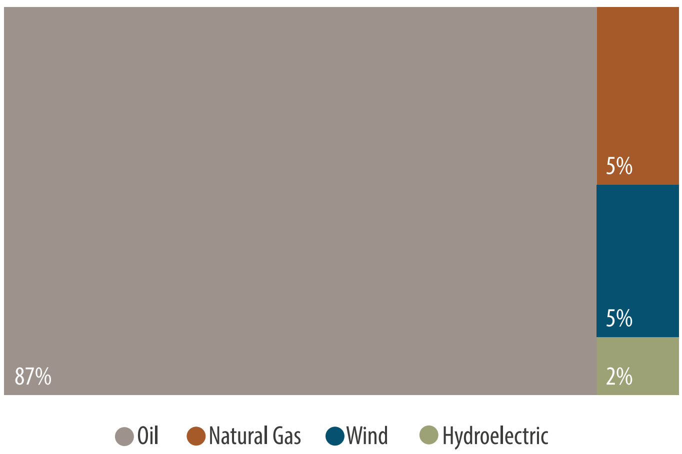
Jamaica will invest a total of USD 1.3 billion by 2030. Of that amount, USD 1.2 billion will be invested in generation (48% in new plants and 52% in replacement of existing ones) and USD 63 million in transmission lines.

Figure C.61. *Total investment: USD 1.3 billion, 2020-2030. (Own elaboration)*



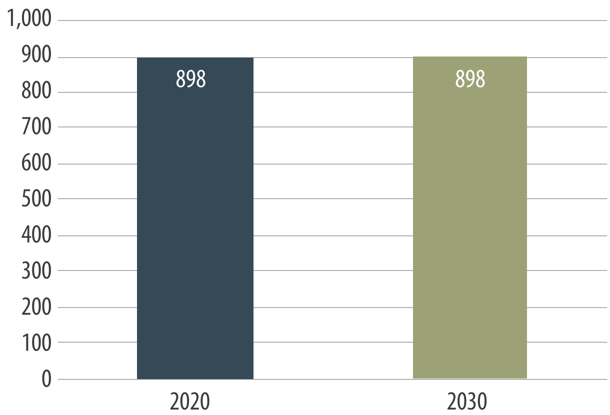
Of the total investment in new generation plants, the country will invest approximately USD 471 million in thermal power plants fueled by oil, USD 39 million in hydroelectric power plants, USD 33 million in wind power plants, USD 30 million in thermal power plants fueled by natural gas, USD 5 million in solar power plants and USD 1.3 million in thermal power plants fueled by biofuels. Jamaica will invest 676 MW in new capacity throughout 2020-2030.

Figure C.62. *Investment in new capacity: 676 MW, 2020-2030. (Own elaboration)*



Jamaica will maintain its emissions intensity, measured as tCO_2/GWh, by 2030.

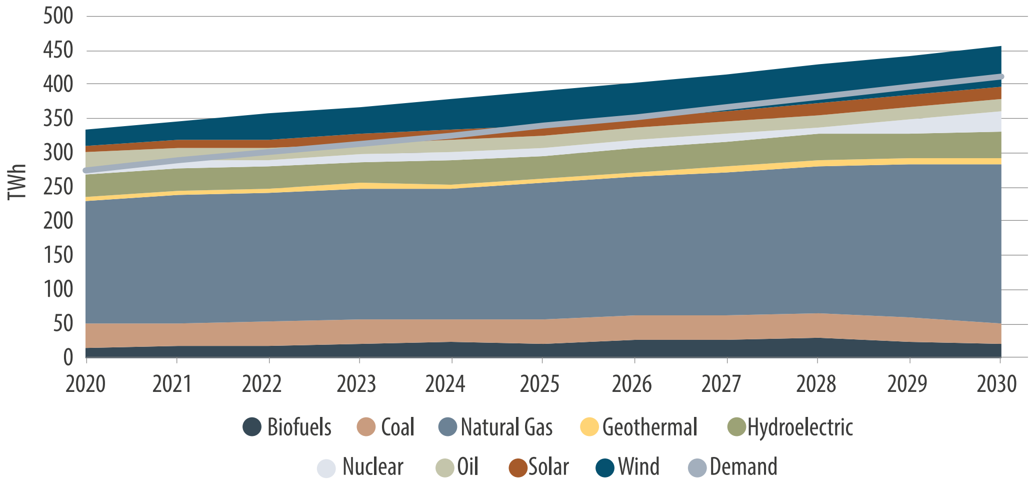
Figure C.63. *intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.17 Mexico

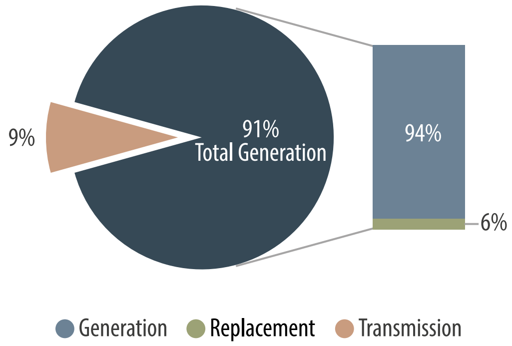
The demand for electricity in Mexico will increase by 4.1% on average per year until 2030. The country will demand 410 TWh by 2030. The generation source in 2030 will be composed of: 51% natural gas; 13% wind; 9% hydroelectric; 6% nuclear; 6% carbon; 5% biofuels; 4% solar; 4% petroleum; and 2% geothermal. The participation of wind power in 2030 will increase by 6 percentage points (pp.) compared to its participation in 2020, nuclear energy by 3 pp., solar energy by 1 pp., and geothermal energy by 1 pp. The share of coal will decrease by 4 pp., oil 3 pp., natural gas 2 pp., and hydroelectric power plants 1 pp.

