

Energy transition: a legacy for the present and the future of Colombia

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President of the Republic of Colombia

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Minister of Mines and Energy



El futuro
es de todos

Gobierno
de Colombia





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Mejorando vidas

Energy transition: a legacy for the present and the future of Colombia

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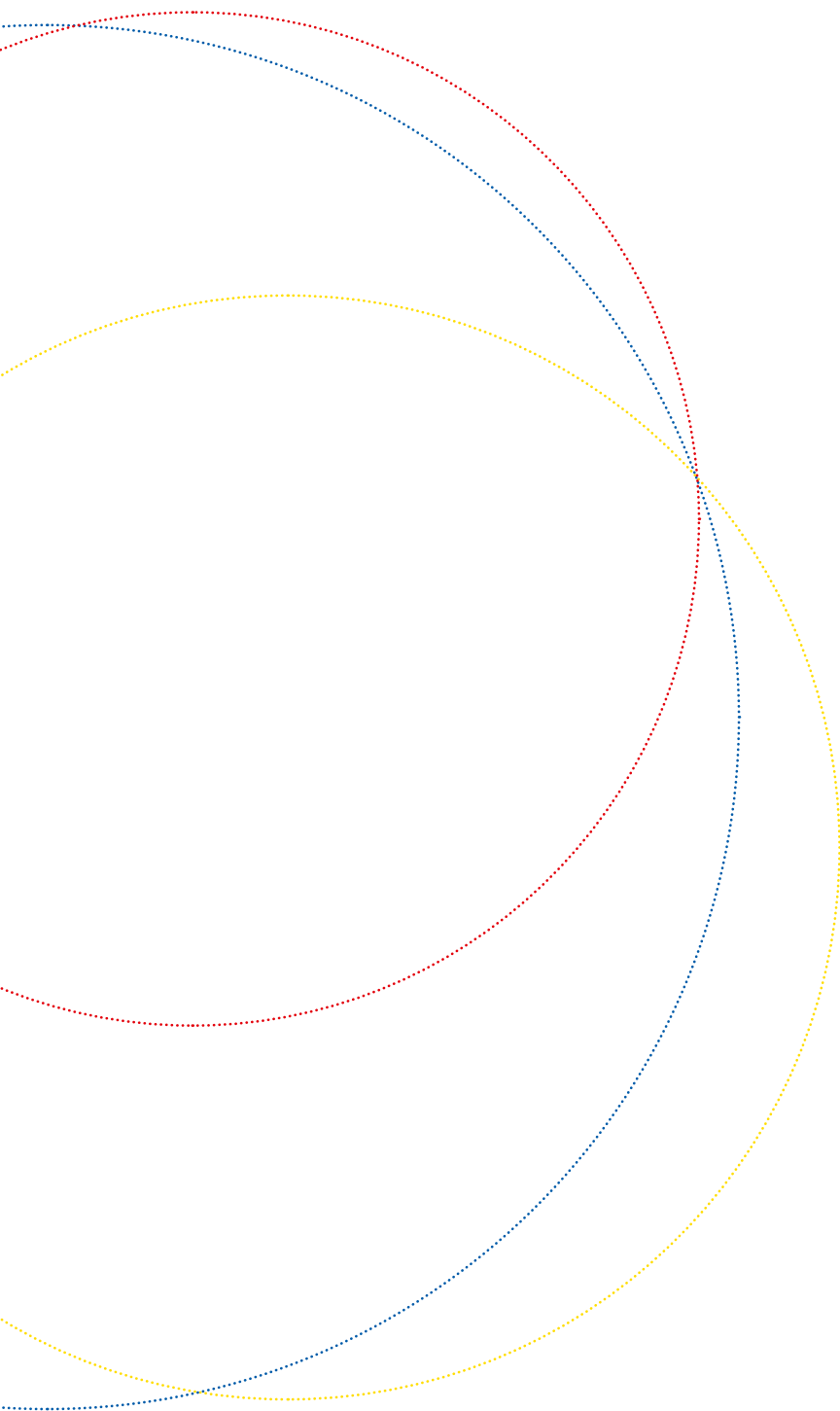
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Table of Contents

	Energy transition is a reality Iván Duque Márquez	5
PROLOGUE	Energy transition in latin america and the caribbean Mauricio Claver-Carone	9
	Energy transition in Colombia Dr. Daniel Yergin	13
	Public policy: the great energy transition enabler in Colombia Diego Mesa Puyo	19
INTRODUCTION	Energy transition: A global reality	27
CHAPTER 1	President Duque's policy on energy transition	39
CHAPTER 2	Auctions: the ideal mechanism for the inclusion of renewable energies	51
CHAPTER 3	Energy resources as complements for the long-term transition	67
CHAPTER 4	Sustainable mobility and energy efficiency	77
CHAPTER 5	The user at the center of the transformation	93
CHAPTER 6	Commitment to equity and the power to transform lives through energy	105
CHAPTER 7	Energy Transformation Mission: roadmap for the modernization and inclusion of new technologies in the electricity sector	119
CHAPTER 8	Energy sector climate change plan	133
CHAPTER 9	Perspectives and new technologies	145
EPILOGUE	Public policy actions to secure the energy transition Miguel Lotero Robledo	159
REFERENCES		171



ENERGY TRANSITION IS A REALITY

Iván Duque Márquez

President of the Republic of Colombia

To initiate an energy transition revolution in Colombia. That was one of the big goals I dreamed of achieving since I served as Senator between 2014 and 2018. In 2016, I shared my vision with businessmen in the energy sector in the midst of an energy crisis unleashed by El Niño phenomenon of that year, which further evinced the risks of our heavy dependence on water sources for power generation.

After I was elected President, I ratified my commitment towards what many believed was an impossible goal: increasing the share of solar and wind energy sources in our power matrix from less than 0.5% to more than 10% during my term in office. In this manner, we would be able to complement our hydro and thermal power generation capacity bringing greater reliability and environmental stewardship to our power system. In the three years since the beginning of my administration, what previously seemed unattainable is now a reality.

In August 2018, the country had only two projects totaling less than 30 megawatts of installed solar and wind generation capacity. Today, Colombia boasts five new solar farms that, together with thousands cogeneration and self-generation projects in departments such as Córdoba, Bolívar, Chocó, Antioquia, Risaralda, Tolima, Meta and Cauca, represent more than 320 megawatts of installed capacity. This is eleven times more than the installed capacity we received at the start of our administration.

In 2021, capacity levels will reach close to 600 megawatts and, in this fashion, we will advance steadily towards our goal of 2,000 megawatts by 2022. That is, variable renewable energy sources will account for over 12% of our power matrix.

To achieve these goals and transition from discourse to action, we worked with Congress to introduce regulatory, tax and commercial incentives in the National Development Plan, the Anti-Bureaucracy Decree-Law, the Finance Act of 2019 and the Energy Transition Law. For example, we extended from 5 to 15 years a 50% uplift on investments in alternative energy sources, and introduced an automatic value added tax (VAT) exemption on the purchase of equipment for solar power.

Furthermore, we reduced the time to access tax incentives to just 45 days, as we eliminated the need to go through the National Environmental Licensing Authority (ANLA). We also introduced a renewable purchase obligation (RPO), whereby between 8% and 10% of the electricity purchased by utility companies to serve regulated users must originate from variable renewable sources.

In addition, we designed and implemented an innovative auction model that allowed our country to take a historic leap in the incorporation of variable renewable energy our power matrix. We secured fourteen wind and solar projects, and attracted new companies to enter the Colombian clean energy market.

Colombia is fast becoming the most attractive country in Latin America for the development of renewable energy projects. We have one of the best legal, regulatory and fiscal frameworks for the expansion of these energy sources, including the recent sanction of the Energy Transition Law in July 2021. This revolution is here to stay, generating employment opportunities and sustainably dynamizing local economies.

In accordance with our commitment to transform the country, along with the use of solar and wind energy, we will incorporate other clean sources such as green hydrogen, which the International Energy Agency labeled the fuel of the future. This year, with the support of the Inter-American Development Bank, we launched the hydrogen roadmap for the next 30 years.

Moreover, with the start-up of the first two geothermal energy generation pilot projects in the Llanos Orientales basin, we continue to make progress in diversifying of our energy mix and enhancing its resilience to meet the challenges posed by climate change.

We also continue to encourage sustainable mobility and energy efficiency. As a result of the Electric Mobility Law enacted in 2019, Colombia became the regional leader in sales of electric vehicles (EVs) and hybrids. In 2020, despite

de pandemic, Colombia increased EV sales by more than 90%, surpassing countries like Chile and the Dominican Republic which used to lead the ranks in Latin America.

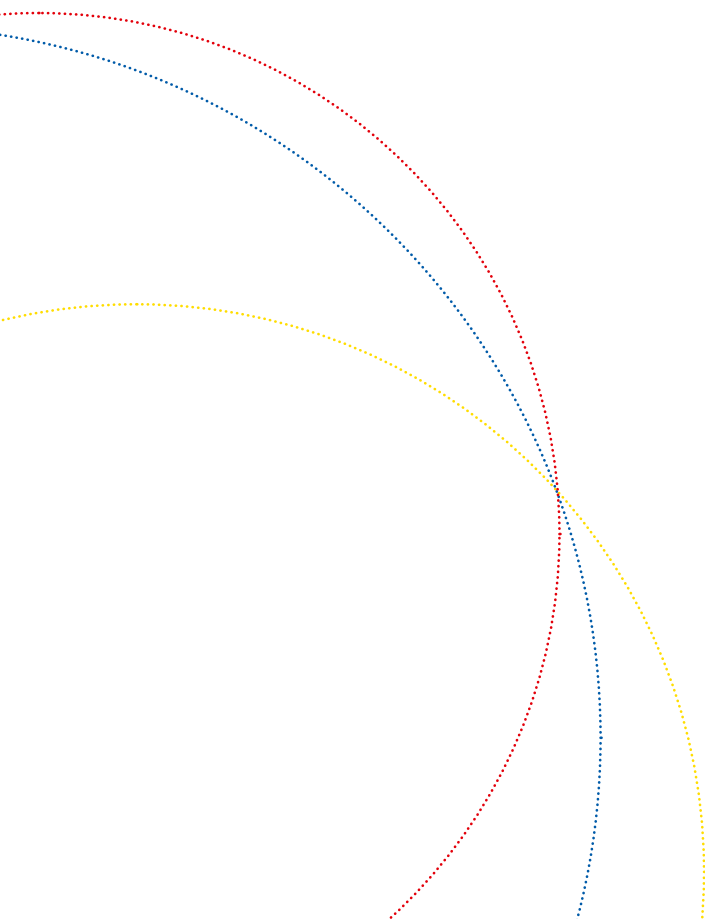
In addition, in september 2021 we launched the Energy Transformation Mission roadmap. This is a set of policy and regulatory actions that will modernize the electricity sector, placing the user at the center of the public policy debate. Moreover, the roadmap will consolidate a strategy designed to achieve an increasingly efficient, reliable and a sustainable electricity service for all Colombians. In this manner, Colombia will maximize its energy potential, increase its capacity to adapt to risks and demonstrate that sustainable development in our country is certainly possible.

Finally, within our post-pandemic economic reactivation strategy, known as the New Commitment for Colombia, the mining and energy sectors have prioritized 42 projects which will generate investments in the amount of 35.7 billion pesos, create 53,500 jobs and benefit 3.3 million Colombians over the next two years.

The world recognizes the effectiveness of this public policy agenda. In 2020, Colombia climbed 14 positions in the World Energy Council's energy sustainability ranking, rising from 49th to 35th place, and ranking sixth among Latin American and Caribbean countries. In addition, according to the World Economic Forum, we are the Latin American country showing the most progress towards energy transition, and in 2020 we climbed nine positions in the Energy Transition Index, moving from 34th to 25th.

This publication, supported by the Inter-American Development Bank, is the consolidation of our unwavering commitment to energy transition in Colombia. Throughout its nine chapters, readers will delve into a rigorous analysis of the transformation that is taking place in our country. We are designing and implementing world class public policies and regulatory frameworks for the benefit of our society and the environment, thus ensuring a green and sustainable development.

I invite readers to embrace a new energy era, as my administration is doing. Colombia and the world face the challenge of ensuring that development and well-being are compatible with safeguarding our planet. Results show that the best way to achieve this is to continue to position ourselves as leaders in the Latin American renewable energy field.



Prologue

ENERGY TRANSITION IN LATIN AMERICA AND THE CARIBBEAN

Mauricio Claver-Carone

President of the Inter-American Development Bank

The momentum with which Latin America and the Caribbean have begun to transform their energy matrix is inexorable, and it demonstrates our region's ability to adapt to economic and social changes. This momentum is nothing new. Historically, Latin America and the Caribbean have had the cleanest energy matrix on the planet due to their extraordinary water resources.

The Inter-American Development Bank (IDB) is committed to supporting countries in Latin America and the Caribbean in the consolidation of a long-term vision for infrastructure services consistent with the Paris Agreement. Our priority is to support the provision of sustainable and quality services, which are indispensable for building modern, productive and healthy societies, particularly within the context of a post-pandemic economic recovery. We see the incorporation of new renewable energy sources as vital for energy security, affordable services, decarbonization of economies and support for the climate change agenda.

In 2018, renewable sources accounted for 58% of total energy generation in Latin America and the Caribbean. However, the region's energy paradigm is shifting due to uncertainty over water availability as a result of climate change. This is compounded by the environmental and social concerns generally associated with the construction of hydroelectric plants in vulnerable ecosystems.

These limitations, along with the decreasing cost of renewable energies such as solar and wind, explain the significant momentum these non-conventional renewable alternatives have gained in the global arena. The region's efforts in this regard are remarkable. In the year 2000, wind generation represented

only 0.03% of the total capacity, and there was practically no solar generation capacity. In contrast, by 2020 solar and wind sources represented nearly 10% of the region's installed electricity generation capacity (3.07% and 6.5%, respectively).

Colombia has emerged as a global leader in energy transition. By 2022, more than 12% of its installed electricity generation capacity will originate from non-conventional renewable sources, compared to less than 1% in 2018. At the IDB, we have been able to assist the country in this effort through public policy instruments aimed at managing long-term contract auctions, strengthening regulatory frameworks, and adopting technical tools to adequately integrate non-conventional renewable energy sources.

