Electrification for sustainable development

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CAF DEVELOPMENT BANK OF LATIN AMERICA AND THE CARIBBEAN

Electrification for sustainable development

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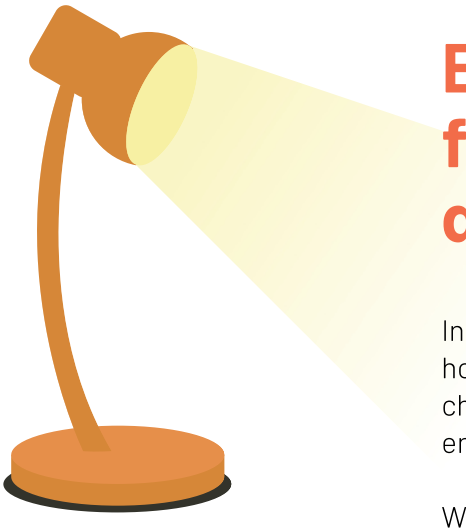


Electrification for sustainable development

In Latin America and the Caribbean (LAC), there are 4.6 million households without access to electricity services,[1] presenting challenges in terms of economic growth, social inclusion, and environmental protection.

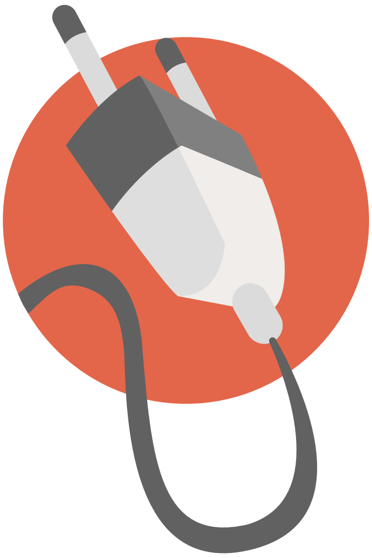
When a household lacks access to electricity, the availability of light hours is reduced. This affects the allocation of time for various activities: adults, particularly women, may have less time for productive work in and/or outside their homes. This situation could constrain their access to better employment conditions and higher incomes, resulting in lower labor productivity.

Additionally, children's education and academic performance can be negatively impacted due to the reduced availability of hours of light for homework and studying. Moreover, all household members may suffer from health issues resulting from indoor air pollution caused by the use of high-carbon energy sources for lighting, cooking, or heating. These factors contribute to a lower quality of life for Latin Americans and Caribbeans, especially those residing in rural areas where the electrification needs are more pronounced.

Ensuring that families have access to electricity is imperative for economic growth. Increased access to this service will lead to better job opportunities, enhanced productivity, and improved educational and health conditions. Moreover, when expanded electrification comes with electricity generation from low or zero-carbon sources, LAC countries can achieve the dual objectives of growth and reducing—or even preventing—greenhouse gas emissions (GHG).[a] This approach paves the way for achieving sustainable development.

Ensuring that families have access to electricity is imperative for economic growth. Increased access to this service will lead to better job opportunities, enhanced productivity, and improved educational and health conditions.

a The main greenhouse gases are carbon dioxide (CO_2), methane, and nitrous oxide. Due to the burning of fossil fuels and land use patterns, a fraction of these gases accumulates in the atmosphere and traps some of the thermal radiation, leading to global warming (Brassiolo et al., 2023).



Electricity coverage and quality issues in LAC

Despite the fact that countries in LAC have achieved nearly universal residential electrical coverage, there are still over 18 million Latin Americans and Caribbeans without access to electricity.

As a result of the progress made in recent decades, countries in LAC have achieved nearly universal residential electrical coverage.[2] The percentage of households connected to electrical distribution networks increased from 90% in 2001 to 98% in 2021.[3]

This increase in electrical coverage has been particularly significant in some countries of the region that had substantial gaps in the early 2000s. Bolivia and Peru serve as notable examples, where in 2001, only 6 out of 10 people in Bolivia and 7 out of 10 in Peru had electrical coverage. However, by 2021, they showed the highest growth rates in electrical coverage, both with increases of around 30 percentage points (pp).[3,b]

Despite these advances, a significant gap remains. In 2021, over 18 million Latin Americans and Caribbeans residing in 4.6 million households had no electrical coverage. This gap is primarily attributed to the absence of electrical connections in rural areas, affecting 3.5 million households.[1] In these areas, distribution costs are higher due to lower population density and the challenges posed by geographical features such as forests and mountains.[2]

In addition to coverage issues, there are problems related to the quality of the electrical grid,[c] leading to service instability that impacts the quality of life for households and the economic performance of businesses. In 2019, 42% of households in LAC reported experiencing electricity service interruptions due to provider issues within the last year, with 21% stating that the last interruption lasted more than 12 hours.[4] This situation also affects businesses in the region, with 58% in 2017 reporting power outages in the last year.[5]