Figure C.64. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



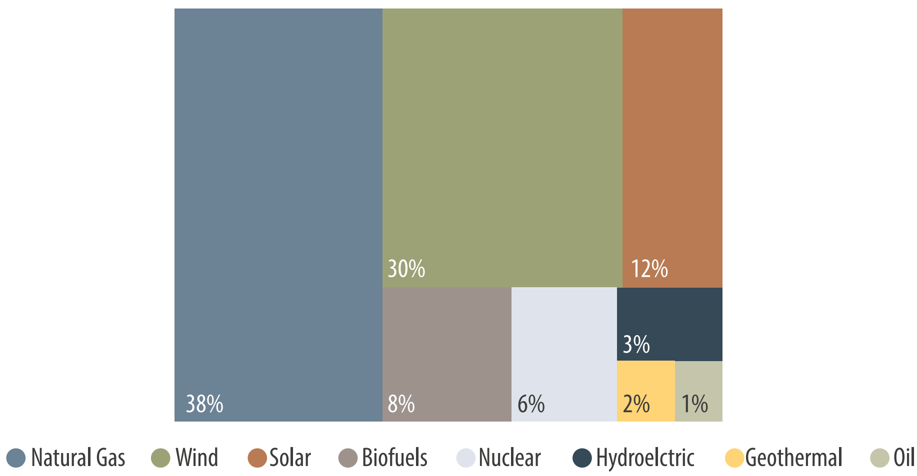
Mexico will invest a total of USD 55.5 billion by 2030. Of that amount, USD 50.3 billion will be invested in generation (94% in new plants and 6% in replacement of existing ones) and USD 5.2 billion in transmission lines.

Figure C.65. *Total investment: USD 55.5 billion, 2020-2030. (Own elaboration)*



Of the total investment in new generation plants, the country will invest approximately USD 11.7 billion in thermal power plants fueled by natural gas, USD 11.6 billion in wind power plants, USD 10.8 billion in nuclear power plants, USD 4.1 billion in hydroelectric power plants, USD 3.7 billion in solar power plants, USD 2.8 billion in thermal power plants fueled by biofuel, USD 1.9 billion in geothermal, USD 392 million in thermal power plants fueled by of oil, and USD 126 million in thermal power plants fueled by coal. Mexico will invest 37 GW in new capacity throughout 2020-2030.

Figure C.66. *Investment in new capacity: 37 GW, 2020-2030. (Own elaboration)*



Mexico will reduce its emissions intensity by 22%, measured as tCO_2/GWh, by 2030.

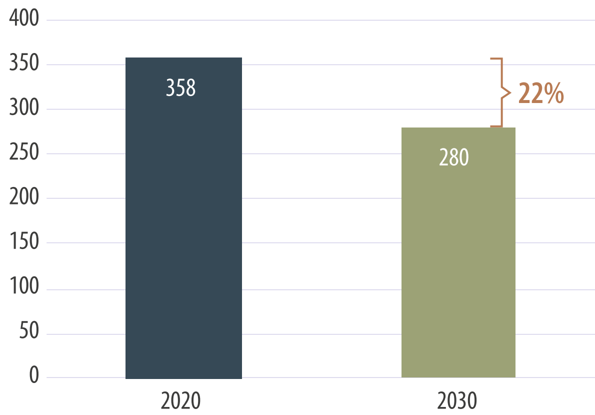
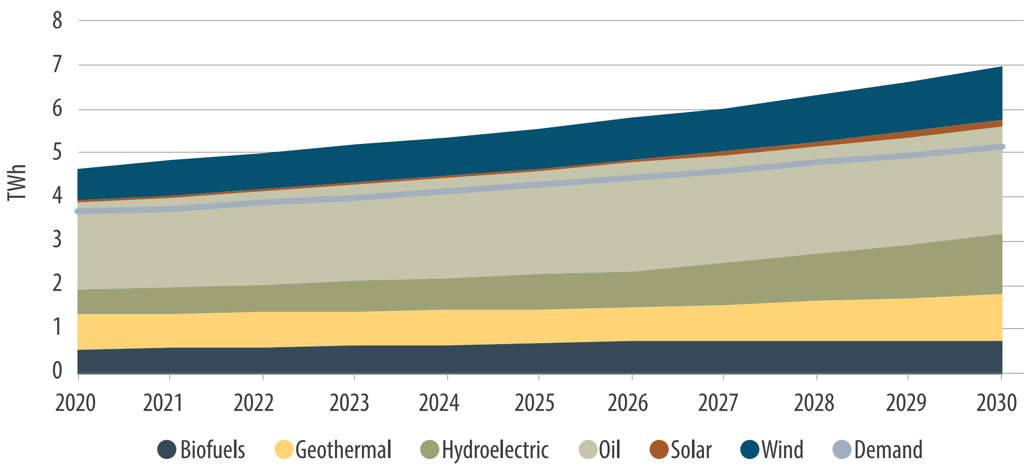


Figure C.67. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*

7.3.18 Nicaragua

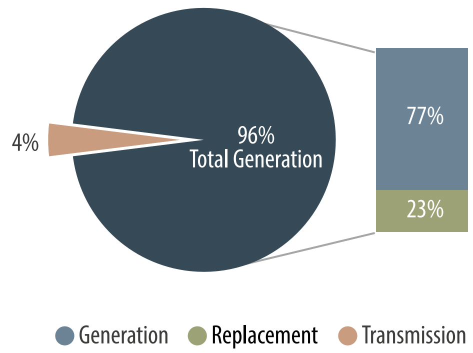
The demand for electricity in Nicaragua will increase by 3.4% on average per year until 2030. The country will demand 5.1 TWh by 2030. The generation source in 2030 will be composed of: 35.4% oil; 19.1% hydroelectric; 17.1% wind power; 15.6% geothermal; 10.5% biofuels; and, 2.3% solar. The participation of hydroelectricity in 2030 will increase by 7 percentage points (pp.) compared to its participation in 2020, solar energy by 1 pp., and wind energy by 1 pp. The share of oil will decrease by 7 pp., biofuels by 2 pp., and geothermal by 1pp.