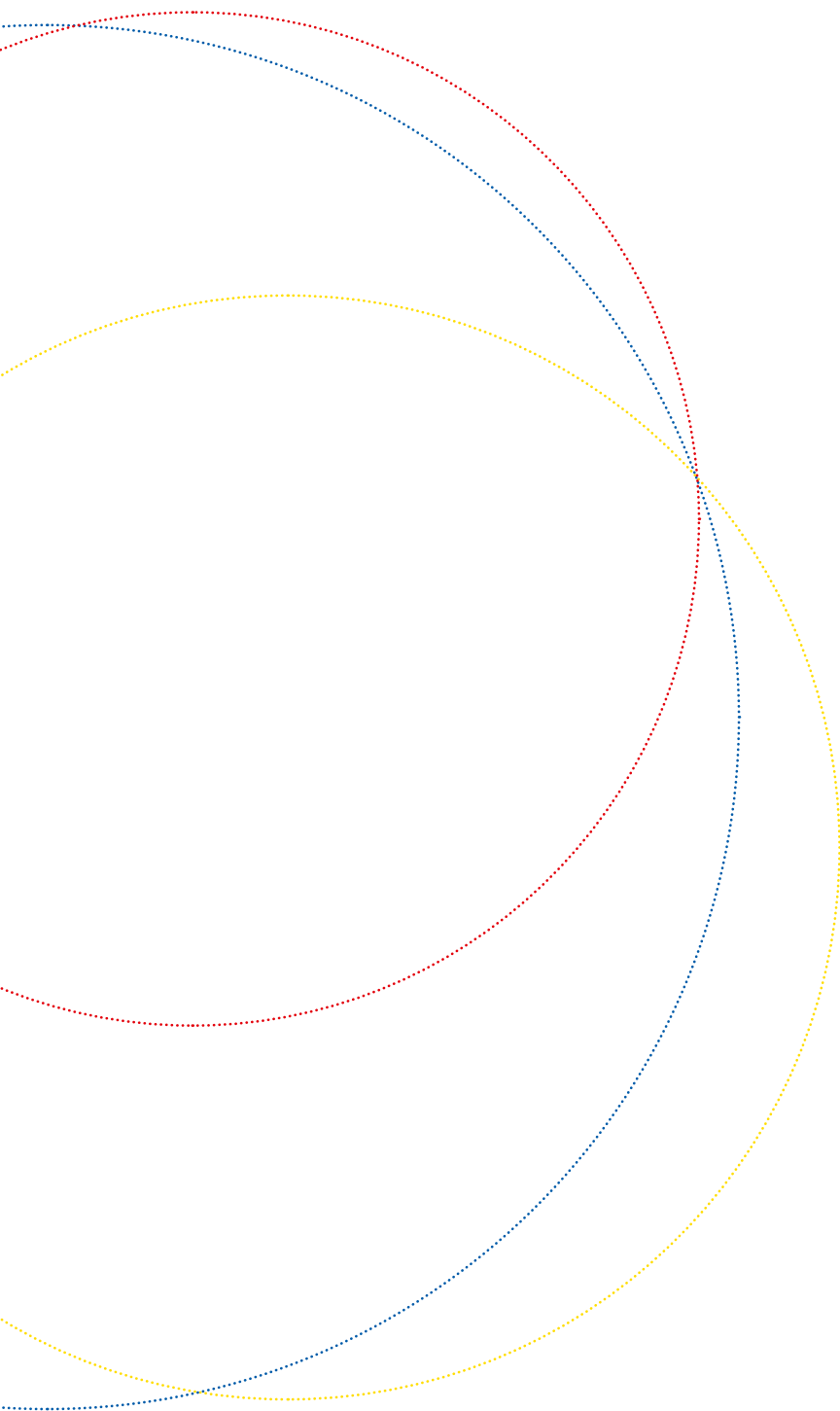
However, much remains to be done in the region to ensure accessible, affordable and quality power service. In terms of infrastructure, there are still 4.5 million users in Latin America and the Caribbean without access to this service according to the IDB's 2020 flagship publication. Regarding the quality of service, 60% of companies state that they suffer from service interruptions.

Even considering these pending tasks, countries cannot lose sight of the transformations the sector will face in the near future. On the one hand, a transition to a digitalized and decentralized power service will have to be encouraged, which will enhance the role of the user. With the potential proliferation of home solar panels, consumers will also assume the production of their own electricity.

Similarly, the role of electric power will inexorably expand as we move towards the decarbonization of our economies and as countries continue to diversify their energy matrices. In this sense, e-mobility comes across as an extraordinary opportunity to reduce the use of fossil fuels and decarbonize the transportation sector. The transformation of the current public and private transport fleet into an electric vehicle fleet, will require reliable, high-quality energy from renewable sources.

These disruptive phenomena will depend, in turn, on new information and communication technologies. In order to take advantage of the benefits offered by these technologies, there is an urgent need to strengthen institutional planning capacity, recognize the challenges of climate change and modernize regulatory frameworks. Public policy actions taken today will enable future

networks to be more competitive, transport large amounts of renewable energy, and offer quality services affordable for everyone. At the IDB, we will continue to construct, along with Latin America and the Caribbean, knowledge and experiences to help countries strengthen their position as leaders in global energy transition.



Prologue

ENERGY TRANSITION IN COLOMBIA

Dr. Daniel Yergin

“Energy transition” has become the shorthand for discussions about the future of energy, especially since 196 countries pledged in the 2015 Paris climate agreement to keep global temperatures from rising 2 degrees Celsius above preindustrial temperatures and to make best efforts to cap the rise at closer to 1.5 degrees. The target for getting there has evolved into the concept of “net zero carbon” by 2050 or shortly thereafter—a goal already adopted by over 100 countries, including the United States, China, the European Union, Britain and Japan, among others. As much as two thirds of global emissions – and roughly two thirds of global gross domestic product – now originate in countries with commitments to net zero of varying degrees. As it progresses, energy transition will transform the way the world produces and uses energy, and the very nature of important parts of the global economy.

The world’s two largest economies are now committed. On his first day as president, Joe Biden returned the United States to the Paris Climate Accord that Donald Trump had abandoned. And just a few months beforehand, China had also committed itself to net-zero emissions by 2060. In 2021, the foundations have been set for a new superpower race for leading roles in the global markets that is coming with electric vehicles, solar and wind power, hydrogen and technologies still to emerge. It will be complicated by the overall change in relations between the United States and China, which leaves many other countries concerned about being caught in the middle between the two largest economies in the world.

The energy transition process will create dilemmas about the nature and pace of change. The “What” – net zero carbon – may be clear. The “How” – how to achieve it – is not at all clear. Most nations pledged to net zero have yet to adopt the laws and regulations to get them there. But with the momentum building, 2021 may mark the beginning of a period of accelerated change in energy and climate policies, laws and regulations. And yet the process of transforming a new climate framework into investment, and new investments into changed energy realities will likely take longer, be more expensive, more complicated and contentious, and will require more technical innovation than many now anticipate. An almost \$90 trillion world economy depends on fossil fuels for 80 percent of its energy, and oil and gas will be part of the energy mix for decades to come. And over those decades, revenues from oil and natural gas will be important for both, funding social needs and helping to fund the energy transition in Colombia.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

Often, the extent of the role of oil and gas beyond transportation in the global economy is poorly understood. For many countries, replacing coal with natural gas is a major initiative for reducing emissions. That will add to the urgency to develop carbon capture technologies. And we can be sure that changes in global geopolitics will hardly be linear, for disruptions, with some frequency, will inevitably redirect the path. The shale revolution was not anticipated, nor were the financial crisis of 2008, the rebirth of the electric car, the plummeting costs of solar, an incredibly transmissible bat virus that would lead to a pandemic or an economic dark age.

Colombia, and indeed the global community, find themselves at an inflection point in the world's energy history. Many will ponder how quickly they can and should reduce emissions, increase efficiency, invest in carbon-free capacities. National resources will be a factor, especially as countries rebuild after the pandemic. But the very challenge of recovery also provokes the question – not just of how countries invest – but (perhaps more importantly) what incentives they create for private capital flows that dominate innovation and growth.

That is the context as Colombia launches the transformation of its energy systems. The directions in policy are clear: increasing the share of non-conventional renewable energy from under 1% to nearly 12% of the energy mix by 2022; raising its target to reduce greenhouse gas emissions from 20% to 51% by 2030; and making “sustainable revitalization” the driving force of its economic recovery strategy coming out of COVID. Colombia's response under the government of President Ivan Duque has not only helped the country weather the COVID “dark age,” but it has also positioned Colombia to capitalize on the economic revitalization anticipated beyond the pandemic.

The global picture will be one of heightened competition. China's commitment to achieve net zero emissions by 2060 is a colossal task due to its massive consumption of coal and other fossil fuels. China is also the world's biggest investor in renewable energy, it controls about 80% of global solar panel exports, a vast share of the materials needed for vehicle and grid storage, and it produces more electric vehicles with more ambitious production targets than any other nation. All of this fits into China's national strategy to reduce dependence on fossil fuel imports – now 75 percent for oil – and to curb the politically crippling impacts of pollution.

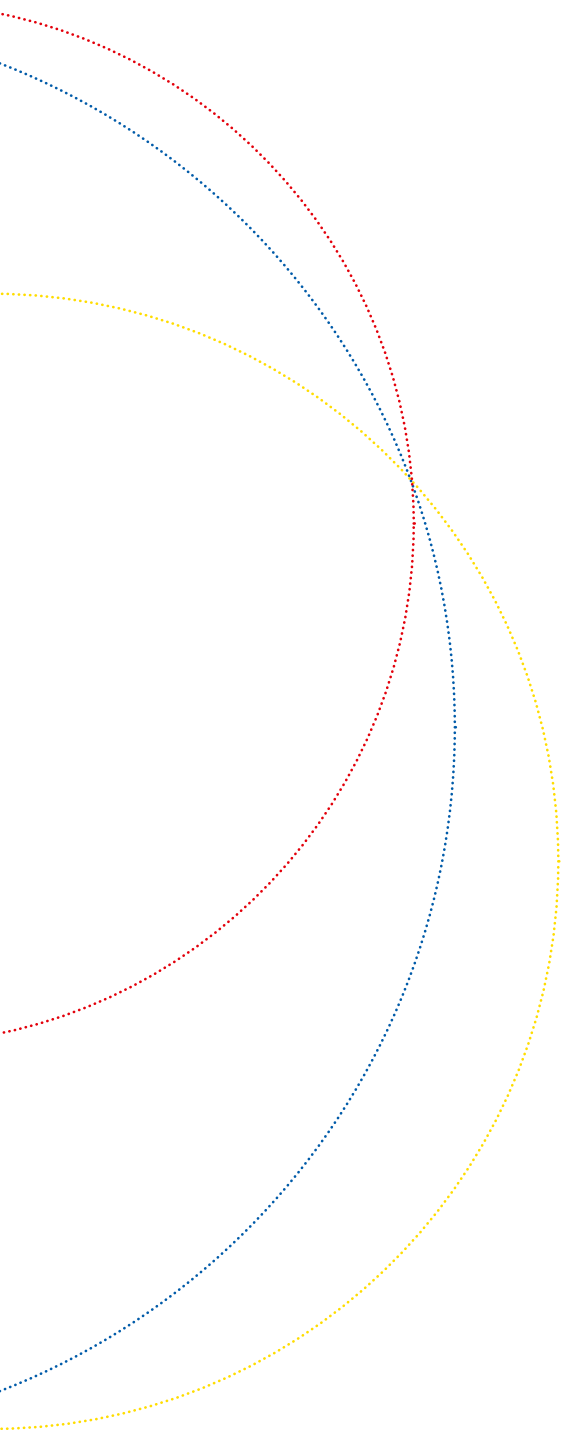
No continent is pushing harder than Europe. In late 2019, Europe adopted the European Green Deal which sets to achieve net zero GHG emissions by 2050 and a 55% GHG emissions reduction by 2030. The European Green Deal, along with the economic recession exacerbated by the unyielding COVID-19 pandemic, required the European Parliament to put forward a recovery plan worth \$1.824 trillion Euros with a big emphasis on sustainability and digitalization. China, the US and the European Union, accounted for 45% of global emissions and 60% of global GDP in 2019. The global pace of policy change on climate change is unknown. The direction is clear.

For Colombia, this global environment creates the context for the next steps regarding transition. For example, Colombia's promotion of energy efficiency and sustainability through renewable purchase obligations should create market conditions to drive improvements and boost reliability in the country's power grid. New fiscal incentives to finance the development of additional solar, wind and storage capacity, as well as streamlining environmental licensing processes, are positive signals to stimulate private investment across the country. Integrating renewable energy into production of oil and gas is another step. For financial markets focused on ESG investing criteria, integrating renewable energy into long term energy plans further underscore the stability and attractiveness of future investments in Colombia.

Indeed, Colombia's actions are about guaranteeing competitiveness in a changing world and creating job security and energy access at home. This will help sustain growth in the coming decades.

Energy access and modernization are also gateways to education, health care, jobs, and prosperity. In a short period, Colombian household's access to electricity has improved significantly. Renewable energy sources in remote areas have pushed the national electrification rate closer to 97%. The increased use of natural gas has allowed households to shift away from burning coal and wood for home cooking, improving health and life expectancy. Meeting the goal of net carbon zero by 2050 -- or even large-scale reduction in anthropomorphic carbon in the atmosphere -- will require breakthroughs and innovations in chemistry, physics and materials science, as well as advances in carbon capture, hydrogen fuel, digitization, manufacturing, artificial intelligence, robotics, software, data analytics and other technologies. Breakthroughs do not occur overnight. They take time -- sometimes decades. They require foresight in policy, new incentives for investment, perseverance in implementation --

and always the discipline to benchmark national action against global trends. Global competition will intensify as nations seek to attract global capital to make real their ambitions to transform their economies and energy systems. Colombia is taking on this challenge.



PUBLIC POLICY: THE GREAT ENERGY TRANSITION ENABLER IN COLOMBIA

Diego Mesa Puyo

Minister of Mines and Energy

The most important sectorial policy of President Duque's administration, and undoubtedly one of the main legacies for future generations of Colombians, is energy transition. The transition has three main objectives: (i) migrating towards a more competitive, efficient and resilient power mix through the massification of variable renewable energy and the adoption of new technologies; (ii) eliminating energy gaps by introducing new business models to accelerate the universalization of electricity and gas nationwide; and (iii) leading the fight against climate change by prioritizing sustainable mobility with the massive adoption of zero and low emission fuels, the use of hybrid and electric vehicles, and energy efficiency policies at residential, commercial and industrial levels.

Before discussing the public policies that have positioned Colombia as a regional leader in energy transition, it is important to highlight two necessary, though insufficient, conditions for this process to have successfully begun in less than four years. First, Colombia's privileged geographic location makes us a world power in renewable energy, both conventional and non-conventional. For example, with 2,360 Km³ of water per year, Colombia is the sixth country in the world with the largest renewable water resources, only surpassed by countries with much greater land extensions such as Brazil, the United States, Canada, Russia and China. Likewise, throughout most of the country, but more significantly in the northern departments of La Guajira and Cesar, Colombia enjoys solar radiation levels and wind speeds that are, respectively, 60% higher and twice as fast as the world average. Secondly, Colombia's political and legal stability, as well as its long tradition of promoting domestic and foreign private investment, are widely recognized internationally. As a result, large domestic and international companies trust our institutions and

regulatory frameworks and are willing to make long-term investments in the country.