When comparing electrical services in LAC with those in developed countries, it becomes evident that there is a significant lag in the quality of electrical service in the region. According to the latest available data, the frequency of service interruptions in LAC reached 3.6 in 2019, while in

b Similar progress in residential electrical coverage, although to a lesser extent, was observed in Panama, El Salvador, Jamaica, and Colombia, with increases of approximately 10pp (OLADE, 2021).

c Quality in access to electrical energy can be evaluated through the frequency and duration of service interruptions (IDEAL, 2022), as well as other attributes of electrical provision that ensure compliance with acceptable standards, such as voltage levels, to prevent fluctuations that may damage equipment and appliances.

Europe and the United States, it was 1.2 and 1.3, respectively, in 2016. Additionally, the average duration of electrical service interruptions in LAC was 6.8 hours in 2019, exceeding the figures for the United States and Europe, which had average durations of 5.7 (2018) and 1.7 hours, respectively.[6]

Electrification as the foundation for economic growth

Countries in LAC not only need to increase the electrification rate, particularly in rural areas, but also to enhance the quality of electrical service provision. Improvements in coverage, access, and the quality of electricity bring positive impacts in terms of economic growth and development.[d] These improvements are reflected in better labor indicators, productivity, living conditions, health, education, and environmental aspects for the populations benefiting from them.

Evidence in LAC: Impacts of electrification

In developing regions like LAC, there is evidence that increased energy development[e] —associated with electricity availability, access, and use— has positive impacts on health and education. Specifically, it is linked to an increase in life expectancy at birth, a reduction in infant mortality rates, higher secondary school enrollment and school attendance.[7]

For some LAC countries, the available evidence suggests significant positive impacts on living conditions, employment, health, and education.

d Establishing a causal association between economic growth and electrification is not a simple task due to the complexity of economic growth, which is a dynamic and long-term process (Stern et al., 2019; Stern y Kander, 2012) found a positive relationship between economic growth and electrification. Additionally, Calderón et al. (2015). identified a positive and significant long-term effect of infrastructure on GDP, using an indicator that includes electricity generation capacity, transportation, and telecommunications.

e The authors measure energy development using a multidimensional index that combines four indicators, both at the residential and commercial levels, namely: total per capita primary energy use, per capita electricity consumption, renewable energy consumption, and access to electricity.

BRAZIL	Electrification had positive effects on living conditions, reflected in a 16 to 20% increase in the Human Development Index (HDI). It also led to improvements in education, associated with a 25% reduction in the illiteracy rate and a 32% decrease in the population with less than four years of education, along with a 47% increase in employment.[8]
NICARAGUA	Rural electrification resulted in a 23% increase in the probability of women working outside the home.[9]
COLOMBIA	Electrification led to a 10% increase in the fraction of eight-year-old children who had completed at least one year of school.[10]
EL SALVADOR	Electrification of rural homes reduced acute respiratory diseases in children by 39 to 65% after three years of the intervention, by decreasing indoor particulate matter concentration by 66%.[11]
PERU	Electrification of rural homes through a domestic solar system reduced household expenses on other energy sources used for lighting, such as candles (-81%) and batteries (-8%). It also increased the time spent on recreational activities like reading and raised children's study time by 11%.[12]

Labor market

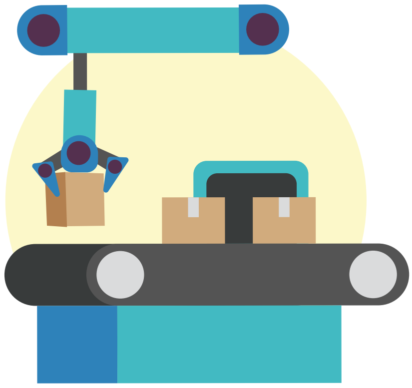
Access to electricity has positive impacts on **labor indicators** such as employment, with increases ranging from 17 to 47%,[13] with some studies suggesting that women tend to benefit to a greater extent,[14, f] and income, with increments ranging from 20 to 70%.[15, g-h]. These improvements could be explained by a reallocation of people's time towards work. For example, having nighttime lighting can allow individuals to increase the time they spent on paid jobs.[16]

f While Dinkelman (2011) only finds positive impacts on female employment, Khandker et al. (2014) find positive impacts for both women and men, though they are greater for women. However, Van de Walle et al. (2017) find an impact only on the employment of male wage workers.

g Lenz et al. (2017) do not find statistically significant effects of electrification on employment and income.

h Khandker et al. (2014) find positive effects on household income but not significant effects on labor income.