Figure C.68. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



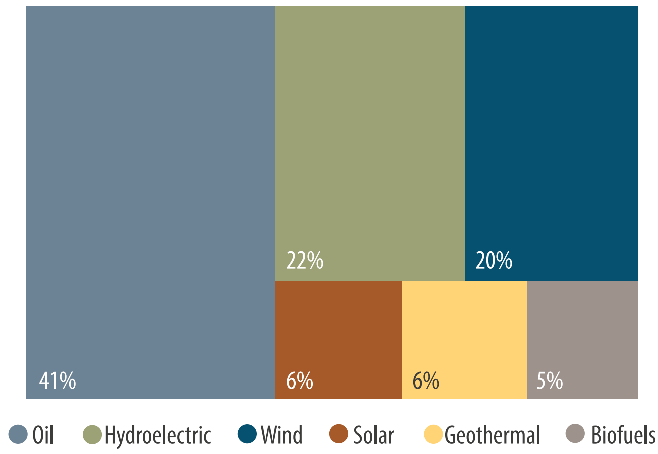
Nicaragua will invest a total of USD 1.4 billion by 2030. Of that amount, USD 1.3 billion will be invested in generation (77% in new plants and 23% in replacement of existing ones) and USD 0.1 billion in transmission lines.

Figure C.69. *Total investment: USD 1.4 billion, 2020-2030. (Own elaboration)*



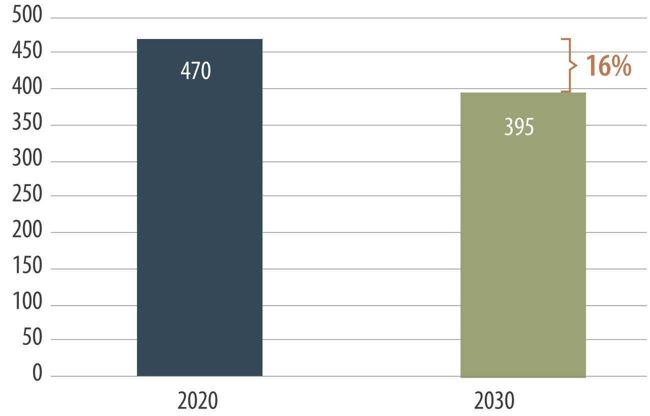
Of the total investment in new generation plants, the country will invest approximately USD 468 million in hydroelectric power plants, USD 217 million in thermal power plants fueled by oil, USD 140 million in wind power plants, USD 130 million in geothermal power plants, USD 35 million in thermal power plants fueled by biofuel and USD 35 million in solar power plants. Nicaragua will invest 665 MW in new capacity throughout 2020-2030.

Figure C.70. *Investment in new capacity: 665 MW, 2020-2030. (Own elaboration)*



Nicaragua will reduce its emissions intensity by 16%, measured as tCO_2/GWh, by 2030.

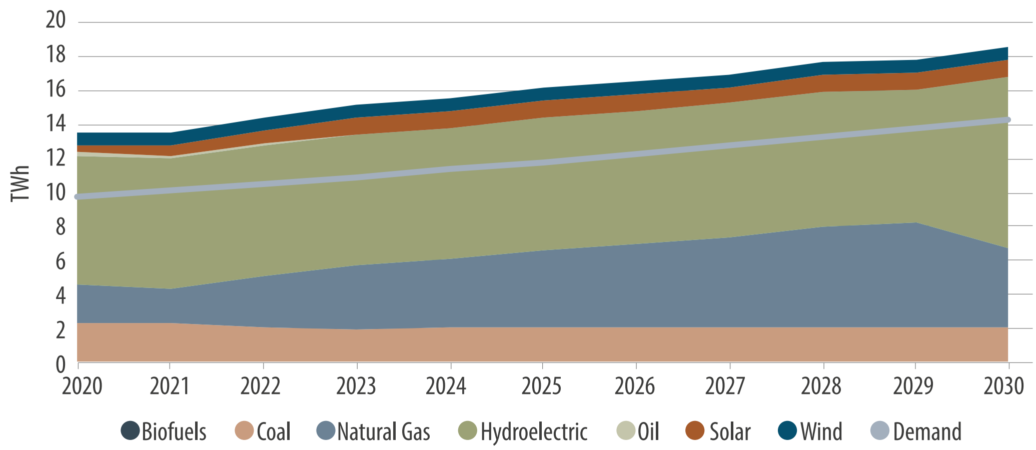
Figure C.71. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.19 Panama

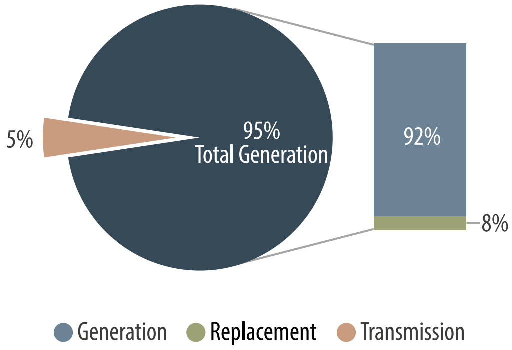
The demand for electricity in Panama will increase by 4% on average per year until 2030. The country will demand 14 TWh by 2030. The generation source in 2030 will be composed of 54% hydroelectric, 26% natural gas, 11% coal, 5% solar, and 4% wind. The participation of natural gas in 2030 will increase by 9 percentage points (pp.) compared to its participation in 2020, and solar energy by 3 pp. The share of coal will decrease by 6 pp., hydroelectric by 2 pp., wind power by 2 pp., and oil by 1 pp.

Figure C.72. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



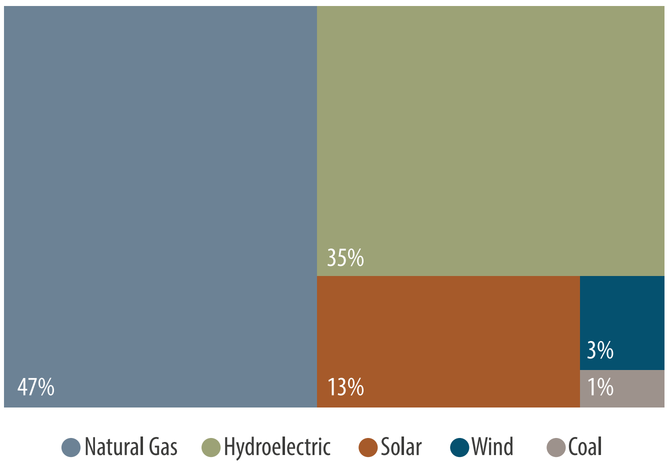
Panama will invest a total of USD 3.6 billion by 2030. Of that amount, USD 3.4 billion will be invested in generation (92% in new plants and 8% in replacement of existing ones) and USD 0.2 billion in transmission lines.