Although these conditions have been present in our modern history, and the cost of solar and wind technologies had been falling steeply over the past 20 years, up until 2018 the country was lagging far behind in the incorporation of variable renewable energy. In 2018, hydropower made up about 70% of the electricity generated in a given year, while solar and wind power represented only less than 0.5% of the power matrix. At the time, there were only one wind park located in La Guajira and one solar farm in Valle del Cauca, which totaled approximately 30 megawatts of installed capacity out of more than 17 thousand megawatts of total generation capacity. This striking contrast between the disproportionate participation of hydropower and the insignificance of variable renewable sources was even more surprising considering that Congress had approved Law 1715 in 2014. This law offered tax incentives to promote alternative energy sources and energy efficiency.

In terms of closing energy gaps, the absence of more ambitious policies to achieve universal electricity and gas coverage was also intriguing, especially in the context of a peace process that aimed to close social and economic gaps in the municipalities most affected by violence. And although between 2010 and 2014 close to 67 thousand families were connected to the power grid for the first time, the number of households that did not have access to this service still amounted to more than 496 thousand. In terms of gas, the figures were no more encouraging, as the country still had less than 10 million households with access to gas distribution systems. Finally, progress in electric mobility was almost non-existent and the opportunity for zero and low emission fuels, which were not yet regulated, was considerable.

In August 2018 the diagnosis was clear: there was an urgent need to design and implement public policies and regulatory measures, as well as to eliminate red tape to better exploit our potential in variable renewable energy and accelerate the three energy transition objectives.

At the beginning of their term in office, all administrations present a National Development Plan (NDP) before Congress, which, after being discussed and approved, is signed into law. Therefore, our first step was to introduce incentives and specific measures in the NDP to promote variable renewable energy sources and energy efficiency, including improvements to Law 1715 of 2014. In this regard, three important measures are worth highlighting.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

The first was to extend from 5 to 15 years the term to use the 50% uplift on investments in equipment used for the generation of variable renewable energy and energy efficiency. This extension was important because the five-year uplift contained in Law 1715 was insufficient. New companies or projects funded under project finance schemes were unable to benefit therefrom, as it is practically impossible to generate taxable income in five years, and therefore the benefit was meaningless.

Secondly, in order to eliminate unnecessary red tape and foster the democratization of the use of solar photovoltaic systems, we introduced the automatic VAT exemption for the purchase of solar panels, inverters, and charge controllers. This change represented an important improvement, given that under Law 1715 the exemption could only be accessed after completing a bureaucratic process that required certifying the end use of the equipment. Finally, we included in the NDP a renewable purchase obligation (RPO) whereby 10% of the electricity sold to end users must originate from variable renewable sources.

The second public policy tool introduced by the Government at the end of 2018 was the Finance Act. It focused on providing general incentives for capital-intensive industries, such as the energy sector. In this regard, the following three measures are noteworthy and complement those included in the NDP. First, the gradual decrease of the corporate income tax rate. Secondly, it allowed that VAT paid on the acquisition of fixed assets could be creditable against corporate income tax. In other words, VAT on capital goods was effectively eliminated, as with this measure the VAT levied on these goods simply became an advance payment of the corporate income tax. Finally, a similar treatment to the VAT scheme for fixed capital assets will be applied to other taxes that have proven to discourage investment, such as the industry and commerce tax (ICA for its Spanish acronym).

These laws were complemented with the issuance of other regulatory and administrative acts to strengthen and accelerate the energy transition legal and fiscal frameworks. Of all these measures, four are worth highlighting here. The first, which marked a turning point for the entry of large-scale variable renewable energy projects, was the auction held in October 2019, after a failed attempt in February of the same year. This auction, which awarded 1,365 megawatts, or just over 45 times the installed wind and solar capacity reported in August 2018, was widely recognized domestically and internationally for its substantial public policy innovations. For example, it was the world's first double-sided renewable energy auction, meaning that both sellers and buyers bid on price and quantity. The auction also ushered in a culture of long-term contracts, 15-year PPAs in this case, which was virtually non-existent in Colombia. And perhaps most important, the auction achieved historic low prices, about 35% lower than the prices of energy contracts traded at the time of the auction. A new auction, similar to the one from 2019, was launched in 2021 and it ended up with the successful award of 800 MW of solar projects, which will start operations in January 2023.

The second major initiative was to convene an Energy Transformation Mission, with the participation of more than 20 local and international experts who provided specific recommendations for the modernization of the energy sector. Although the current system has operated successfully for over 25 years, technological changes, the emergence of business opportunities and new users' needs required a comprehensive review. The mission roadmap was published in september 2021 and these recommendations are already being implemented in various areas of the sector, including the structure and competition of the electricity market, decentralization and digitalization, and

a review of the institutional framework. The third major milestone was the successful award of the first large-scale battery energy storage auction in Latin America, a development that combines the needs for expanding the generation capacity and complementary services to the transmission and distribution networks, as well as support for non-conventional renewables. And fourth, but no less important, is the construction of the roadmap and the national hydrogen strategy, which will allow us to position Colombia as a powerhouse in the production of green and blue hydrogen for different applications and with the possibility to export over the next 30 years.

This account of the most representative policies introduced by this administration shows how this set of measures became the great enabler for the energy transition. The results, which I summarize below, speak for themselves. Today, Colombia has variable renewable energy projects - including biomass, biogas and geothermal projects - in operation or in various degrees of execution that will result in 2,000 megawatts of installed capacity by



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

2022 plus about 1,300 megawatts that will be compromised for the following years. This means we will increase their share in the power matrix from less than 0.5% in 2018 to close to 12% in 2022. Furthermore, and this is due in part to the massification of individual solar solutions, by the end of 2021 more than 70,000 families will have access to electricity for the first time, and we will reach 100,000 new homes by 2022. In addition, the inclusion of new business models, such as logistics networks, will allow us to accelerate the universalization of electric power service before 2030. Likewise, before the end of 2021 we will have met the four-year goal of providing natural gas to more than 10.3 million families. To conclude, and thanks to the E-Mobility Law, Colombia positioned itself as the regional leader in electric vehicle sales in 2019, surpassing countries such as Chile and the Dominican Republic. In 2020, and despite the pandemic, we had a growth in sales of hybrids and electric vehicles of over 90%. Additionally, in 2020 we also regulated the use of zero and low-emission fuels and authorized voluntary programs for biofuel blends higher than those provided for in the regulation, thus further improving air quality for all Colombians.

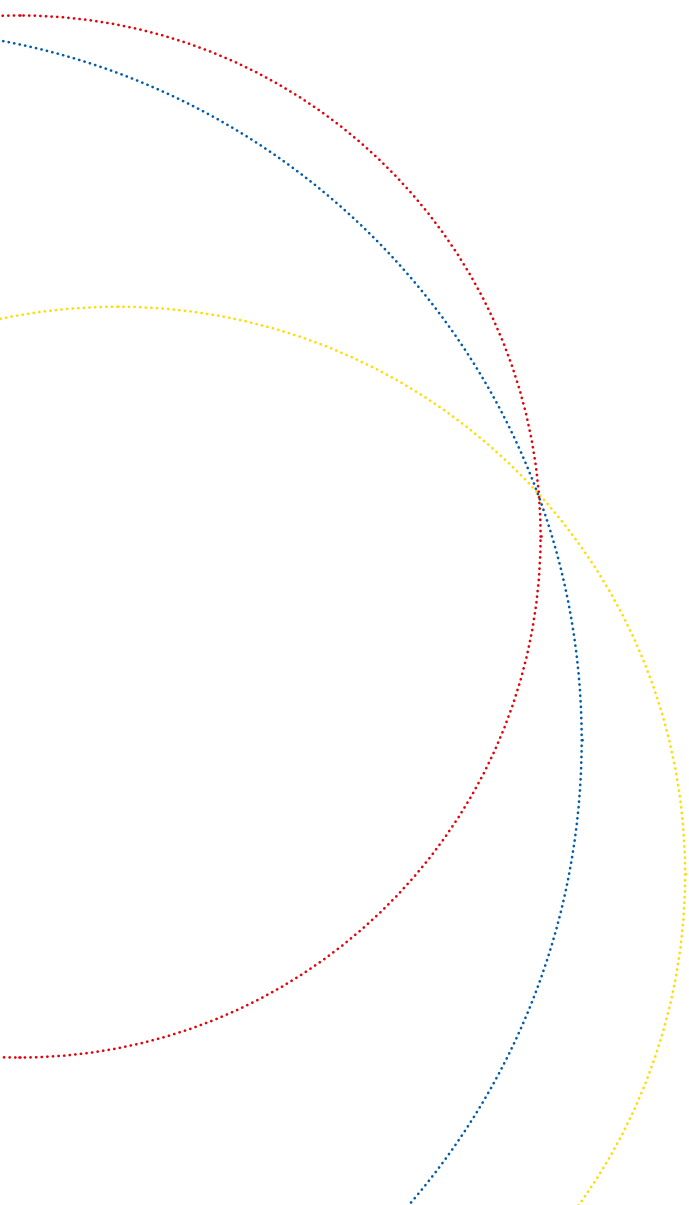
All of these concrete and tangible results have placed Colombia as a global leader in energy transition. According to the World Economic Forum, Colombia is the Latin American country showing the greatest progress towards energy transition: climbing nine positions in the 2020 Energy Transition Index, from 34th to 25th place. After Uruguay, which is ranked 11th, Colombia is the second country in Latin America and the Caribbean to appear in this ranking, surpassing countries such as Chile and Costa Rica. The country also climbed 14 positions in the 2020 World Energy Council's energy sustainability ranking, rising from 49th to the 35th position worldwide, and ranked sixth among Latin American and Caribbean countries.

Moreover, the United Nations invited Colombia, together with Denmark, Brazil, Germany, Spain, India, and the United Kingdom, to be a global champion on Energy Transition in the High-Level Dialogue on Energy under the auspices of the 76th United Nations General Assembly held in 2021. Additionally, at the XI General Assembly of the International Renewable Energy Agency (IRENA), Colombia was elected as a principal Council member for that same year.

We aim to consolidate Colombia's position as a leader in the incorporation of renewable energies in Latin America. For this reason, we decided to guide the definition of a new regional goal for the incorporation of these types of sources,

with the support of Honduras, Guatemala, Haiti, the Dominican Republic, Chile, Ecuador, Costa Rica, Bolivia, Uruguay and Paraguay. Our regional goal, the most ambitious in the world today, is to generate 70% of the electricity we consume in Latin America and the Caribbean from renewable sources by 2030. We will continue to prove our commitment to energy transition through our actions, an unwavering and unprecedented commitment to equity, development and the protection of the environment. We consider this to be our greatest legacy to the generations of today and tomorrow.

The support of entities such as the Inter-American Development Bank will be essential in making this vision a reality. The IDB has proven to be an unconditional partner throughout this energy transition, as well as in the preparation of this book.



Introduction

ENERGY TRANSITION: A GLOBAL REALITY

In October 2020, the International Energy Agency (IEA) published its annual report on the world energy sectorⁱ. The expectation surrounding the report was understandable, given the extraordinary global circumstances: the outbreak of a pandemic that not only caused an acute healthcare crisis, but also a severe recession that affected the wellbeing of millions of people.

Predictably, the multilateral agency reported that the COVID-19 situation had resulted in a 5% contraction in global energy demand, a 7% contraction in carbon dioxide emissions and an 18% contraction in investment in the sector. However, the agency also came to the unexpected conclusion that the impact on renewable energy sources was minimal.

In fact, the IEA predicts that the rate of growth of clean technologies for generating electricity will be very high for the foreseeable future. The estimate is that 90% of the increase in demand over the next two decades will be covered by alternative sources such as solar panels or wind turbines. Such a prediction confirms that the global energy transition is no longer a promise, but a realityⁱⁱ.

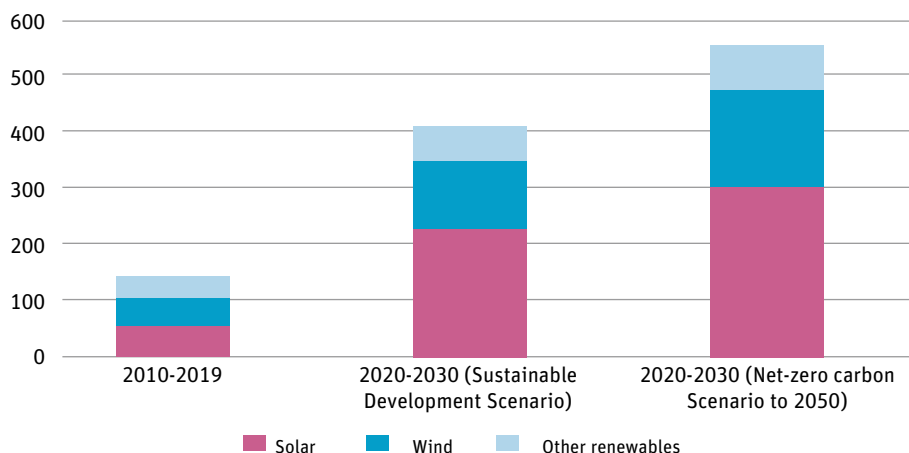
Although there are those who would like to see a speedier evolution, it is undeniable that a transformation process is underway. If things continue as they are, the share of renewable energy in the supply of electrical power could increase from 5% today to 50% by 2050. Part of the reason this is happening lies in the commitments stemming from the Paris Agreement, signed by 196 nations on September 12, 2015, and ratified to date by 190 of its signatoriesⁱⁱⁱ.

The Agreement requires that all parties make individual contributions aimed at significantly reducing each country's greenhouse gas emissions. The commitments made require substantial changes in the model on which a large number of countries based their development during the 20th century. The consumption of fossil fuels, both for energy production and mobility, is being subjected to fundamental changes in favor of cleaner methods with lower environmental impact.

The effort will involve a significant rate of investment. The IEA estimates that USD 1.2 trillion per year, equivalent to almost 1.5% of the global GDP, will be needed over the next few decades to deploy plants and new industrial or service processes to accommodate the new conditions. Despite the magnitude of the challenge, there are reasons to be confident the goals can be reached. From a policy objective standpoint, numerous countries have committed to net zero emissions by 2050 or 2060. Moreover, resources are available to support countless projects. Both public budgets and sources of funding are on the rise. Of particular significance is the fact that large investment funds and the larger commercial banks are including environmental sustainability criteria as a requirement for the approval of operations.

The progress that has already been made must also be underscored. While a few years ago the cost of generating a kilowatt from alternative sources was higher than that of fossil fuels, this is no longer the case. Improvements in efficiency and economies of scale due to the massification of renewable energy have made this new option competitive in terms of price, and even cheaper in certain cases.

Figure 1: Average annual renewable energy capacity (MW) added in the Sustainable Development scenario and the Net-Zero Carbon scenario to 2050.



Source: World Energy Outlook, IEA, 2020

No less important are the advances in the use of hybrid or electric vehicles. As their driving distance improves and charging systems reduce their prices, consumer appetite increases. Estimates suggest that by the beginning of the next decade, more than half of all vehicle sales will be in this category. Here, too, public policies play a role. Several countries have set dates after which the supply of fossil-fuel-powered vehicles will be banned, while most are stricter on emissions from those powered by oil derivatives.