Production



Electrification can also have positive impacts on **production**. For the industrial production sector, in particular, the positive impact is 14%.[17] This impact can be attributed to improved access to the electrical grid in terms of quantity and quality, reduced energy input costs, refrigeration of production inputs, use of electrical machinery and equipment, and technological equipment for business management, among others. In agriculture, for example, electrification enables the implementation of additional technologies such as water pumps.[17] Additionally, according to available studies, electrification would have positive effects on productivity per worker.[18]

Living conditions

Access to electricity also has positive effects on household **living conditions**, including a 16 to 20% improvement in human development and a 13.3pp reduction in poverty.[19] These positive impacts can be explained by the fact that electrification allows beneficiaries to increase their energy consumption.[20, i] This can occur through greater demand for domestic lighting, increased use of appliances such as stoves,[21] televisions, and refrigerators, and better access to services like clean drinking water and hot water.[22] Additionally, the increased availability of light during the night enables people to allocate their leisure time to recreational activities, such as watching TV, listening to the radio, reading a book, etc.[23]

Furthermore, access to electricity has positive effects on levels of social capital and cohesion, as it creates opportunities for individuals to develop relationships and interact with each other through greater access to information and entertainment services, public or community spaces, and services or personal safety. Improved lighting of public spaces is an example. [22]

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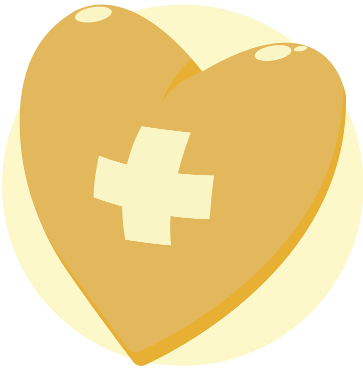
i Rural electrification projects, in addition to improving access for the population directly benefiting from electricity services, could generate spillover effects on neighbors and relatives who indirectly access the service. This would allow them to increase their electricity consumption and reduce their energy expenses (Van de Walle et al., 2017 and Lenz et al., 2017), as well as access better services in areas like health, education, and the supply of goods.

Health



Access to electricity, or improved access to it,[j] generates improvements in **health indicators**. They include a reduction in hospital admissions for respiratory diseases, a decrease in the incidence of respiratory diseases in children by 39 to 65%, as well as reductions in eye, cardiovascular, and/or diarrheal diseases. It is also linked to a reduction in infant and maternal mortality and an increase in life expectancy due to reduced exposure to indoor air pollution.[24] The positive effects on air quality can be attributed to two channels. First, access to electricity allows households to replace CO_2-emitting energy sources[25] that affect air quality, such as biomass or kerosene used for lighting, heating, or cooking.[26] Second, the improvement in air quality may be due to the change in electricity generation methods. For instance, the substitution of electricity generated by coal-powered power plants with electricity from hydroelectric plants, wind farms, and solar parks that use renewable energy sources like water, air, and the sun.

Additionally, access to the electrical grid enables healthcare facilities to enhance their physical infrastructure and healthcare services. This improvement includes proper lighting during medical procedures, better storage of vaccines, and the operation of medical equipment. It also facilitates the management of these services through the use of and access to telecommunications.[27]

Education

Electrification and/or improved access to electricity also have positive impacts on **education indicators**.[k] This includes a 25% reduction in the illiteracy rate, an 11% increase in children's study time, a 6% to 72% increase in years of schooling for children (ranging from 0.3 to 2 years), improved progression from primary to secondary school, increased school attendance, and improved academic performance.[28] These positive impacts could be explained by an increase in effective school hours, greater access to and use of information and communication

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j Improved access to electricity refers to the availability and use of safer electric services, with measures to ensure the safety of electrical installations to minimize the risks of accidents and damages. These services should also be reliable, with continuous availability and minimal interruptions, and efficient, minimizing significant losses during the transmission and distribution of electricity.

k Squires (2015) found negative effects of electrification on attendance, years of schooling, and school graduation. This could be explained by increased child labor market participation and because adult women in the household might be attracted to the labor market, leaving older children in charge of caring for their younger siblings.

technologies (ICTs),[22] and the availability of light, which allows for extended study time at home, not only for children[29] but also for adults. Additionally, access to electricity in educational institutions enhances classroom lighting conditions, working conditions for educators, and educational quality by enabling practical classes in laboratories and the use of educational equipment such as computers, photocopiers, televisions, and projectors during lessons.[22]