Figure C.73. *Total investment: USD 3.6 billion, 2020-2030. (Own elaboration)*



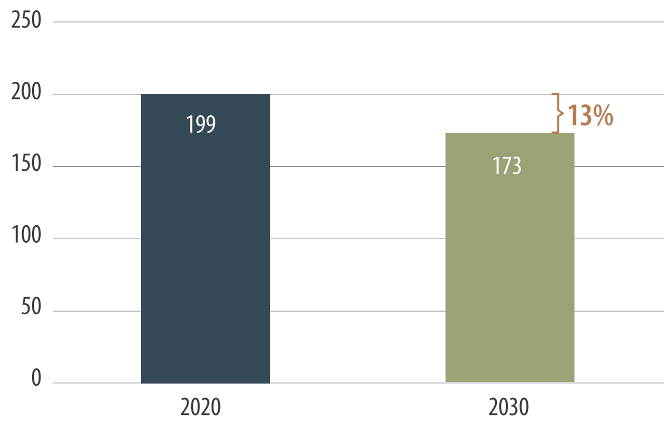
Of the total investment in new generation plants, the country will invest approximately USD 2 billion in hydroelectric power plants, USD 734 million in thermal power plants fueled by natural gas, USD 201 million in solar power plants, USD 61 million in wind power plants, USD 41 million in thermal power plants fueled by coal, USD 3 million in thermal power plants fueled by biofuels, and USD 2 million in thermal power plants fueled by oil. Panama will invest 1.9 GW in new capacity throughout 2020-2030.

Figure C.74. *Investment in new capacity: 1.9 GW, 2020-2030. (Own elaboration)*



Panama will reduce its emissions intensity by 13%, measured as tCO_2/GWh, by 2030.

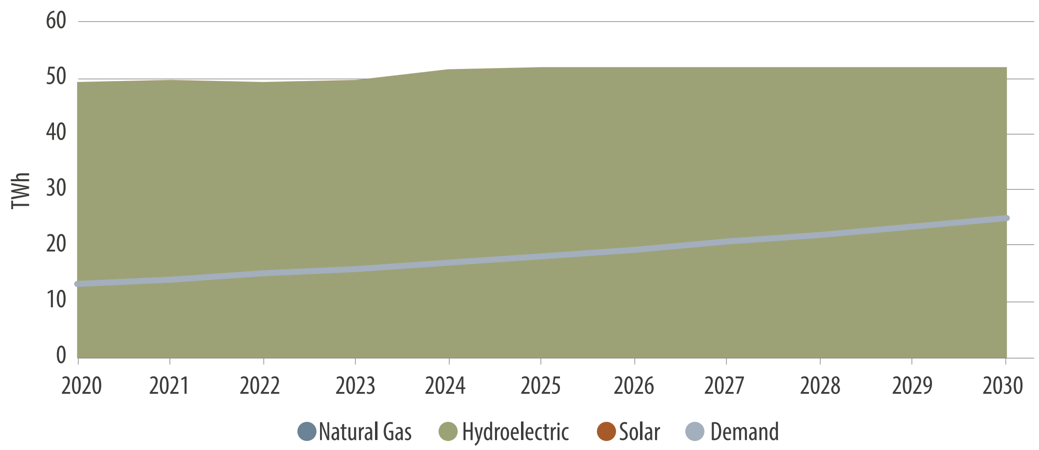
Figure C.75. *Emissions intensity (tCO₂/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.20 Paraguay

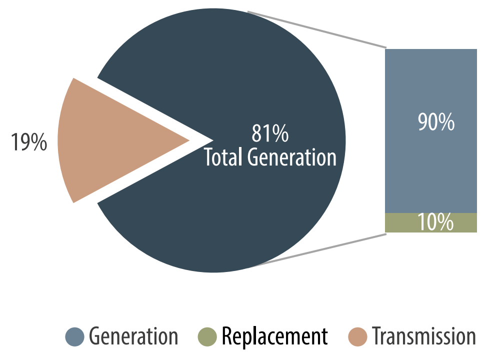
The demand for electricity in Paraguay will increase by 6.7% on average per year until 2030. The country will demand 25 TWh by 2030. The generation source in 2030 will be composed of 99.96% hydroelectric and 0.04% solar.

Figure C.76. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



Paraguay will invest a total of USD 2.5 billion by 2030. Of that amount, USD 2 billion will be invested in generation (90% in new plants and 10% in replacement of existing ones) and USD 0.5 billion in transmission lines.

Figure C.77. *Total investment: USD 2.5 billion, 2020-2030. (Own elaboration)*

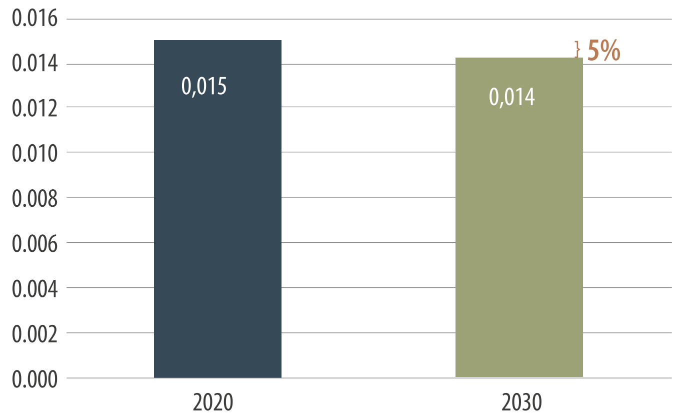


Of the total investment in new generation plants, the country will invest approximately USD 1.8 billion in hydroelectric power plants and USD 6 million in solar power plants. Paraguay will invest 568 MW in new capacity throughout 2020-2030.