For their part, building regulations have been adapted to achieve greater energy efficiency, especially in buildings that require heating or cooling systems. Although it is impossible to fully eliminate the thermal footprint, the achievements regarding the use of materials or designs that allow for greater insulation or ventilation in periods of low or high temperatures are not negligible. Nor can we ignore the possible advances that may be achieved in all matters related to electricity storage or the use of tools associated with the fourth industrial revolution, such as artificial intelligence, for the design of more energy-efficient systems. The development of clean hydrogen, progress made in biofuels, or carbon capture techniques may give rise to quantitative leaps that will accelerate the energy transition that is already underway.

Sustainable Development Goals - SDGs

In its 2015 General Assembly, the United Nations adopted the 2030 Agenda for Sustainable Development, which comprises 17 core goals, ranging from the elimination of extreme poverty to equality for women and fighting climate change.^{iv} The seventh goal is “*affordable and clean energy*”, which includes “*ensuring access to affordable, reliable, sustainable and modern energy services*” and significantly increasing the share of renewable energy in the energy mix.

The most recent assessment is not entirely encouraging.^v The data prepared prior to the outbreak of the pandemic provide a very mixed outlook. Significant progress has been made, but the pace of progress is not ideal to reach the ambitious goals set.

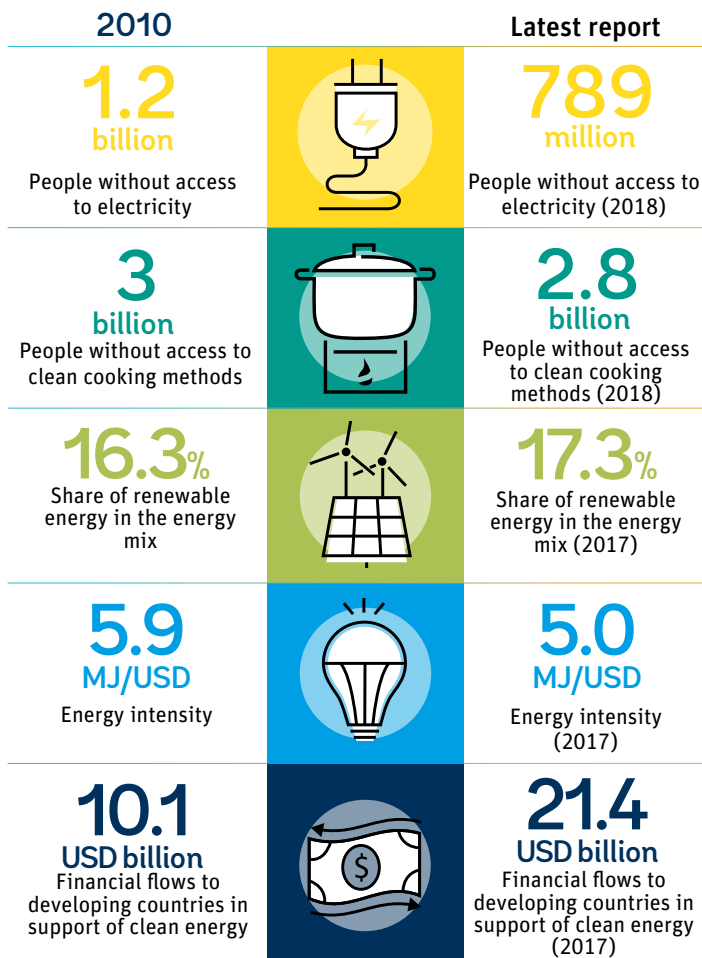
Some of these difficulties are associated with inequalities between regions. For example, while about 90% of the world’s population has access to electrical power, considering the population growth rates observed leads to the conclusion that by 2030, 620 million people would not have access to this service, 85% of whom would be located in sub-Saharan Africa. Even more complex is access to clean cooking fuels and technologies, which remain inaccessible for 2.8 billion people.

In turn, the share of renewable energy in total consumption has been increasing faster than the demand for this service. In terms of electricity generation, the share rose to almost 25%, thanks to dynamics in solar and wind technologies.

Here too, there are significant variances between different parts of the world. Part of the explanation is that the evolution towards cleaner systems will result in a group of winners and losers, the latter being those who are most dependent on hydrocarbons or those who fail to redirect their strategies in a timely manner.

In any case, it is clear that this segment exhibits a great vitality. By 2018, a total of 106 countries had conducted auctions aimed at increasing their renewable energy sources, impacting in turn the labor market. The number of jobs in the sector increased from 7.3 to 11.5 million between 2012 and 2019. Moreover, it could triple by 2030 according to estimates made by the International Renewable Energy Agency (IRENA).

Figure 2- SDG tracking



Source: United Nation's SDGs

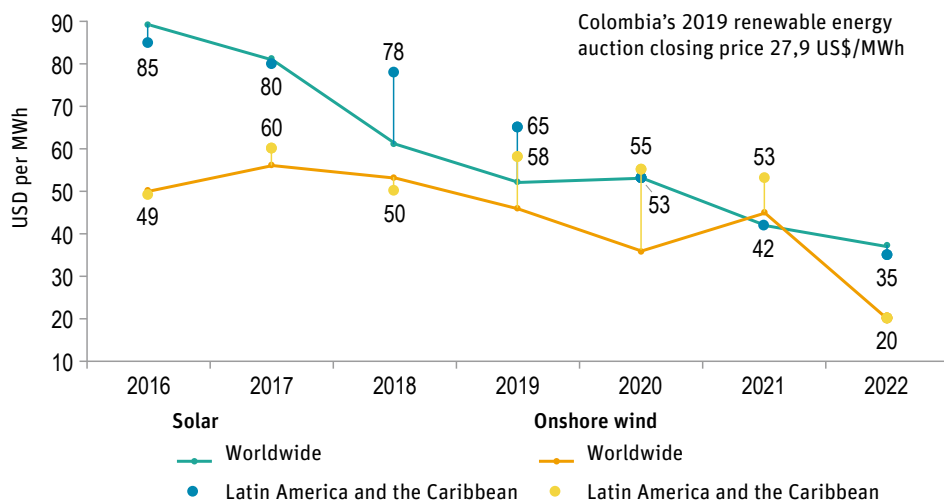
Latin America's response

Compared to other regions, Latin America has had the cleanest energy matrix in the developing world.^{vi} The reason is none other than the presence of hydroelectric plants, which in 2018 accounted for 58 % of total supply, according to calculations by the Latin American Energy Organization (OLADE for its Spanish acronym). However, the future development of projects of this type is limited on account of environmental regulations and the impact on communities. That is a key reason why expansion depends on the adoption of non-conventional renewable sources (NCRE); sources that were almost non-existent at the beginning of the century, but have increased their presence during the past decade and by 2018 accounted for 6% of the total basket.

Geographic and natural conditions favor the region, especially in relation to solar and wind energy generation. The potential is so great that it could fully cover its current needs with these alternatives. This advantage has been exploited through the use of market mechanisms such as auctions, whose prices are among the lowest in the world. Even so, and as in other latitudes, the issue of storage, without which a constant supply cannot be assured, has yet to be resolved.

On the other hand, Latin American countries have a long way to go in terms of digitalization and decentralization, which will increasingly become two of the most significant forces in the sector. The modernization of regulatory frameworks and institutional development are some of the most important challenges and will determine the possibility of advancing with the required investments and the timely entry of new technologies. In addition to resources, a sound oversight framework is essential, one that prevents excesses and at the same time is able to adapt over time. Only in this manner will this part of the world maintain the leading position it currently holds, in an effort to benefit consumers whose demand should increase, beyond the effects caused by the pandemic.

Figure 3. Evolution of wind and solar energy costs, worldwide and in Latin America and the Caribbean



Source: From Structures to Services, the Path to Better Infrastructure in Latin America and the Caribbean. Inter-American Development Bank

A different future

In the midst of the uncertain outlook brought about by the COVID-19 pandemic, it is possible to affirm that a substantial reorganization of the energy generation and consumption model that began with the industrial revolution is underway. This shift could be described via the replacement of carbon by electrons, which will have a profound impact across all five continents, both from an economic standpoint, as well as in terms of investment flows or geopolitics.

This also poses a globalization scenario in electricity sales as a result of the development of transmission lines that can be extended over thousands of kilometers to meet a specific buyer's needs. This vision is complemented by the participation of companies and individuals, creating a two-way relationship: sale of surpluses and acquisition of shortages in an increasingly interconnected network.

All this will occur on a planet that is consuming the greatest amount of energy in its history. Not only will the population continue to grow to nearly eleven billion people by the end of the 21st century,^{vii} but average income will continue to rise once the health crisis is over, and with it the tendency to use more electricity.

Whether for cooking, heating or cooling a home, working remotely or moving around, world population will increasingly depend on readily available energy. This will also be key to making nations more or less competitive, and therefore it is essential to examine the comparative advantages and regulations that may hinder or encourage a transition that is likely to be much faster in the coming years.

Understanding the future requires adopting different strategies, including the gradual replacement of traditional and polluting sources, as well as keeping abreast of technological advances. For example, coal has a great opportunity in the development of cleaner alternatives such as blue hydrogen. There is much speculation about what will happen in the years to come, and no one can say with certainty that they have all the answers. Still, it is safe to suggest that the world of the next decade will be so different in terms of energy that solar panels and wind turbines, among other options, could replace the thermoelectric power plants of yesteryear.

Like any process, there will be winners and there will be losers. The condition to be among the former begins with looking to the future with open eyes and minds in order to identify new opportunities and to understand that there is no turning back from the evolution that has already begun.

Colombia's role

Colombia, which played a leading role in the deliberations prior to the pact reached within the framework of the World Summit on Climate Change in Paris (COP21), is not only a signatory to the pact, but has also incorporated into its legislation and policies the determinations to reduce its greenhouse gas emissions, in addition to having a mostly clean electrical energy matrix.

By 2030, there is a commitment to reduce greenhouse gas emissions by 51%. In this regard, the mining and energy sector is at the forefront of implementing



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

a comprehensive climate change management plan, with which it plans to reduce the equivalent of 11.2 million tons of carbon dioxide by the same date.

Achieving the proposed objectives requires a decisive strategy that involves diversifying the energy matrix, reducing the high dependence on fossil fuels, increasing the participation of renewable sources and promoting the use of cleaner technologies. This is precisely what President Iván Duque Márquez's administration has been doing through a set of actions that include the adoption of policies, new schemes and concrete results regarding the development of non-conventional renewable sources, and the gradual transition from fossil fuels used in generation and transportation to renewable sources, complemented with the modernization and digitalization of the sector.

The purpose of this document is to describe these advances, which could well be called one of the most significant legacies of the current administration. Aside from taking advantage of the optimal natural conditions existing across

parts of the country in terms of solar radiation or wind, what is most remarkable is the concrete implementation of plans that some time ago would have been described as unrealistic.

Thanks to a modern regulatory framework, innovative market mechanisms and strong political will, by 2022 Colombians will have a diverse generation portfolio with 2000 megawatts of installed capacity derived from non-conventional renewable sources. That amount is more than nine times the current 2020 installed capacity, and is constantly increasing. When projects that will be under construction in 2022 are included, this amount increases to over 3,000 megawatts, equivalent to more than 12% of the country's energy matrix.

The efforts made in terms of energy transition go beyond the inclusion of renewable energy in the power matrix. To this end, several strategies have been



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

pursued, which will be further explained below, including the diversification of fuels in the energy matrix, the promotion of zero or low-emission fuels, sustainable mobility, opportunities for the incorporation of clean hydrogen options, digitalization and the efforts to reach remote areas in order to provide service to those households that do not have access to the electrical interconnection system.

Said progress will allow us to not only meet the commitments made within the framework of COP21, but also those set within the Sustainable Development Goals for 2030. Continuing along this path will allow Colombia to benefit from a more reliable architecture, which will not only serve to place the user at the center of the transformation, but also to close gaps and open new opportunities for further progress.

This effort is an essential part of a more sustainable recovery strategy, which is key to mitigating the damage wrought on employment and social welfare by the pandemic. Moving forward on the energy transition path will serve the dual purpose of building a cleaner energy matrix and driving growth in a responsible manner.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

CHAPTER 1

President Duque's policy on energy transition

Building on what already existed and improving the quality of past decisions to ensure and implement the undertakings that make energy transition a reality. This defines in a single sentence the policy adopted by the current administration, which includes not only regulatory adjustments, but also clear objectives that are expressed through tangible progress.

The conviction that Colombia needed to accelerate the process towards a more sustainable energy matrix dates back to the electoral campaign that carried Iván Duque to the Presidency of the Republic. When the National Development Plan was issued, the matter received special attention and was recorded as one of the key objectives of his government. In a process such as this, it pays to lead by example. Not only does the country consider that there is a shared responsibility among all nations to avoid the worst scenarios that would come about as a result of global warming, but it is also convinced that it is possible to prove with facts that evolution is likely and economically justifiable.

In 2014, prior to the beginning of this administration, Law 1715 was issued, whereby a regulatory framework was created which could be described as the first major step towards the country's energy transition. The regulation provided guidelines to eliminate economic, technical and market barriers encountered by new technologies, in addition to creating the concepts of Energy Efficiency and Sustainable Development, which are some of the strategy's guiding principles.

It is worth noting that the Law also defined self-generation, cogeneration and distributed generation, opening the door for users to access non-conventional sources to generate part of their consumption, thus contributing to the

reduction of the sector's carbon footprint, the electrical power grid congestion and the promotion of energy efficiency. In accordance with the established guidelines, the Energy and Gas Regulatory Commission (CREG for its Spanish acronym) issued a series of resolutions in this regard.^{viii}

In addition, the Non-Conventional Energy and Efficient Energy Management Fund (FENOGÉ for its Spanish acronym) was created to finance these projects, and, at the same time, economic incentives for the development of non-conventional energies were established, such as an exemption from customs duties and VAT, a 50% uplift on investments against income tax for five years and accelerated depreciation of assets when purchasing equipment, machinery or services used in non-conventional renewable sources or efficient energy management projects.

Subsequently, public policy guidelines were identified to define and implement a mechanism to encourage long-term contracting for electricity generation projects, with the following objectives:^{ix}

- i. Strengthen the resilience of the energy matrix against climate change and variability events through risk diversification.
- ii. Foster competition and increase pricing efficiency through long-term contracting of new and/or existing electric power generation projects.
- iii. Mitigate the effects of climate change and variability by taking advantage of the potential and complementarity of available renewable energy resources to manage the servicing risk of future electricity demand.
- iv. Foster sustainable economic development and strengthen regional energy security.
- v. Reduce greenhouse gas emissions from the electricity generation sector in accordance with the commitments made by Colombia at the COP21.

Additional adjustments

A review of the first draft of regulations revealed that further revision and improvements were essential to rapidly deploy potential projects. Consequently, it was possible to construct a modern regulatory framework that led to tangible results in terms of entrepreneurship.