Environment

Lastly, electrification also has positive impacts on **environmental indicators.**[22] Three channels lead to these improvements. First, by substituting the use of CO_2-emitting energy sources with electricity,[30] such as a reduction in the use of firewood for cooking or heating,[21] that reduce energy consumption and, consequently, CO_2 emissions when electricity is generated using such energy sources. Secondly, due to the use of more energy-efficient appliances that reduce energy consumption and, consequently, emissions of CO2 when electricity is generated using these types of energy. Third, by replacing the use of CO_2-emitting energy sources with renewable energy sources[31,I] or non-fossil energy sources with low carbon content, such as nuclear energy. This substitution, joined with energy efficiency, can result in not only positive externalities like improved air quality and reduced GHG emissions,[31] but also a decrease in household energy expenses.[32]

I However, it should be noted that the implementation and operation of renewable energy technologies can generate pollution and affect the conservation of ecosystems and biodiversity (Moore et. al, 2020; IDEAL, 2022). For example, wind farms and hydroelectric dams can affect migratory species, and solar power plants can impact natural habitats by using large land areas for their development (Pörtner et al., 2021). Additionally, GHGs are generated during the construction phase of these technologies, e.g., in the construction of hydroelectric power plants and in the manufacturing processes of solar panels and wind turbines (Spadaro et al., 2000). Furthermore, the development of renewable energies requires minerals—for example, for wind turbines—obtained from mining activities that can affect ecosystems. Also, waste is generated from the disposal of photovoltaic panels and wind turbines once they reach the end of their useful life or are replaced prematurely. In addition to these environmental consequences, other types of pollution such as noise pollution – for example, the noise from wind turbines can have adverse effects on people's health (Punch et al., 2010), such as headaches and stress (Pedersen, 2011).

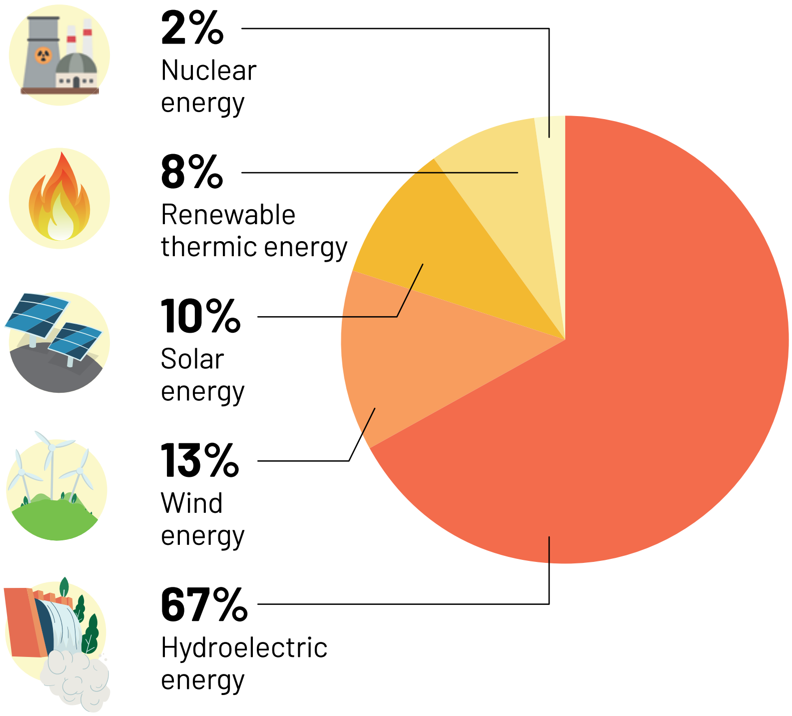
Electrification based on renewable energy sources

The share of installed capacity from renewable energy sources established at 62% in 2021.

The expansion of electricity coverage and access in the last 20 years in LAC has been accompanied by significant growth in installed capacity, which has increased by over 100%.[m] At the same time, the share of installed capacity from renewable energy sources reached 62% in 2021.[3]

It's worth noting that within the group of renewable energy sources, hydropower holds the largest share of installed capacity.[3]

PERCENTAGE OF RENEWABLE ENERGY SOURCES ACCORDING TO THEIR INSTALLED CAPACITY IN LAC



This regional effort to make their electricity generation matrices low in carbon is part of a global initiative to reduce greenhouse gas emissions and mitigate their environmental consequences.

m The installed capacity of electricity generation, which is the theoretical maximum capacity that a power generation plant can produce under optimal conditions, increased from 221,000 MW to 481,000 MW between 2001 and 2021. During the same period, there was also a 75% increase in electricity generation, which is the actual amount of electricity produced, rising from 937,028 GWh to 1,637,868 GWh.

GHG emissions, global warming, and its consequences

The accumulation of GHGs in the atmosphere leads to what is known as global warming, an increase in the average surface temperature of the Earth. Over the last decade (2013-2022), this increase has been 1.1°C compared to the pre-industrial era (1850–1900),[33] and it is expected to continue rising in the coming decades.[n]

Global warming has direct negative effects such as increased heat stress, flooding, droughts, wildfires, and a higher frequency of intense storms. It also has indirect consequences that threaten public health through adverse changes in air pollution, the spread of diseases, food and water insecurity, displacement, and mental health issues.[34]

These damages can be massive and potentially irreversible unless countries worldwide, including those in LAC, take urgent measures to prevent further temperature increases.[35]

LAC accounts for 10% of global emissions, and there has been a significant increase over the last 50 years.