Figure C.78. *Investment in new capacity: 568 MW, 2020-2030. (Own elaboration)*

Paraguay will reduce its emissions intensity by 5%, measured as tCO_2/GWh, by 2030.

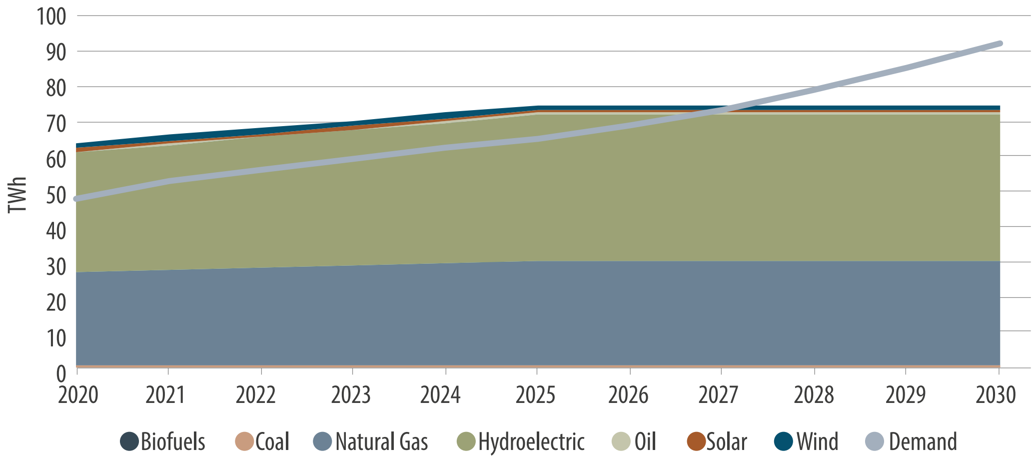
Figure C.79. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.21 Peru

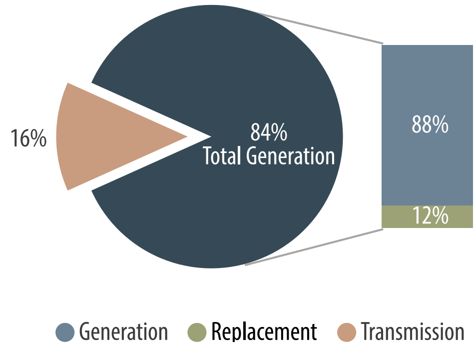
The demand for electricity in Peru will increase by 6.8% on average per year until 2030. The country will demand 92 TWh by 2030. The generation source in 2030 will be composed of: 56.1% hydroelectric; 39.8% natural gas; 2.3% wind power; 1.1% solar; and, 0.4% biofuels. The participation of hydroelectric energy in 2030 will increase by 2 percentage points (pp.) compared to its participation in 2020. The share of natural gas will decrease by 2 pp.

Figure C.80. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



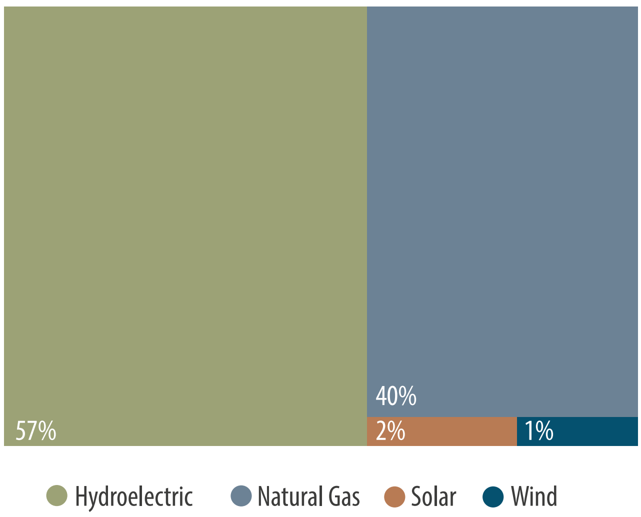
Peru will invest a total of USD 11.1 billion by 2030. Of that amount, USD 9.4 billion will be invested in generation (88% in new plants and 12% in replacement of existing ones), and USD 1.7 billion in transmission lines.

Figure C.81. *Total investment: USD 11.1 billion, 2020-2030. (Own elaboration)*



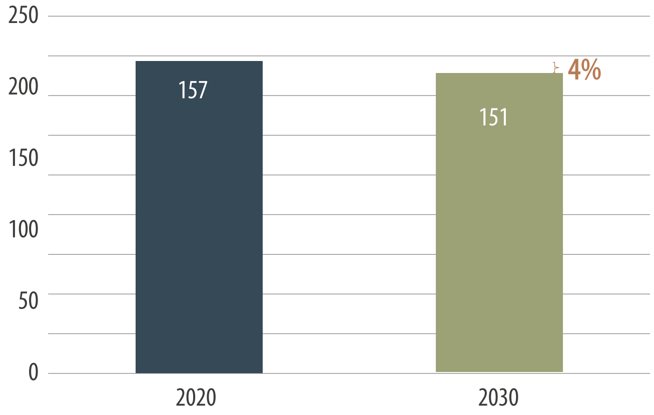
Of the total investment in new generation plants, the country will invest approximately USD 7 billion in hydroelectric power plants, USD 1.2 billion in natural gas, USD 61 million in wind power plants, USD 38 million in solar power plants, USD 31 million in thermal power plants fueled by oil, USD 5 million in thermal power plants fueled by coal and USD 4 million in thermal power plants fueled by biofuels. Peru will invest 3.7 GW in new capacity throughout 2020-2030.

Figure C.82. *Investment in new capacity: 3.7 GW, 2020-2030. (Own elaboration)*



Peru will reduce its emissions intensity by 4%, measured as tCO_2/GWh, by 2030.