Such was the case of Law 1955 of 2019, which adopted the National Development Plan of the current four-year term, designated “*Pact for Colombia, Pact for Equity*”. This improved the tax incentives established by Law 1715, extending the uplift against corporate income tax to 15 years, in addition to creating an automatic VAT exemption for solar panels and their controllers and inverters, without any additional procedure required to receive this benefit. In addition, it was established that between 8% and 10% of the purchases made by retailers in the wholesale energy market must originate from long-term contracts with non-conventional renewable energy plants in order to advance towards a complementary and resilient energy matrix committed to the reduction of carbon emissions.

At the same time, an auction policy was developed, which included the first “two-sided” process in the world, aimed at combining a supply and demand bidding process. It is worth noting that lessons were learned from a first unsuccessful trial.

Another important effort was the measures taken to cut red tape. For example, Decree 2462 of 2018 determined that generation projects that use solar, wind, tidal, geothermal or biomass energy sources of less than ten megawatts do not require an Environmental Alternatives Diagnosis (DAA for its Spanish acronym) as a requirement for their operation, unlike generation projects using conventional technologies. Also, the Anti-Bureaucracy Decree (Decree 2106 of 2019) included two articles aimed at expediting the obtention of tax incentives for non-conventional renewable sources. And recently, the Energy Transition Law (Law 2099 of 2021) declared that transmission lines will be exempted of the Environmental Diagnosis Analysis requirement.

Subsequently, the Economic Growth Law established a gradual reduction of the income tax rate, as well as the possibility of crediting the VAT paid on the acquisition of capital goods against the income tax, which benefits the promoters of generation projects and, in general, companies in the electricity sector.

Likewise, with the aim of facilitating and modernizing the process of connecting generators, guidelines were established for assigning transportation capacity to generators that connect to the National Interconnected System (SIN for its Spanish acronym).^x Barriers to accessing the network were also eliminated by specifying an expiration for the connection permit given to generators that failed to comply with the requirements within the established deadlines, promoting efficiency in the use of the available networks and defining criteria for prioritizing connection access projects.

As part of the initiative to involve new technologies, the first breakthroughs have been made in the development of large-scale energy storage systems, and in 2021 Colombia successfully awarded the first auction in Latin America to implement a battery system of more than 45 megawatts, in order to reinforce the national transmission network in the department of Atlántico. Similarly, Decree 099 of 2021 was issued, which allows Network Operators to expand coverage within their areas of influence through non-physical or logistical networks, such as individual solar solutions or micro-networks, which will help close gaps in the access to electricity services in rural areas.

And the work is not over. In 2020, the Ministry of Mines and Energy published a Draft Decree “Whereby provisions are established to develop activities oriented to the generation of electricity through geothermal energy” that sets out the requirements for the exploration and exploitation of this resource with a view to generating electricity. During 2021, the government will continue working to issue the final version of this regulatory project. On the other hand, CREG will issue regulations whose drafts have already been published, which include advanced metering strategies, updating the network code and opportunities for user participation in the power market.^{xi} In addition, the roadmap for hydrogen is being developed, which will be discussed in detail in Chapter 9 herein.

In the following years, decisions will be made that will complement what has been done so far, with the conviction that our international commitments will be fulfilled, thereby fostering a better quality of life for Colombians. Many of the changes that will occur will be related to the contributions offered by the Energy Transformation Mission, which conducted a serious study of the regulations and proposed far-reaching corrective measures.

Ultimately, the improvements enable goals such as reaching remote areas or encouraging e-mobility, issues that will be further developed throughout this document. Therefore, our nation with its 50 million inhabitants is making a significant contribution to the collective goal of restraining global warming, while moving forward in the search for equity and unlocking opportunities for investment and progress.

Tangible breakthroughs

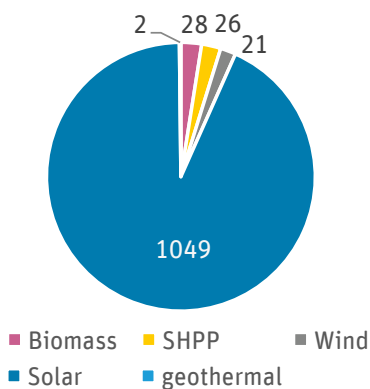
The favorable combination of a modern and competitive legal framework, along with a reduction in the cost of available technology, has allowed Colombia to make a rapid leap in the development of clean energy. This is evidenced by the number of initiatives that will be delivered before the end of 2022, soon adding thereto the numerous projects already under construction. If we augment this list with the large and small hydroelectric power plants, both existing and under construction, we can affirm that the country will have a solid and sustainable energy matrix. This is why international rankings distinguish Colombia as a benchmark, given its ability to take advantage of the natural conditions and issue regulations that encourage both investment and innovation.

These ground rules encouraged investment in energy efficiency projects and non-conventional renewable energy sources that were key to the realization of energy transition in the country. According to the Mining and Energy Planning Unit (UPME for its Spanish acronym) database, which is the entity responsible for certifying projects eligible for the tax benefits established in Law 1715, 1,126 certificates have been issued since 2018 endorsing projects that use non-conventional energy sources (NCREs) and 327 certificates for energy efficiency (EE) projects.

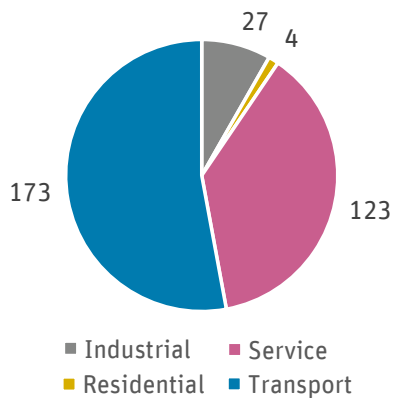
Furthermore, since 2018, a VAT discount has been endorsed for close to 1.1 trillion pesos, of which 417 billion correspond to non-conventional projects and 695 billion to energy efficiency projects. The above is directly related to investments of approximately 2.5 trillion pesos in the former and 4.5 trillion pesos in the latter.

Figure 4. Number of Certificates issued by UPME since 2018, for tax benefits associated with Law 1715 of 2014

Certificates issued by source - NCRE



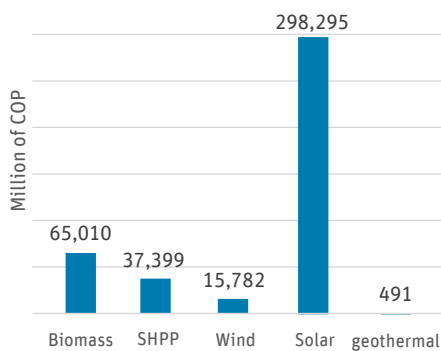
EE Certificates issued by sector



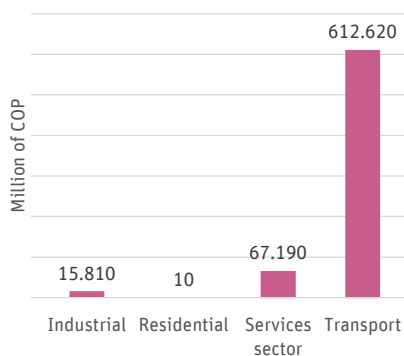
* Small Hydro Power Plants
Source: Upme, September 2021

Figure 5. VAT endorsed by UPME since 2018

Endorsed VAT - NCRE

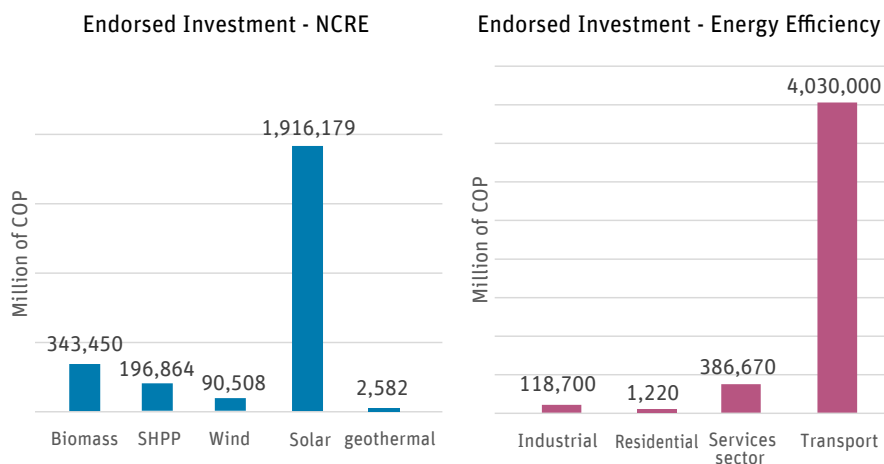


Endorsed VAT - Energy Efficiency



* Small Hydro Power Plants
Source: Upme, September 2021

Figure 6. Investment endorsed by the UPME since 2018

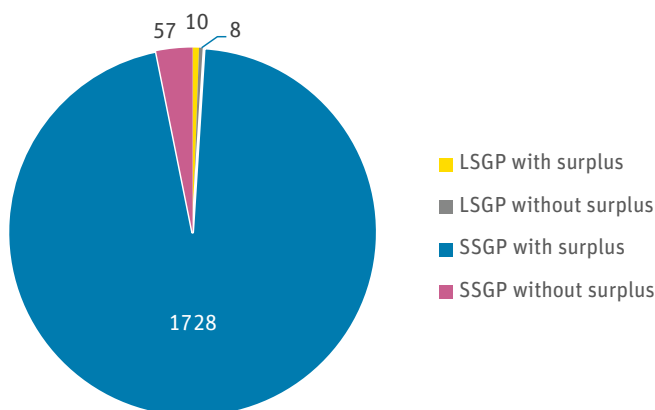


* Small Hydro Power Plants

Source: Upme, September 2021

Moreover, since 2018, 1,803 large-scale (LSGP) and small-scale (SSGP) self-generation projects have been approved, of which 98.6% are solar. The installed power for these initiatives is 337 megawatts and the power available for surplus delivery to the network is 89.7 megawatts.

Figure 7. Number of self-generation projects in operation or approved for connection since 2018



Source: Upme, December 2020

An essential policy element: gender equality

The World Economic Forum's Global Gender Gap Report 2020 ranks Colombia 22nd out of 153 countries in the global gender gap index. Although the country is near the top of the list, it still has a long way to go. In March 2019, with support from the Inter-American Development Bank, the roadmap for the construction of sectoral guidelines to address this issue was presented and during the course of the year several roundtables were held in different regions, with the participation of representatives from women's organizations, unions, companies, academia, and local authorities. The objective was to gather feedback and views on gender equality issues in the sector, as well as proposals for action. The main conclusions derived from this exercise showed that female employment is different for each subsector. The presence of women is higher in the electrical power subsector, followed by hydrocarbons and, finally, mining.

In March 2020, the gender guidelines for the mining and energy sector were presented, with the purpose of creating a "framework for action that allows the mining and energy sector to foster, strengthen and articulate initiatives that focus on gender from a labor and community standpoint, as well as to promote its inclusion in sector planning and project implementation." This is the first exercise in Latin America aimed at fostering, strengthening and articulating gender equality initiatives in the mining and energy sector; it includes 29 indicators and suggested targets. The guidelines in question seek to:

- Increase the number of women employed in the sector (in direct/indirect jobs, decision-making positions, community participation scenarios and the value chain) through actions that foster gender equality. This not only responds to the legitimate right to equality, but also to the need to increase the skilled labor required by the industry and build a business case leading to greater diversity for the sustainability of the sector.
- Foster proposals aimed at cultural transformation for gender equality in the sector, promoting measures for work-life balance; communicative and pedagogical strategies that contribute to the pro-

gressive modification of a culture free from sexism, and furthering responsible male behaviors, among others.

- Articulate and coordinate differentiated actions for the sector in an inter-institutional and inter-sectoral manner, such as: creating alliances with academia, national and local entities, and the mining and energy industry in order for more women to pursue sector-related careers, as well as promoting the integration of a gender approach in sectoral planning, in the Ministry's project framework and mission actions, and in those of its affiliated entities.
- Prevent all types of violence against women in the industry and its surrounding communities, sharing information on the prevention and attention mechanisms available for people who report cases of abuse within the workplace and community environments.

Within the implementation framework, two organizations, Insuco and CoreWoman, launched a multi-stakeholder (public-private) collaboration scheme called "Energy that transforms: Mining-Energy Alliance for Gender Equality". This collaboration involves 34 companies from the three sub-sectors and 11 trade associations. The general objective is to involve trade associations and companies in the implementation of the guidelines, through the definition of priorities, the establishment of goals, and the management of information relating to good practices and lessons learned. In addition, focused technical assistance was provided to three companies and two trade associations in the preparation and implementation of their Gender Action Strategies.

Change starts at home: the Ministry of Mines and Energy's cultural transformation

One of the key goals set by the Ministry of Mines and Energy was the comprehensive transformation of the sector. This includes several cornerstones, one of which is culture. At the beginning of this administration, adjustments were designed to align with the strategic mission goals and to leverage and overcome the challenges of the country's energy and mining transition.

The Ministry's transformation includes the following elements: processes, leadership, transparency, strategy and digital integration. Each of these includes short and medium-term goals aimed towards achieving a scenario where, from an administrative point of view, the institution's skills and capabilities are strengthened. In particular, from the culture standpoint, a higher purpose exercise was conducted, which began with a change of mindset and set forth the guidelines for employee behavior, using the slogan "We are a source of energy that drives the country's progress and transforms lives" as its key message.

Additionally, an appropriation of values exercise was conducted, based on an acrostic of the word SIENTO (I FEEL): Service, Integrity and Transparency, Excellence and Commitment, Our People, Collaborative Work and Results Orientation. These values are tied to the desired culture, which is based on elements such as Principles, Sustainability, Citizenship, Innovation, Achievement, Leadership, Talent, Relationships and Communication. Both the values and the dimensions of the desired culture have been the cornerstones of various strategic initiatives developed within the Ministry.

The Cultural Transformation Plan has created an opportunity to drive the country's progress on the basis of public sector officials' ability to lead a work structure based on trust, performance, humanization and results. It has also been an opportunity to strengthen commitment and excellence, delivering a better service to all Colombians. The Ministry of Mines and Energy has understood the challenges posed by a cultural transformation. To this end, it continues to work towards closing the gaps between the existing culture and the desired culture. Among the victories and breakthroughs achieved in this transformation is an evident change in the service mindset of civil servants, good corporate practices have been reinforced, as well as excellence, attention to detail, a results-orientated approach, improvement in collaborative work, appropriation of digital tools for decision making, and improvement and efficiency in internal processes.

These victories in terms of internal culture have allowed the ministry to develop better capabilities as an institution and as individuals, in an effort to achieve a transformation in the energy and mining sector that helps drive the country's progress and shapes the lives of the society. During 2021, the Ministry of Mines and Energy will continue to make progress in strengthening the competencies and skills of its leaders, further developing the performance management model and actions to enhance the commitment of all its employees.

LAW 2099 2021: ENERGY TRANSITION LAW

Consolidating the energy transition and promoting sustainable recovery post COVID 19, the Colombian government sanctioned the energy transition law. This law has the objective of closing gaps, boost equality, and continue promoting key transition elements such as electric mobility and new renewable energies and energy carriers.