Currently, LAC accounts for 10% of global emissions.[35,o] While the region has lower total emissions and per capita emissions compared to the developed world, there has been a significant increase in emissions over the last 50 years. In 1971, the average per capita CO_2 emissions in LAC were only 15% of those in the developed countries of the Organisation for Economic Cooperation and Development (OECD). However, by 2021, this percentage had doubled to reach 30%.[36]

n In fact, the projected average temperature for LAC in 2021-2040 is 1°C higher than in 1985–2014 (Brassiolo et al., 2023).

o In LAC, the energy sector, which includes electricity generation, contributes only 13% to this total of emissions, while the sectors with the highest contributions are those related to land use, land-use change, and forestry, as well as agricultural practices (58%), industry (16%), and transportation (11%), among others (Brassiolo et al., 2023).

LAC's commitment to reduce GHG emissions

In the Paris Agreement, 33 LAC countries (out of a total of 196 signing countries) committed to limiting the increase in temperature to 1.5°C above pre-industrial levels.

Through their Nationally Determined Contributions (NDCs), 21 countries in the region, which account for over 80% of current GHG emissions in LAC, established specific goals for reducing GHG emissions and adapting to the impacts of climate change, as well as the measures and actions to achieve these objectives based on each country's circumstances and capabilities.

In 2020, the countries in LAC emitted 3,293 megatons of carbon dioxide equivalent ($MtCO_2e$), and by 2030, as part of their NDCs, they committed to a reduction of 11% in their emissions (2,952 $MtCO_2e$).[35,p]

Therefore, for the countries in the region to achieve sustainable development through increased electrification and greater economic growth, the increase in per capita income must be such that the GHG emissions of the countries in LAC do not grow or grow at a lower rate.[35]

Two possible ways to achieve this dual objective of growth without increasing—or even reducing—GHG emissions are the electrification of residential energy demand and the decarbonization of the electricity generation matrix using renewable sources.

Two possible ways to achieve this dual objective of growth without increasing—or even reducing—GHG emissions are the electrification of residential energy demand and the decarbonization of the electricity generation matrix using renewable sources. As mentioned, the first allows for the substitution of energy consumption from fossil fuel sources that emit CO_2 with electricity, while the second enables meeting the energy consumption needs of the region's countries by replacing electricity generation from high-carbon sources with renewable sources that do not emit CO_2 during generation. As available evidence for developed countries shows, increased investment in renewable energy results in lower CO_2 emissions in both the short and long term.[37]

p Efforts to reduce emissions in LAC should increase substantially if population or per capita income growth is considered. If LAC's per capita GDP were to grow between 2% and 4%, given the projected population growth of 0.6% on average annually between 2020 and 2030, it should reduce its emissions per GDP by between 31% and 43%. This reduction is similar to what the European Union would have to achieve in this variable if its per capita income were to grow by 2% (42%) [Allub et al. (publication forthcoming) at www.caf.com]

Renewable energy sources can be developed on a smaller scale, allowing them to reach rural and/or remote areas where there is still significant work to be done in terms of electricity coverage and access. Connecting homes to the main electricity grid in these areas would be very costly.

Renewable energy sources can be developed on a smaller scale, allowing them to reach rural and/or remote areas—which are more dispersed and have a smaller population size—where there is still significant work to be done in terms of electricity coverage and access. Connecting homes to the main electricity grid in these areas would be very costly.

Consistent with the evidence for residential energy demand electrification, existing studies on the impact of solar and wind energy projects, outside the interconnected electricity system (*off-grid*), suggest positive impacts on indicators related to living conditions, employment, health, education, and the environment.

IMPACT OF RENEWABLE ENERGY PROJECTS IN RURAL AREAS

LIVING CONDITIONS

- ⬆ use of household lighting[38]
- ⬇ in household energy expenses by 33 to 59%[39]

EMPLOYMENT

- ⬆ probability of women participating in agricultural work by 33% and probability of men participating in domestic work by 26%[40]

HEALTH AND ENVIRONMENT

- ⬇ consumption of polluting fuels such as kerosene by 50 to 77% and spending by 68 to 80%[41]
- ⬇ probability of using kerosene lamps by 43%[40]
- ⬇ respiratory and vision-related illnesses[42]
- ⬇ CO_2 emissions[43]

EDUCATION

- ⬆ school attendance by 14%[42]
- ⬆ study time for children by 8 to 30 minutes[44] and completion of school tasks by 24%[42]
- ⬆ probability of children in the household completing first grade by 15%[40]

CAF's action and its impact on GHG emission reduction

CAF, aware of the region's needs for both rural and urban electrification and the demand for low-carbon and environmentally sustainable energy generation, finances energy generation projects using renewable sources such as wind, solar, and hydroelectric power.