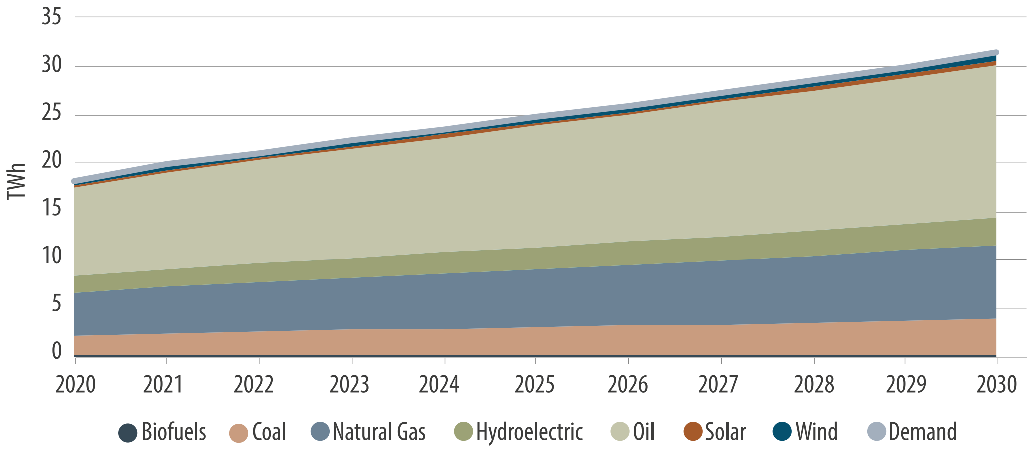
Figure C.83. *Emissions intensity (tCO₂/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.22 Dominican Republic

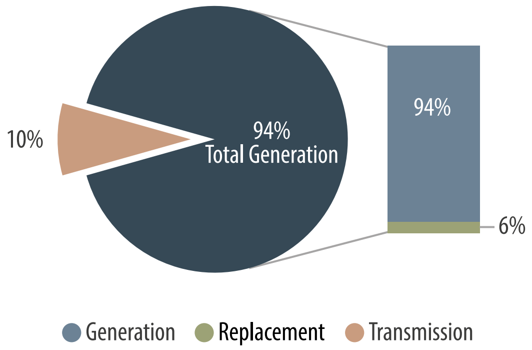
The demand for electricity in the Dominican Republic will increase 5.6% on average per year until 2030. The country will demand 31 TWh by 2030. The generation source in 2030 will be composed of: 50% oil; 24% natural gas; 12% carbon; 9% hydroelectric; 3% wind; 1% solar; and, 1% biofuels.

Figure C.84. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



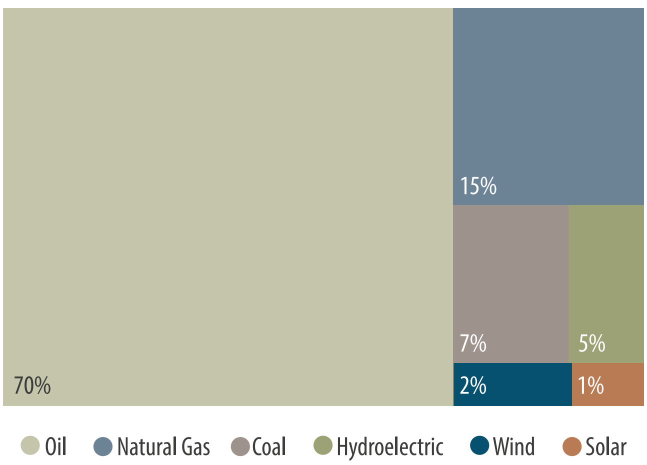
The Dominican Republic will invest a total of USD 5.3 billion by 2030. Of that amount, USD 4.8 billion will be invested in generation (94% in new plants and 6% in replacement of existing ones) and USD 0, 5 billion in transmission lines.

Figure C.85. *Total investment: USD 5.3 billion, 2020-2030. (Own elaboration)*



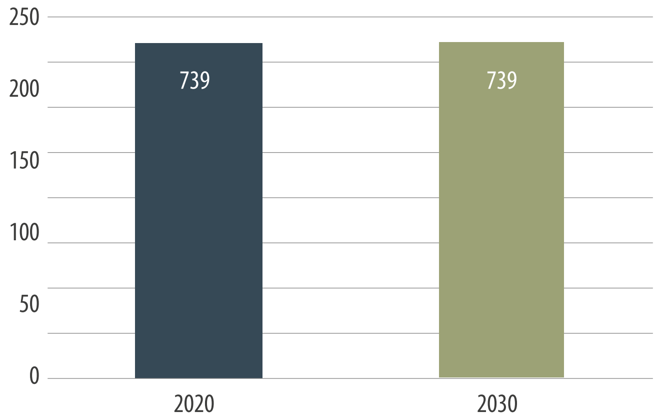
Of the total investment in new generation plants, the country will invest approximately USD 2.5 billion in thermal power plants fueled by oil, USD 700 million in hydroelectric power plants, USD 606 million in thermal power plants fueled by coal, USD 552 million in thermal power plants fueled by natural gas, USD 99 million in wind power plants, USD 47 million in solar power plants, and USD 26 million in thermal power plants fueled by biofuel. The Dominican Republic will invest 4.5 GW in new capacity throughout 2020-2030.

Figure C.86. *Investment in new capacity: 4.5 GW, 2020-2030. (Own elaboration)*



The Dominican Republic will maintain its emissions intensity, measured as tCO_2/GWh, by 2030.