In terms of tax incentives, the law extends the benefits of law 1715 of 2014 to investments in new sources of renewable energy, smart metering equipment, and new energy vectors such as hydrogen. Through this law green hydrogen is defined as a non-conventional renewable energy source and blue hydrogen as a non-conventional energy source. Furthermore, incentives to promote carbon capture and storage are established and a national registry for geothermal projects is created as a reference for the due control of this resource and a means to improve knowledge about the subsoil and the country's geothermal potential.

Other measures are adopted to simplify the recognition of these incentives designating UPME as the only competent state agency for the evaluation and certification of projects; promoting solar self-generation in public buildings, especially in education and health; facilitate the participation of territorial entities - departments and municipalities in alternative energy projects; modernization of the gas subsidy regime; strengthen the Fund for Renewable Energies and Energy efficiency management (FENOGE) as a financial vehicle with the capacity and resources to finance energy transition.

Finally, the clean product seal is created, this certification will be awarded to companies that use only renewable energy and invest in efficient energy management, contributing to the reduction of greenhouse gas emissions, guiding users towards a clean and environmentally sustainable consumption.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

CHAPTER 2

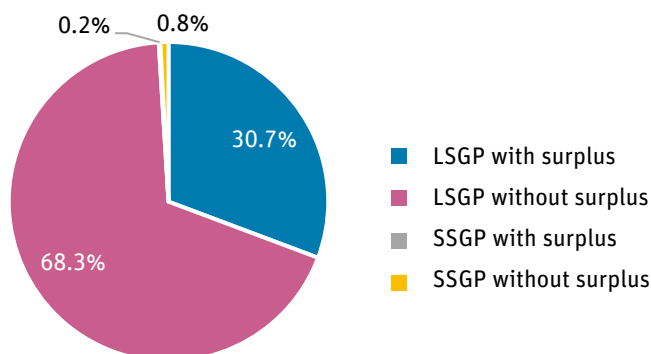
Auctions: the ideal mechanism to incorporate renewable energies

Due to the conditions of its geography and the wealth of its rivers, Colombia's energy generation matrix has depended mostly on water resources and, to a lesser extent, on fossil fuels for thermoelectric generation. This positions it among the cleanest power systems in the world, even though there are vulnerabilities associated with climate variability occurrences such as the El Niño event, which impacts precipitation patterns, river flows and reservoir capacities.

Until 2018, installed capacity of non-conventional renewable energy accounted for a very small percentage of the national total. The figures are self-evident: of the 17.3 gigawatts installed in Colombia for the aforementioned year, less than 30 megawatts fell into this category. This is despite the great potential noted in certain areas of the country. To cite a specific case, and according to the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM for its Spanish acronym), in La Guajira the wind speed is double the world average, reaching a speed of 9 m/s at 80 meters above sea level, while solar radiation in that department is 60% higher than the world average.

Although electricity generated from hydropower falls into the renewable category, the Colombian energy generation system has faced critical situations. The worsening of drought periods as a result of the presence of the El Niño event (which is expressed by a rise in temperatures in an area of the Pacific Ocean), has jeopardized the continuity of service on several occasions over the last 30 years. In these cases, thermal plants are called upon to assume a greater weight in the supply of kilowatt-hours, despite the fact that this option entails higher costs and greater pollution.

Figure 8. Installed capacity share by resource as of 2018



LSGP, large scale generation projects
SSGP, small scale generation projects

Source: Own elaboration based on data from XM

The fundamental mechanism for expanding system capacity is the Reliability Charge (RC), which, through an auction, assigns Firm Energy Obligations (FEO) to new and ongoing projects in order to compensate the availability of plants to generate energy at the most critical hydrological moment, thus guaranteeing the reliability of the service. The model has allowed bidders to receive a stable income, rendering the operation financially viable, consequently strengthening supply by providing a sufficient backup to overcome periods characterized by water shortages.

According to the methodology used to calculate FEO for each technology, resources such as solar and wind do not contribute significantly to reliability due to their variability and intermittency. However, it is increasingly accepted that these options have a great potential to increase the flexibility and resilience of energy generation due to their ability to complement water resources, because sun and wind are abundant in times of drought. Besides, the resilience provided by this sources is potentiated when combined with storage systems.

Despite the above, until the middle of the last decade there were no mechanisms to encourage new technologies to enter the market. An almost insurmountable barrier to the realization of renewable energy projects was that bilateral energy purchase contracts did not have the necessary duration to obtain credit and render the projects financially viable.

Law 1715 of 2014 represented a major first step towards altering this situation. Even so, the regulatory development took time and examining successful experiences in other latitudes was essential, as well as listening to the observations of industry experts.

A strategy that favors renewable energies

The development of renewable energy was a priority during Iván Duque's presidential campaign, and consequently, once his administration began, the goal was to translate the adopted legal frameworks into concrete actions. The purpose was none other than to diversify the energy matrix by fostering projects based on non-conventional renewable sources.

Once the comparison of available Firm Energy Obligations and projected electricity consumption according to UPME's "High Demand" scenario was made, on February 28, 2019, a Reliability Charge auction was held with the goal of assigning enforceable Firm Energy Obligations as of December 1st, 2022.^{xii} This auction marked a milestone in the history of the Reliability Charge as it was the first auction of this type to allocate Firm Energy Obligations to non-conventional renewable plants. As a result, Firm Energy Obligations were allocated for 164.33 GWh/day, equivalent to an additional net effective capacity of 4,010 megawatts, of which 1,160 megawatts are wind and 238 megawatts are solar, with this being the first time that non-conventional plants participated and were awarded contracts under this type of mechanism, competing directly with traditional energy sources (hydro, gas, coal and liquid fuels).

Furthermore, in an effort to counteract the vulnerability generated by a non-diverse matrix and as a tool to mitigate the effects of climate change on the system, a joint effort was undertaken to develop a mechanism that would allow the installation of Non-Conventional Renewable Energy projects, allowing them to sell their energy by means of long-term contracts that would consider the generation curve of each technology. Thus, a long-term contract auction was designed to value the benefits of renewable sources for the system and allow them to attain financial viability. The objectives that governed the process were as follows:

- Diversify the energy generation matrix by encouraging the incorporation of new technologies and energy sources, particularly clean and renewable energy.
- Tap the potential of renewable resources available in the country, such as biomass, solar radiation and wind. According to UPME's atlases for each of these resources, the department of La Guajira offers significant potential for the development of wind energy as a result of its wind speed. Likewise, the north and eastern part of the country have strong solar potential, and throughout the territory in many departments there is potential for generation from biomass.
- Increase the resilience of the power system by taking advantage of the complementarity of solar and wind renewable sources with the country's hydrology.
- Foster investment in renewable generation projects, which generates jobs for Colombians and allows the areas where the projects will be installed to boost local economic growth.
- Achieve all of the above at competitive energy prices, lower than those of traditional bilateral contracts.

In early 2019, the first two-sided auction was held. However the call for bids was declared void because the competition and dominance criteria established by the regulator were not met.

The main issue identified for this auction was the low participation of demand, which was not surprising given the lack of interest of the incumbent industry companies, especially those with a presence in both the generation and retail segments of the market. A valid criticism is that the product to be auctioned was a physical product, under the pay-as-bid modality, in a market where financial contracts under the pay-as-you-go modality prevailed. Other difficulties encountered included the fact that some participants did not obtain a bid bond, there were courier logistics issues since the documents were required in physical form, there were errors in the participants' corrections to the requirements, and some did not meet the minimum qualification threshold. In addition, mistakes were detected in some of the participants' bidding strategies due to the complexity of the methodology. Based on these lessons learned, adjustments were made to the mechanism through a joint effort between the agents, the Ministry of Mines and Energy, UPME and CREG. A financial product was proposed, which gave greater assurance to the demand, needs for improvement were identified in the qualification criteria to participate in

the auction, in the competition criteria, in the guarantee structures and in the participation of the demand. In addition, problem-solving and value mapping techniques were applied in order to obtain a functional auction design.

As a result of this work, a new auction mechanism was designed, with balanced rules to guarantee the financial viability of the projects and adequate contracting conditions for demand. In addition, there was constant communication with agents, which included workshops and training sessions in various departments to explain how the mechanism works and its requirements, address misgivings, listen to feedback and take their opinions into account. Thus, adjustments were made for the second auction of long-term contracts, which took place in October 2019.^{xiii} The differences between the first and the second attempt are summarized in the following table:

Long-term contracts auction February 2019	Long-term contracts auction October 2019
Any technology that complies with the minimum classification criteria could participate	Exclusive auction for NCREs. No classification criteria were established
Projects with capacity greater than or equal to 10 MW	Projects with capacity greater than or equal to 5 MW
Average annual energy	Energy by hourly blocks
Physical contract – pay-as-you-bid	Financial contract – pay-as-you-go
The seller could not hedge its obligations using other market mechanisms	The seller could hedge its obligations using other market mechanisms
Price set in COP updated against the PPI*	Price set in COP updated against the PPI*
Obligation enforceable as of December 1st, 2021	Obligation enforceable as of January 1, 2022
Term of contract: 12 years	Term of contract: 15 years

*Producer price index

Source: Ministry of Mines and Energy

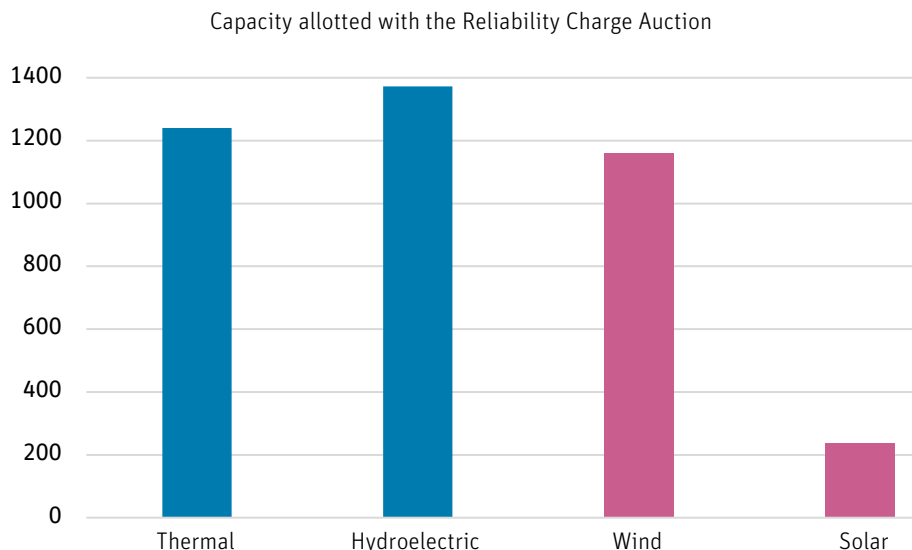
It is worth noting that the auction was innovative because of its two-sided design, i.e., both, generators and buyers participated with offers for quantities and prices, making it the first auction of its kind in the world. In addition, the resulting contracts were organized according to time slots for the delivery of energy, matching the times when there is more solar radiation or more wind, allowing the demand to acquire energy at different prices for each one. Some of the most significant general elements that enabled a favorable result were the following:

- Exclusion of the Environmental Alternatives Diagnosis requirement for wind, solar, geothermal and tidal projects and for biomass projects under 10 megawatts (Decree 2462 of 2018).
- Automatic application of VAT exemption for the purchase of solar panels, and related inverters and controllers (National Development Plan 2018 - 2022).
- Requirement that between 8% and 10% of the purchases made by retailers originate from renewable sources (National Development Plan 2018 - 2022).
- Extension of the uplift on income tax to 15 years for investments, as established in Law 1715 (National Development Plan 2018 - 2022).

Current snapshot

As previously mentioned, the Reliability Charge auction marked a historic milestone by awarding for the first time, reliability obligations to renewable energy power plants. The auction closed at USD \$15.1/megawatt-hour and allocated 2.51 gigawatt-hours/day of Firm Energy Obligations to wind farms and 0.76 gigawatt-hours/day to solar farms. Firm Energy Obligations were allocated for eight non-conventional renewable projects, three of which were also awarded obligations in the long-term contract auction.

Figure 9. Additional installed capacity (MW) in the system as a result of the Reliability Charge auction

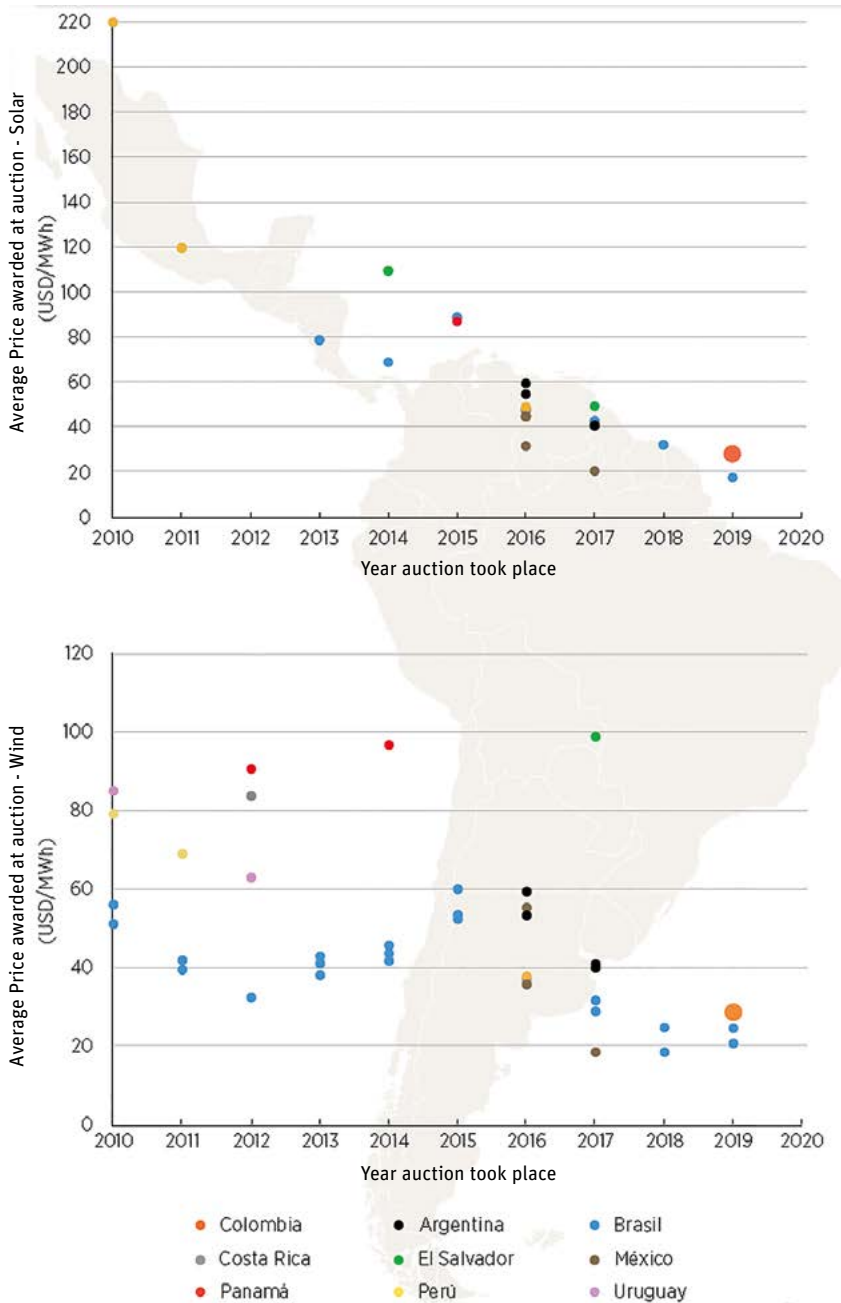


Source: Own elaboration

Likewise, the long-term contract auction yielded successful results that, as in the case of the Reliability Charge, were historic. It awarded contracts to 23 buyers representing regulated demand and nine renewable energy generators: six wind generators totaling 1,084 megawatts and three solar generators totaling 289 megawatts. In total, 1,373 megawatts of NCRE installed capacity were awarded in the departments of La Guajira, Valle del Cauca, Córdoba and Tolima, obtaining a total energy allocation of 12,050 megawatt-hours/day, with an average price of COP \$95.65/kilowatt-hour.