This strategy is part of a comprehensive plan aimed at promoting a just energy transition[q] with both conventional and unconventional renewable sources. This transition supports economic growth and decarbonization, ensuring energy security, coverage, affordability of electricity services, and promoting *powershoring*.[r]

Financing energy generation projects based on renewable sources

These renewable energy projects financed by CAF would contribute to 2,850 GWh of electricity generation per year, which is equivalent to supplying energy to a total of 1.1 million of families.

Between 2014 and 2023, CAF financed 11 renewable energy projects with a total amount of USD 347 million in Argentina, Brazil, Chile, Ecuador, Peru, and Uruguay. These projects involved the construction, commissioning, and maintenance of six wind farms, 26 solar plants, and two hydroelectric power plants.

Based on our calculations, these projects[s] would contribute to 2,850 GWh of electricity generation per year, which is equivalent to supplying energy to a total of 1.1 million of families, based on each country's average electricity consumption. This represents 2% of the total renewable electricity generation in these countries.

q A just energy transition involves shifting from an energy system based on fossil fuels and coal to one based on primary sources that contribute to reducing GHG emissions, increasing the share of electricity in the energy matrix, improving efficiency—by reducing losses in the transformation, transmission, and distribution of electric power or through the use of energy-efficient appliances—and developing CO_2 capture and storage technologies.

r *Powershoring* refers to the decentralization of production to countries that offer low-carbon, safe, affordable, and abundant energy and are close to major consumption centers, among other advantages to attract industrial investments. LAC meets many of these conditions: several countries have low-carbon energy matrices, and they are geographically close to North America and Europe, in addition to their significant renewable energy potential (CAF, 2022).

s The contribution of the Chico Mendes solar plant in Brazil and the 23 solar panels in Chile is excluded from this calculation. These projects, approved in 2022 and 2023, respectively, were not yet completed at the time of publishing this report. The estimated annual emission reduction would be 270 and 48,300 tCO_2eq, respectively.

Furthermore, this generation of energy from renewable sources reduced GHG emissions by a total of 4 million tons of CO_2 equivalent (tCO_2eq) since the start of each renewable energy project until 2022. In 2022, the reduction in GHG emissions from these projects was 980,000 tCO_2eq, which accounts for 1.1% of the total CO_2eq emissions attributable to grid-connected electricity generation in the five countries with operational projects.

The Social Cost of Carbon (SCC)[t] is a measure that estimates the monetary value of the impacts associated with changes in CO_2 emissions in a given year, expressed in terms of equivalent consumption.[45] According to SCC assessments, the reduction in GHG emissions from CAF projects translated into a benefit ranging from USD 169 million to 937 million during the same period. In 2022, the benefit due to reduced emissions is estimated to range from USD 42 million to 233 million[u].

CAF'S ACTION IN THE LAST 10 YEARS (2014-2023)

$347 million dollars

6 wind farms

26 solar panels

2 hydroelectric centrals

6 benefited countries
Argentina, Brazil, Chile, Ecuador, Peru and Uruguay

2,850 GWh
electricity generated a year

↓4 million tons of CO_2 equivalent

between $170 million and $940 million dollars in benefits
achieved by the reductions of GHG emissions

t Estimates based on the global SCC estimation by Tol (2023) for three discount rates: a) 1%: USD 610 million, b) 2%: USD 937 million, and c) 3%: USD 169 million.

u The benefit calculations based on the SCC estimation made by Tol (2023), with a 1% discount rate amounted to USD 152 million, estimates of benefits with a 2% discount rate were USD 233 million, and with a 3% discount rate, they were USD 42 million. Benefit calculations based on the SCC estimation by Wang et al. (2019) with a 3% discount rate amounted to USD 111 million.

ARGENTINA

CAF financed two renewable energy projects for USD 60 million: the Cafayate solar park and the Villalonga and Chubut del Norte wind farms. The nominal capacity of the solar park was 81.3 MW, accounting for 7.4% of the total photovoltaic solar power installed in the country (1,104 MW in 2022), and the combined capacity of both wind farms was 80.6 MW, representing 2.4% of the total wind power capacity in the country (3,309 MW in 2022). These projects increased energy production by 649 GWh per year, which is enough to supply electricity to 216 thousand households. It is estimated that they contributed to reducing GHG emissions by 1 million tCO_2eq from the start of each project until 2022. In 2022, the total reduction in GHG emissions was 276,000 tCO_2eq, accounting for 0.66% of the total emissions from electricity generation in the country. This reduction would result in a benefit ranging from USD 43 million to 242 million, according to the SCC estimate.