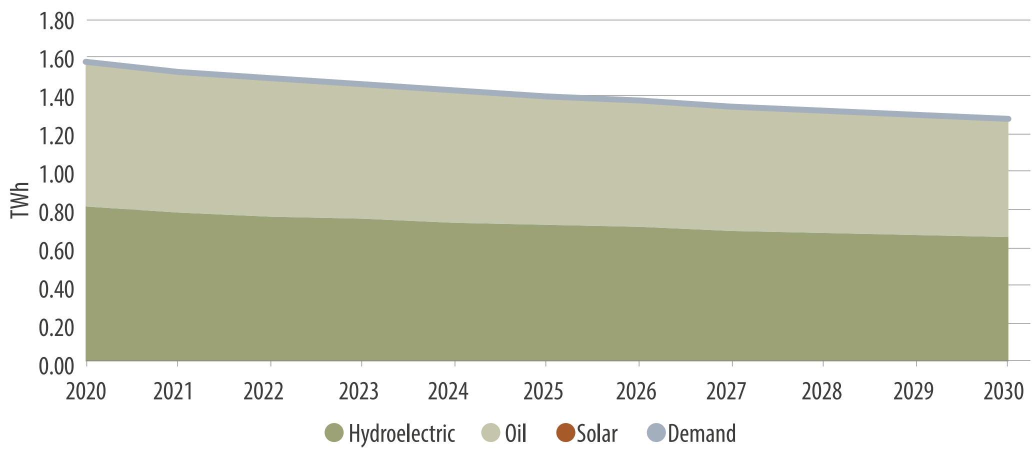
Figure C.87. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.23 Surinam

The demand for electricity in Suriname will decrease by 2.14% on average per year until 2030. The country will demand 1.27 TWh by 2030. The generation source in 2030 will be composed of 51.31% hydroelectric, 48.20% oil, and 0.49% solar.

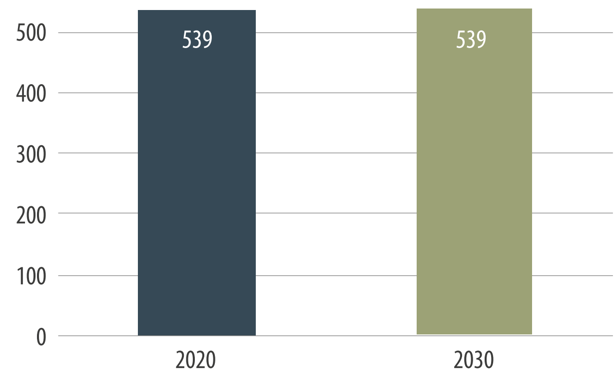
Figure C.88. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



Suriname will invest a total of USD 116.33 million by 2030. Of that amount, USD 116.33 billion will be invested in generation (0% in new plants and 100% in replacement of existing ones).

Regarding its emissions, Suriname will not reduce its intensity, measured as tCO_2/GWh, by 2030.

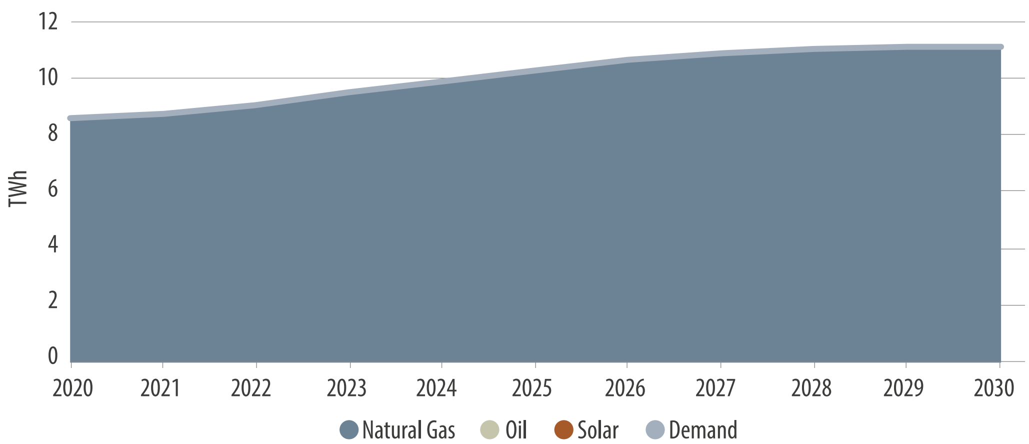
Figure C.89. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.24 Trinidad and Tobago

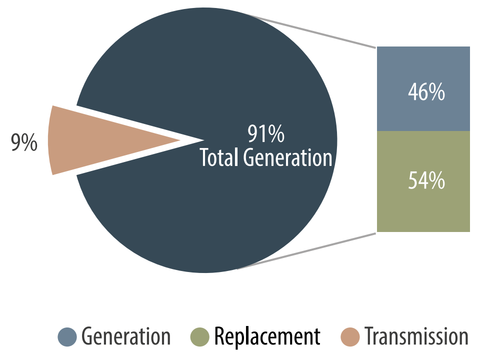
The demand for electricity in Trinidad and Tobago will increase by 2.6% on average per year until 2030. The country will demand 11 TWh by 2030. The generation source in 2030 will be composed of 99.58% natural gas, 0.37% oil, and 0.05% solar.

Figure C.90. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



Trinidad and Tobago will invest a total of USD 1.07 billion by 2030. Of that amount, USD 970.92 million will be invested in generation (46% in new plants and 54% in replacement of existing ones), and USD 98.73 million in transmission lines.

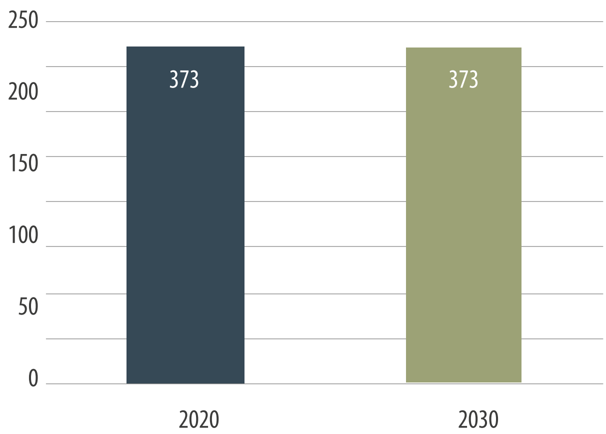
Figure C.91. *Total investment: USD 1.07 billion, 2020-2030. (Own elaboration)*



Of the total investment in new generation plants, the country will invest approximately USD 440 million in thermal power plants fueled by natural gas, USD 3.54 million in thermal power plants fueled by oil, and USD 0.39 million in solar power plants. In terms of capacity, Trinidad and Tobago will invest 535 MW in new capacity throughout the decade by 2020-2030.