In other words, a much more competitive price was obtained, approximately 50% lower than the historical value for traditional bilateral contracts. The energy allocated represents nearly 9% of the projected regulated demand in 2022. The price attained is among the most competitive in the region, below that of most of the auctions held during the last decade and reaching similar values to those obtained in Brazil in 2018 and 2019.

Figure 10. Average Price awarded at Auctions in Latin America, for solar and wind technologies between 2010 and 2019

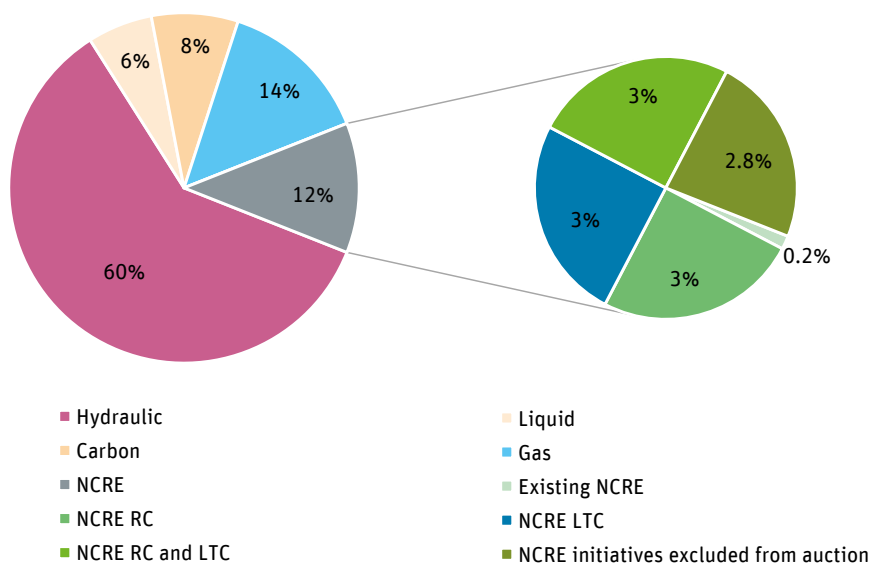


Source: Renewable energy auctions in Colombia: Context, design and results, IRENA-USAID

The outstanding results point towards the creation of more than 6,000 jobs and investments in excess of USD \$2 billion, benefiting all regulated users - close to 15 million - who will be able to notice a reduction in their energy rates once the contracts enter into force. Non-regulated users also benefit indirectly, since they will be able to negotiate lower prices in the wholesale energy market following the precedent of the price attained in the auction.

In summary, the participation of non-conventional renewable energy in the energy matrix, taking into account the Reliability Charge auction and the long-term contract auction, along with the construction of private initiative power plants, will account for 12% of all capacity by 2022.

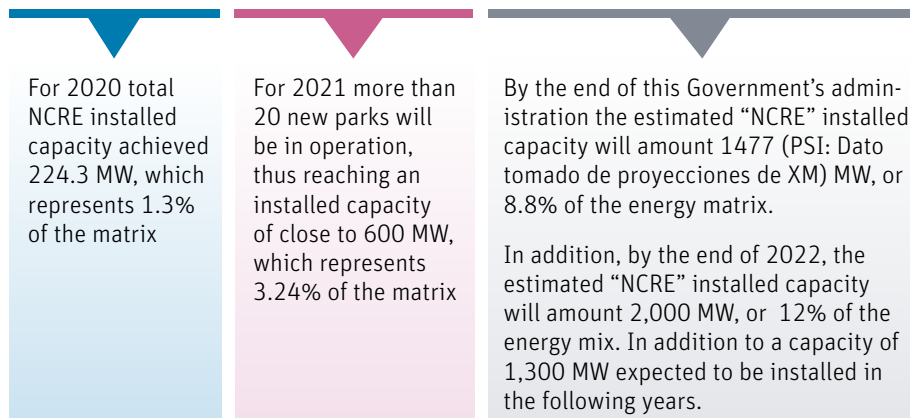
Figure 11. Energy mix after Reliability Charge (RC) auction and Long-term contract (LTC) auction



Source: Own elaboration

The significant magnitude of the progress made is clear, both given the size of the program and the speed of its execution. Thanks to this, Colombia will soon have a much more resilient and complementary matrix.

Figure 12. Forecast of non-conventional renewable energy share in the Colombian energy matrix



Source: Own elaboration

Furthermore, considering the number of renewable projects with allowed grid connection, the successful results obtained in the 2019 energy auction, and the need for a sustainable economic recovery after COVID19, the government called for a third renewable energy auction.

The auction closed with the successful award of 800 MW of solar projects, which will start operations in January 2023.

Understanding the territory

Beyond the success attained, it is clear that conducting successful auctions is not the only challenge. Another challenge for renewable energy lies in the social issues faced by the populations living in the areas of influence of the projects.

Reflecting once more on La Guajira, the department holds great potential in terms of solar and wind resources, although concurrently there are populations therein whose basic needs are not being met. Therefore, the government and the promoters of renewable energy projects in the department should focus their efforts towards generating a positive impact on these communities, respecting their culture, beliefs and idiosyncrasy. This is the case of the Wayúu indigenous people who have inhabited the territory for many generations.

Extreme poverty, coupled with the lack of access to water, education, health and electricity, hinder the prior consultation process and consequently a general acceptance of the projects. Hence, the Ministry of Mines and Energy has endorsed a strategy called “*Mesas Guajira*” (Guajira Roundtables) aimed at finding common ground between the National Government and wind farm developers in the municipalities of Uribia, Maicao and Riohacha, along with the two transmission networks needed to deliver energy to the system, in an effort to provide an adequate solution for all parties. In addition, there is an obligation to contribute 1% of the value of the investments towards projects benefiting ethnic communities and municipalities in the area of influence.

The aforementioned strategy is based on a collaborative work forum whose principles include the formulation of proposals by the participants involved and the definition of commitments, including responsibilities and deadlines for compliance, both for public and private stakeholders. This has provided an opportunity for the construction and operation of the projects to become an incentive to implement actions that will have a positive impact on the population, facilitating sustainable and long-term solutions to the problems identified. This creates a sense of ownership with regard to the project, thus benefiting its operation and preservation.

Additionally, it includes training and professional education initiatives for the local population to ensure that their construction is also a source of employment and economic development for the area, encouraging the expansion of roads, and supports prior consultation processes to protect the rights, beliefs and culture of the community. The areas addressed in the strategy are:

Work group	Description and results
Transport and logistics	<p>Issues: Deficiencies in port and road infrastructure required to receive and transport oversized and heavy wind turbine cargoes to project construction sites.</p> <p>Main achievements: A coordination mechanism was established between the entities responsible for the roads (National Infrastructure Agency (ANI for its Spanish acronym), National Roads Institute (INVIAS for its Spanish acronym) and Ministry of Transportation) and the private agents interested in transporting these cargoes to develop an action plan for roads, sidewalks and bridge works along a common route for all energy generation projects in mid and upper Guajira, which will also benefit the community. In addition, the Ministry of Transportation enabled the use of private ports to import the necessary equipment.</p>

Work group	Description and results
Social, environmental and safety	<p>Issues: Difficulty reaching agreements with the community during prior consultation processes due to differences in the expectations of stakeholders and uncertainties associated with the limits of the area of influence of the projects.</p> <p>Main achievements: Agreement between the Ministry of the Interior and the Ministry of Mines and Energy to provide personnel for the development of processes related to the right to prior consultation of the communities near the generation and transmission projects in the department of La Guajira, through FENOGE.</p> <p>A social relationship strategy was developed with the Wayúu indigenous people, which will allow the government to maintain a presence in the territory, explaining the positive and negative impacts and the reasons behind the development of wind projects in La Guajira. This is being done jointly with the Ministries of the Interior, Housing and Transportation, the UPME and the National Learning Service (SENA for its Spanish acronym).</p>
Water, customs and workforce	<p>Issues: The community of La Guajira has severe limitations in terms of access to drinking water and vocational training that hamper the inclusion of the population as workforce for the projects. In addition, the agents expressed doubts regarding the nationalization process for the machinery and equipment needed for the projects.</p> <p>Main achievements: The Ministry of Housing and the project developers were able to work together on a common plan for the supply of raw water for industrial use in the projects and a solution for the provision of drinking water services for the communities in the long term, within the framework of the <i>Guajira Azul</i> plan of the Office of the Deputy Minister of Water.</p> <p>SENA and the agents have worked together to design vocational training programs for the local population in accordance with the needs identified.</p> <p>A collaborative space was established with the Office of the President of the Republic and specifically with the Office of the Advisor for Women. A preliminary version of a strategy that incorporates the gender differential approach in the development of wind projects is already underway, talks were held with the National Tax and Customs Directorate (DIAN for its Spanish acronym) to clarify doubts regarding the nationalization of equipment, and synergies were generated between the agents and this entity.</p>

Work group	Description and results
Access to electrical power in rural areas	<p>Problem: Electric power coverage in the Department of La Guajira is only 58.8%, leaving nearly 81,500 households without service, of which 77,000 are rural households.</p> <p>Main achievements: CREG Resolution for the use of individual solar photovoltaic solutions to expand electricity coverage, defining tariffs and subsidy schemes for this type of solutions.</p> <p>Solutions are being structured by the Institute for Planning and Promotion of Energy Solutions for Non-Interconnected Zones (IPSE for its Spanish acronym) for 1,800 users, private ventures through the Financial Support Fund for Electrification of Non-interconnected Rural Zones (FAZNI for its Spanish acronym) for 4,000 users and through OCAD PAZ for 1,710 users.</p>

Regional leadership

Colombia has positioned itself as an undisputed regional leader in the energy transition. According to the World Economic Forum Energy Transition Index 2021, Colombia is the third country in Latin America with the greatest progress towards energy transition.

Similarly, the country climbed 14 positions in the World Energy Council's Energy Trilemma Index 2020, mostly due to the achievements in the integration of renewable energy into the energy mix.

Likewise, since 2019 Colombia has led the initiative Renewable Energy for Latin America and the Caribbean (RELAC), which aims to steer the region's power systems towards net-zero carbon scenario, thus seeking to improve the resilience and efficiency of the sector. This initiative is aimed at achieving at least 70% renewable energy entry in Latin America and the Caribbean by 2030 and has the support of the Inter-American Development Bank, OLADE and IRENA. The implementation of RELAC, which is currently composed by 11 members stands for an increase in the region's ambition to respond to the climate crisis by coordinating economic growth and the reduction of GHG emissions in the sector.

In January 2021, Colombia was appointed as an Energy Transition Global Champion by the United Nations, within the framework of the UN High Level Dialogue of Energy, which took place in September 2021. The country, along with 9 other nations, led the energy transition thematic dialogue, which covered renewable energy, energy efficiency, sustainable mobility, and just transitions. As a Global Champion, Colombia proposed recommendations for the discussions of the High Level Dialogue on Energy . Also, the country presented a national and a regional energy compact, seeking to promote the energy transition, encouraging the adoption of concrete actions to achieve SDG7 goals and fight climate change.

Also, Colombia was elected member of the IRENA Council for 2021. This election was the result of important negotiation efforts by the National Government during the 2020 regional consultative meetings and will allow the country to influence IRENA's program agenda, as well as to make visible the country's proposals and progress in terms of energy transition.

Finally, on July 2021 the International Energy Agency welcomed Colombia as the newest accession country to begin the formal process to get full membership. This decision of the IEA ratified Colombia's leading role in securing a sustainable and reliable energy system.

Sustainable mining, an essential element within the energy transition process

Within the framework of the vision for Colombia's Mining and Energy transition, the Ministry of Mines and Energy has considered the diversification of Colombia's mining matrix as one of its main tasks. This task is driven by international and domestic energy transition trends, the commitments associated with climate change mitigation and adaptation plans and, consequently, the opportunities and challenges that this new condition represents for the Colombian mining sector.

According to the World Bank (2018), the mining sector plays a key role and has an intrinsic relationship within the global energy transition, given that many minerals will serve as main inputs for equipment such as wind turbines, solar panels, batteries or electric vehicles. For example:

- Copper will play a vital role in energy transition as it is used in most of the technologies involved in the generation of clean energy and its storage: wind turbines, solar panels, geothermal and nuclear energy, among others.
- 90% of solar panels contain silver conductors that activate the possibility of generating electrical energy.
- The next generation of vehicles could use gold to improve corrosion resistance and electrical conductivity.

Diversification seeks to continue working towards a modern, socially responsible, technologically innovative and competitive mining sector. To this end, we have assigned ourselves three tasks:

- Enhance geological knowledge: working on identifying mining potential, seeking to increase knowledge thereof and the dissemination of this knowledge.
- Strengthen mining exploration: an essential step towards the generation of territorial knowledge and planning.
- Improve projects during their exploration, construction and assembly stage so they can advance to the next stage; likewise in the exploitation stage, so they develop as planned.

These challenges offer important opportunities for the mining sector, such as the Colombia Mining Round 2021 where companies can apply for access to manage high potential mining areas in different regions of the country, especially for key metallic minerals indispensable for energy transition, such as gold, silver and copper.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

CHAPTER 3

The complementarity of energy resources for the long-term transition

As pointed out in an IEA report ^{xiv}, gas consumption in the world has been steadily growing: in 2018 it accounted for 22.8% of the total worldwide energy supply, while in 2010 it represented 21.3%, two and a half points higher than in 1990 ^{xv}. The same trend is observed in Central and South America, where in 2018, natural gas accounted for 21.5 % of the total energy supply, while in 2010 it was 20.3 % and in 1990, 14%. ^{xvi} In the case of Colombia, we observe that the share of natural gas in the total energy supply almost doubled in the last thirty years: while in 1990 its share was 13.94%, in 2018 it reached 26.38%.