BRAZIL

As part of the São Caetano do Sul Environmental Development and Sanitation Program approved in 2022 for USD 50 million, CAF allocated USD 1.7 million to finance the Chico Mendes solar park to supply the municipality with low-carbon electricity. This project would increase energy production by 0.73 GWh per year and is estimated to contribute to reducing GHG emissions by approximately 270 tCO_2eq per year.

CHILE

CAF financed the Atacama photovoltaic solar park for USD 79 million. The installed nominal capacity was 170 MW, representing 2.7% of the total solar power capacity in the country (6,250 MW in 2022). This park produces a total of 470 GWh per year, which would provide electricity to 215 thousand families. It is estimated to have contributed to reducing emissions by 310,000 tCO_2eq from the start of the project until 2022. In 2022, the total reduction in emissions was 141,000 tCO_2eq, accounting for 0.46% of the total emissions from electricity generation in the country. This reduction would result in a benefit ranging from USD 13 million to 74 million, according to the SCC estimate. As part of the oEnergy PMGD Solar Project in Chile, approved in 2023 for USD 30 million, CAF will finance **23** solar panels that will produce 160.7 GWh of net annual energy. This energy could supply **73,500** families and generate a reduction of **48,300 tons** of CO_2 equivalent, representing 0.16% of the emissions from electricity generation in the country.

ECUADOR

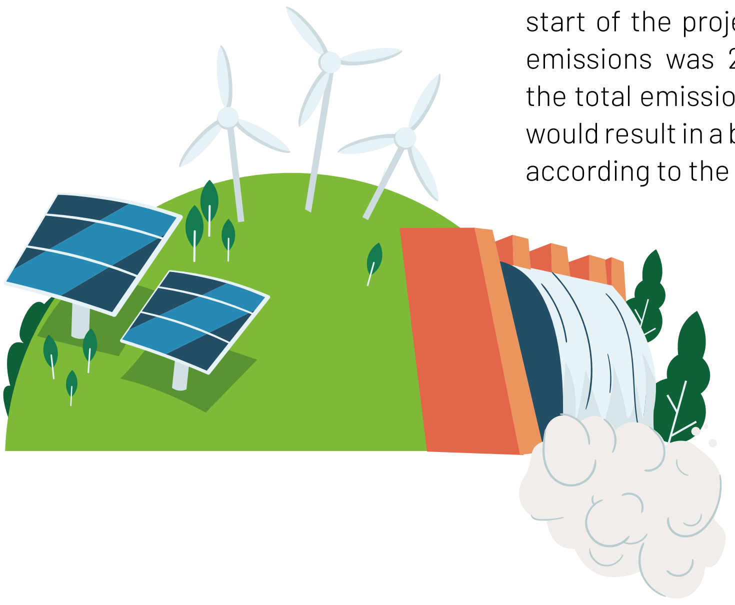
CAF financed the hydroelectric plant DUE Hidroalto for USD 22 million. The installed nominal capacity was 49.5 MW, representing 1% of the total hydroelectric power capacity in the country (5,191 MW in 2022). This plant produces 348 GWh per year, enough to supply electricity to 205 thousand families. It is estimated to have reduced emissions by 385 thousand tCO_2eq from the start of the project until 2022. In 2022, the total reduction in emissions was 51 thousand tCO_2eq, accounting for 1.2% of the total emissions from electricity generation in the country. This reduction would result in a benefit ranging from USD 17 million to 92 million, according to the SCC estimate.

PERU

CAF financed four renewable energy projects for USD 90 million: the Marcona, Tres Hermanas, Huambos and Dunas wind farms, and the La Virgen hydroelectric plant. The three wind farms have a combined installed nominal capacity of 166 MW, representing 41% of the total wind power capacity in the country (409 MW in 2022), and the hydroelectric plant represents 1.5% of the total hydroelectric power capacity in the country (5,503 MW in 2022). These projects increased energy production by 1,119 GWh per year, equivalent to supplying approximately 373 thousand households. It is also estimated that they reduced emissions by 2.1 million tCO_2eq from the start of each project until2022. In 2022, the total reduction in emissions was 485 thousand tCO_2eq, accounting for 5.6% of the total emissions from electricity generation in the country. This reduction would result in a benefit ranging from USD 92 million to 507 million, according to the SCC estimate.