In terms of its emissions, Trinidad and Tobago will maintain its intensity, measured as tCO_2/GWh, by 2030.

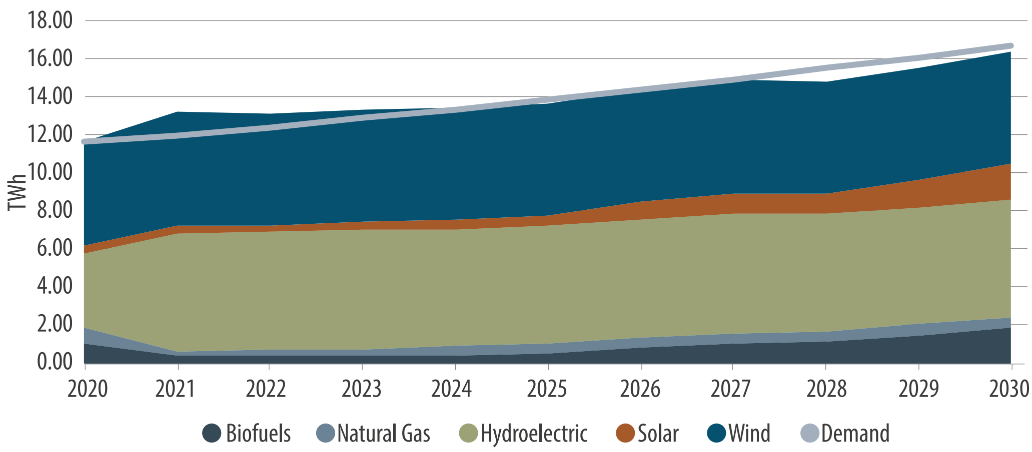
Figure C.92. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



7.3.25 Uruguay

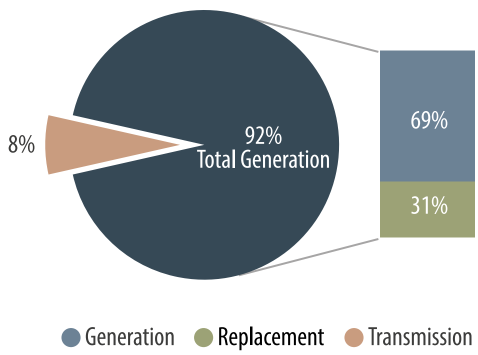
The demand for electricity in Uruguay will increase by 3.7% on average per year until 2030. The country will demand 17 TWh by 2030. The generation matrix in 2030 will be composed of: 37.6% hydroelectric; 36% wind; 11.6% solar; 11.65% biofuels; and, 3.2% natural gas. The participation of natural gas in 2030 will increase by 8 percentage points (pp.) compared to its participation in 2020, hydroelectric power plants by 4 pp., and biofuels by 3 pp. The share of wind energy will decrease 11 pp. and natural gas by 4 pp.

Figure C.93. *Demand and supply of electricity, projection 2020-2030. (Own elaboration)*



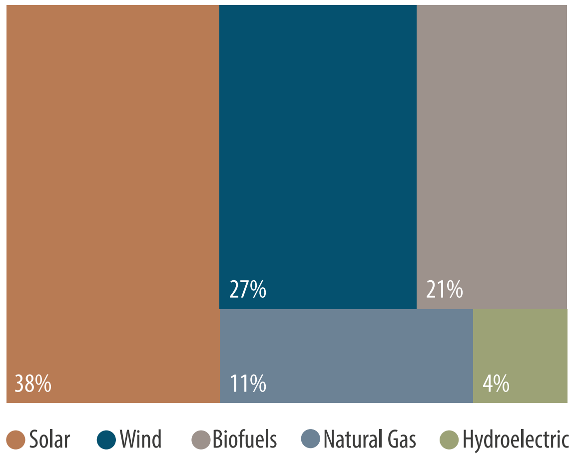
Uruguay will invest a total of USD 2.60 billion by 2030. Of that amount, USD 2.41 billion will be invested in generation (69% in new plants and 31% in replacement of existing ones) and USD 0.19 billion in transmission lines.

Figure C.94. *Total investment: USD 2.60 billion, 2020-2030. (Own elaboration)*



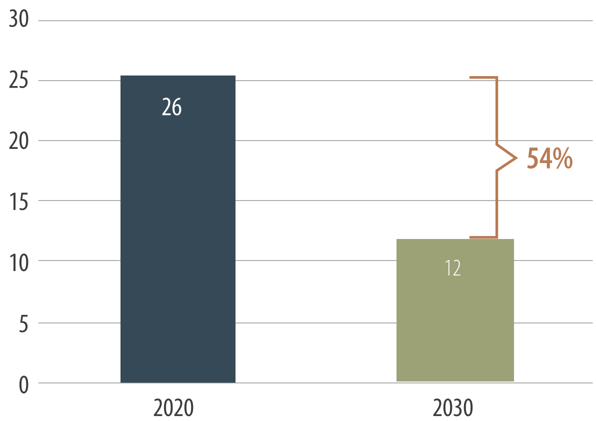
Of the total investment in new generation plants, the country will invest approximately USD 510 million in solar power plants, USD 463 million in wind power plants, USD 328 million in thermal power plants fueled by biofuels, USD 216 million in hydroelectric power plants, and USD 144 million in thermal power plants fueled by natural gas. Uruguay will invest 1.6 GW in new capacity throughout 2020-2030.

Figure C.95. *Investment in new capacity: 1.6 GW, 2020-2030. (Own elaboration)*



Uruguay will reduce its emissions intensity by 54%, measured as tCO_2/GWh, by 2030.

Figure C.96. *Emissions intensity (tCO_2/GWh), 2020 vs. 2030. (Own elaboration)*



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