URUGUAY

CAF financed the Artilleros Rouar wind farm for USD 58 million. The installed nominal capacity was 65.1 MW, representing 4.3% of the total wind power capacity in the country (1,514 MW in 2022). This farm produces 257 GWh per year, equivalent to supplying electricity to 93 thousand families. It is estimated to have reduced CO_2 emissions by 99 thousand tCO_2eq from the start of the project until 2022. In 2022, the total reduction in emissions was 26 thousand tCO_2eq, accounting for 1.9% of the total emissions from electricity generation. This reduction would result in a benefit ranging from USD 4 million to 23 million, according to the SCC estimate.



Other supports to increase electrification and reduce GHG emissions in LAC

CAF'S ACTION IN THE PAST 6 YEARS (2018-2023)

8 technical cooperation projects
related to energy

$961 **thousand dollars**

in 19 countries[v]
from Latin America and the Caribbean

These resources were directed toward the financing of:

19 COUNTRIES

» Comprehensive analysis studies of the electricity sector in LAC toward 2050).

» Forums to promote regional energy integration.

ARGENTINA

» Feasibility studies for renewable energy projects in rural areas.

ECUADOR

» Improvement of the public electricity service.

MEXICO

» Technological adoption study and demonstrative projects for energy storage systems.

PARAGUAY

» Implementation of a smart system for electricity measurement management in distribution infrastructure.

URUGUAY

» Training of university students in renewable energy.

» Study on the inclusion of green hydrogen in the electrical system.

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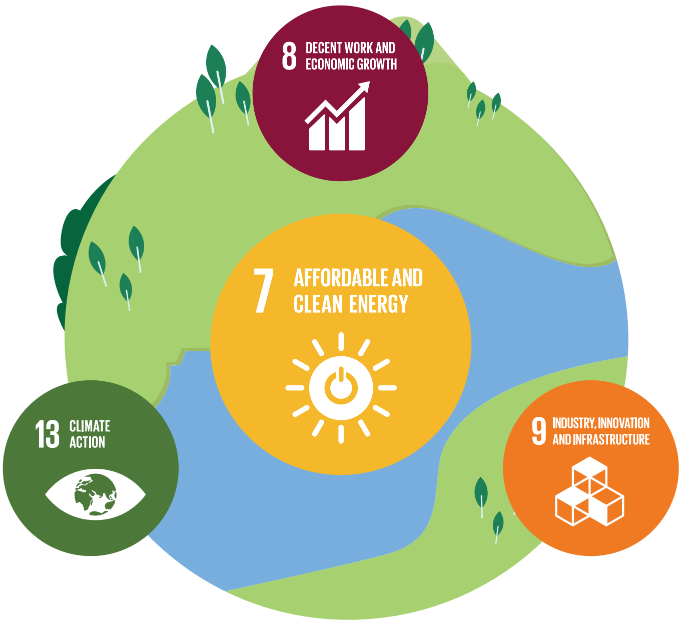
v Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

Additionally, CAF's knowledge agenda is working on a new edition of its annual Report on Economic Development (RED), which will focus on a just energy transition. This report will explore the opportunities and challenges presented by the energy transition for the sustainable and inclusive development strategy of countries in the region. It is scheduled to be published in 2024.

CAF's actions are framed within the achievement of the Sustainable Development Goals (SDGs) established in the United Nations Agenda 2030. Through their implementation, they primarily promote:



In summary

Despite the progress made in electrification across LAC countries, there are still over 18 million Latin Americans and Caribbeans without access to electricity. This situation is more pronounced in rural areas, where nearly 3.5 million households lack access to this service. Additionally, there are still issues with the quality of service that affect its reliability.

These challenges in electrification are compounded by environmental concerns. While LAC as a region accounts for 10% of global CO_2 emissions, its share has increased in recent decades. Urgent mitigation measures are needed to achieve the emission reduction targets set within the framework of the NDCs and to prevent further global temperature increases, which come with economic and social damages.

Therefore, the countries in the region face a triple challenge: investing in electrification, which is essential for economic growth; incorporating energy infrastructure that enables low-carbon electricity generation, which is necessary to protect the environment; and including the most disadvantaged populations, especially those living in rural areas, crucial to leaving no one behind.

CAF finances projects for electricity generation from renewable sources—wind, solar, and hydropower—that have increased rural and urban electrification in the region.

These projects have positive impacts in terms of economic growth and development, reflected in improved labor market indicators, production, living conditions, health, education, and the environment for the beneficiary populations.

The environmental protection impacts increase significantly when electricity generation comes from renewable sources. It is estimated that renewable electricity generation projects financed by CAF reduced GHG emissions by a total of 4 million tons of CO_2 equivalent (tCO_2eq) from the start of each project until 2022—equivalent to a benefit ranging from USD 169 million to 937 million. This accounts for 1.1% of the total emissions from electricity generation in the five countries benefiting from projects in operation, contributing to LAC's mitigation targets within the framework of the NDCs.

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