These dynamics can be traced back to two main sources. From the supply side, the development of non-conventional techniques, such as hydraulic stimulation and horizontal drilling, has served to unlock significant deposits, especially in North America. On the demand side, the use of this fuel is on the rise thanks to its lower relative cost and reduced environmental footprint, the latter all the more significant when it replaces high carbon dioxide-emitting sources.

Today, natural gas is a more tradeable and liquid product from the market's perspective, largely due to the proliferation of liquefaction and regasification plants around the world and, after non-conventional renewable energy sources, has the highest growth rate among energies used for electricity generation. In addition, the flexibility it offers complements the penetration of variable power generation sources. ^{xvii}

In Colombia particularly, hydrocarbon production reached an important turning point in the 1990s with the discovery of the Cusiana, Cupiagua and Floreña fields, which led the country to position itself as one of the main producers in the region. The increase in the supply of this energy source recorded an average annual growth rate of 5% between 1999 and 2018.^{xviii}

Even so, currently available reserves are relatively limited. The search for new reserves that will allow extending the country's energy self-sufficiency horizon while the transition process moves ahead should continue. Likewise, a sustainable and long-term natural gas supply plan is needed to ensure the provisioning of the demand and reliable thermal generation, given the complementarity it provides during low rainfall periods.^{xix}

In this sense, President Iván Duque's administration launched one of the most efficient mechanisms for the awarding of prospective hydrocarbon areas, named the Permanent Process for the Allocation of Areas (PPAA), which was introduced during the first quarter of 2019 in order to award exploration and production areas. After nearly five years without signing new contracts, with this new mechanism 39 contracts for exploration and production of onshore and offshore areas have been awarded so far, whose investment commitments exceed USD \$4 billion.

The country still has considerable unexplored potential in offshore blocks and the development of fields through the use of non-conventional techniques, which display an interesting gas potential. These reservoirs may increase twentyfold natural gas reserves.

The figures speak for themselves. If the conversion of coal-fired power plants to natural gas were possible globally, emissions of up to 1.2 gigatons of CO₂ would be avoided, especially in the United States and Europe where important gas fields or pipelines are located. In this sense, gas can be described as a transition fuel which, to the extent it replaces other more polluting sources. The above compounds its importance from a social standpoint, as it is used for cooking by the vast majority of households in the country.

A long-term plan

The core elements of the country's strategy for the coming years are supply, market and commercialization, along with the expansion of the national transportation system. These criteria are based on the considerations and recommendations of the Energy Transformation Mission further explained in Chapter 7 of this document.

Regarding domestic production, as mentioned above the National Hydrocarbons Agency (ANH for its Spanish acronym) and the Ministry of Mines and Energy have been fostering higher levels of exploration in new fields, both onshore and offshore, which should yield positive results in the coming years and which show high prospective gas deposits. The bases of the National Development Plan 2018- 2022 state that “the ANH will establish the areas for the exploration and production of non-conventional fields and the Ministry of Energy and the Ministry of the Environment will update, if necessary, the specific technical and environmental regulations for their exploration and production.”^{xx}

Additionally, legislation introduced important tax incentives for capital intensive industries, such as energy and hydrocarbons: the gradual reduction of the income tax rate, the possibility to credit total VAT paid on capital goods against income tax, the 50% ICA refund for the next two years and 100% as of 2021. These incentives resulted in a 68% increase in foreign direct investment during the first quarter of 2019 versus the same period of the previous year.

Moreover, the commission that evaluated the feasibility of exploring non-conventional reservoirs submitted a detailed report suggesting a series of technical, environmental and social conditions to be realized prior and simultaneous to the development of the Integral Pilot Research Projects (PPII for its Spanish acronym) before determining the commercial viability of this type of reservoirs through hydraulic fracturing and horizontal drilling (*Comisión Interdisciplinaria Independiente*, 2019). This process is moving forward and, if successful, should lead to an increase in recoverable reserves.

Based on a duty previously assigned, during 2020 UPME released the “Technical Study for the Natural Gas Supply Plan”. This was adopted by the Ministry of Mines and Energy through Resolution 40304 of 2020, whereby eight new works that will support fuel supply infrastructure until 2028 are

adopted. The estimated investment amounts to approximately USD \$800 million.

The document in question ratified the need to build a regasification plant in the Colombian Pacific, aimed at importing this energy source. The reasoning is the progressive loss of natural gas self-sufficiency (in 2020, proven reserves dropped from 9.8 to 8.1 years), combined with the time of entry into operation of new domestic gas production projects and the reliability of this service.

Technical analyses indicate that this new supply point for imported natural gas, which will enter into operation in December 2025, will diversify supply sources, in addition to increasing the flexibility of the national transportation system in the event of a system failure, thus reducing the risk of not meeting demand. The terminal located in the Buenaventura bay in the Pacific coast will have a storage capacity of 170,000 cubic meters of liquefied natural gas, will be able to re-gasify 400 million cubic feet per day of natural gas, and will be connected to a gas pipeline to a delivery point to the national transportation system in the municipality of Yumbo, Valle del Cauca.

The Energy Transformation Mission experts stated that the regime applicable to regasification plants should be open access or open access with exemptions. This will allow non-regulated gas users (refinery, thermoelectric, steel or, in general, large consumers) to participate in government contracting processes for regasification plants. In addition, it was suggested that the selection criteria for the project developers of said plants should be minimizing annual revenue, in order to cover their CAPEX, profitability thereof and the annual operating expenditure during a 10-year horizon. In the discussions, the option of constructing these plants at risk by private parties was examined, but experts consider that coordinating demand in this scenario was too difficult to be able to rely on this supply option, at least during a transition stage.

Regasification plant developers and/or operators would be subject to a revenue-cap type regulation (Annual Revenue Quota subject to an internal rate of return) for the provision of standard integrated liquefied natural gas (LNG) service, defined as: "Package of services offered by the Terminal Operator consisting, at minimum, of the right to berthing of LNG vessels for a certain period of time, the right to unload LNG, a temporary LNG storage capacity, and regasification service with a corresponding delivery capacity."



With the addition of regasification plants into the market there would potentially be a significant new number of bidders, which is why the experts propose liberalizing this market and allowing the parties to freely negotiate through bilateral contracts for both domestic gas and imported LNG through the regasification infrastructure. All gas traded should be supported by written contracts with standardized clauses, or should be subject to oversight in such a way as to avoid the inclusion of anti-competitive provisions, or stipulations that restrict competition.

Besides the regasification plant, the Natural Gas Supply Plan adopted by the Ministry of Mines and Energy includes other transportation infrastructure works that will start operating as of 2022 and will connect the different domestic markets.

Finally, regarding transportation, CREG has been working on modifying the methodology to remunerate the activity, which was submitted for public consultation through CREG Resolution 160 of 2020. The main objective of

this proposal is to contribute towards more efficient pricing and to increase the competitiveness of the natural gas market.

Following the guidelines explained above, the natural gas market will become a more liquid and competitive market that will allow a continued massification in the use of this low-emission energy source, as a transitional energy source towards net-zero carbon.

A key element in mobility

Traditionally, there was only one liquid fuel option in the country, and that was Compressed Natural Gas for Vehicles (CNG). According to Naturgas, in 2019 Colombia surpassed 600 thousand converted or dedicated CNG-powered vehicles.^{xxi}

Since 2019, the future demand for natural gas for this sector has been examined in detail by way of sustainable consumption in the private fleet and planning for a tenfold increase in the number of cargo fleet and public transport vehicles converted over a ten-year period. The projections include the assumption that, as of 2023, cargo vehicles running on liquefied natural gas will enter the market, which would substantially increase consumption in the sector. According to the National Energy Plan, the entry of 11 thousand LNG-powered tractor-trailer units is estimated for 2030 (14% of vehicles). Owing to these goals, some cities have incorporated LNG-powered vehicles into their public transportation fleets, such as TransMilenio (Bogotá), MIO (Cali) and Transcaribe (Cartagena).

In order to have a single source of official information to control natural gas vehicles, equipment and conversion workshops, the National Government implemented an information module for compressed natural gas vehicles in the Liquid Fuels Information System (SICOM for its Spanish acronym), which ensures traceability and security in the conversion and import process.

The substitution of diesel for LNG in cargo transportation is based on lower investment costs for production and storage infrastructure, greater vehicle driving distance and lower storage capacities for different uses, determining construction, operational and regulatory features of the technologies to be implemented nationwide.

Propane gas, on the other hand, is not only a cleaner and more environmentally friendly fuel, but it is also efficient and cost-effective in terms of its calorific value, which provides a vehicle with the same power as if it were using liquid fuels. In addition, it is classified as a low-emission energy source, as explained in the following chapter: its use reduces CO₂ emissions by 21% and particle emissions by 81% compared to gasoline. Due to its physical properties, it is very easy to transport, which facilitates its use in any area of the country, and therefore the Ministry issued in 2020 the technical regulations that service stations interested in supplying liquefied petroleum gas (LPG) for vehicle use and river transport must comply with.

We are all part of the transition

Energy transition is not a process foreign to Colombian hydrocarbon companies. For example, the Ecopetrol Group's strategy, in line with its purpose of leading the energy transition and reducing greenhouse gas emissions in Colombia, has been moving forward by incorporating renewable energies into its energy matrix. Likewise, the acquisition of ISA, one of Latin America's largest transmission companies will allow it to strengthen its commitment to the electrification of the economy, complementing its activities in hydrocarbons and becoming one of the most important energy companies in the world.

This Group expects to have at least eight solar farms in operation before the end of 2021 in order to supply part of the energy demand of its operations in the departments of Meta, Bolívar, Antioquia and Huila. Their operation will reduce the emission of approximately 1.1 million tons of CO₂, a figure that is equivalent to the planting and upkeep of more than 7.7 million trees.

In order to reach 400 megawatts of installed renewable energy by 2023, Ecopetrol is also considering projects in wind energy, biomass, geothermal energy, small hydroelectric power plants and the use of batteries.

Another great example to highlight is that of Parex Resources, a company which, with the support of the Universidad Nacional de Colombia – Medellín Campus, is working on a pilot project for the co-production of hydrocarbons and electricity from geothermal resources in the Las Maracas and Rumba fields in the department of Casanare. With an investment of approximately USD \$1.3 million, it will produce enough energy to supply the needs of 600 households.

The project seeks to harness the heat of wastewater co-produced when extracting hydrocarbons from the subsoil. The high temperature of this water is used to generate electricity to partially replace the consumption of fossil fuels for the energy production of oil fields. Once commissioned in March 2021, this project could be considered the first system for generating electricity from geothermal resources in the country.

The use of geothermal energy from producing oil wells is presented as a solution that fits the new reality of the oil industry, since it does not entail the generation of large amounts of waste and seeks to replace, as much as possible, the consumption of fossil fuels for the energy production of oil fields, thus supporting the decarbonization goal set by the country.

Finally, the complementarity of energy sources contributes to an increase in the country's electricity coverage, as demonstrated in the case of the municipality of Puerto Carreño, which as of 2021 will enjoy a reliable and quality service, 100% locally sourced, due to the collaboration between Electroviachada and Refoenergy. As a result of this joint effort, an 8.98-megawatt capacity diesel-biomass hybrid power generation project is being developed, which will provide energy to the 18,000 inhabitants of Puerto Carreño.

In its initial phase, power supply will be generated with diesel and, once all operational conditions are secured, as of March 2021 it will start generating energy from biomass, thus becoming pioneers in this clean and renewable production technology.

The initiatives highlighted above are a clear example of how the energy transition is shaping the operations of conventional energies, and thus fostering the industry's sustainability.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

CHAPTER 4

Sustainable mobility and energy efficiency

The transportation sector consumes 40% of the country's energy and 96% of this energy is concentrated in the consumption of fossil fuels. The negative impact thereof on the environment is undeniable. Additionally, this activity carries 54% of total energy losses due to low performance, with an approximate annual cost of USD 3 billion. The diagnosis reveals the implementation of energy efficiency measures and technological change is imperative.

Moreover, pollution has a direct impact on the quality of life and health of our society. According to the National Planning Department, the costs associated with low air quality nationwide amounted to COP 12 trillion in 2018 and were associated with 8,000 deaths.

As if the above were not enough, and as indicated in the Colombian National Greenhouse Gas Inventory under the responsibility of IDEAM, the transportation sector is responsible for 12% of the country's emissions, which represents the equivalent of 28 million tons of carbon dioxide. Given that the signing of the Paris agreement on climate change gave way to a commitment to reduce these emissions by 51% by 2030, the fulfillment of the national goal depends on the outcomes of this sector.

The answer, then, lies in technological changes and the incorporation of new energy sources that allow for the migration towards sustainable and low-carbon transportation. The actions developed in recent years point towards that direction.

Steps taken

The National Development Plan for this four-year period is aligned with the aforementioned objectives and establishes guidelines to achieving this objective. For example, there is a set target of 6,600 electric vehicles registered in the National Traffic Registry (RUNT for its Spanish acronym) by 2022. At least four documents issued by the National Council for Economic and Social Policy (CONPES for its Spanish acronym) establish specific policies on this issue.^{xxii}

As part of this effort, a sustainable transportation inter-institutional work group is in place, comprised of the Ministries of Transportation, Environment, and Mines and Energy, as well as the National Planning Department and UPME. In 2020, two workshops were held for the creation of the National Strategy for Sustainable Transportation in road, rail, river, lake and small boat maritime modalities, in order to identify the barriers to the use of low- or zero-emission technologies and establish an action plan.

In a complementary fashion, Resolution 40177 of the same year defined low and zero-emission energy sources based on the content of harmful components to health and the environment. Thus, electric energy and hydrogen were classified as zero-emission energy sources, while natural gas, liquefied petroleum gas, gasoline, fuel alcohol and their blends, with a maximum sulfur content of 50 ppm, and diesel, biodiesel and their blends, with a maximum sulfur content of 50 parts per million (ppm), are classified as low-emission energy sources. However, zero and low-emissions sources of energy for the transportation sector will depend in turn on the vehicle technology wherein they are incorporated.

Likewise, Law 1964 of 2019 seeks to generate structures to encourage the use of electric and zero-emission vehicles, so that the strategies and actions formulated contribute to the deployment of sustainable mobility. The law established tax benefits for the import and purchase of such vehicles, as well as business discounts on the technical-mechanical inspection and mandatory insurance, and exemption from mobility restriction measures such as the *“pico y placa”* (peak/off-peak restrictions) and *“día sin carro”* (car-free day). It also encourages the deployment of charging infrastructure and the incorporation of electric vehicles in public and official transportation, among others.

The National Electric Mobility Strategy is part of the efforts made through an action plan aimed at the creation of a regulatory and policy framework to foster e-mobility, the generation of economic mechanisms to boost the market for these vehicles, and the definition of technical guidelines and actions for the deployment of charging stations.

Additionally, the Ministry issued the technical regulation through Resolution 40405 of 2020, which was modified by Resolution 40198 of June 24, 2021. This Resolution provides the necessary guidelines for authorized automotive or mixed service stations to offer, as part of their services, the recharging of electric energy for hybrid and electric vehicles, as well as compressed natural gas for motor vehicles.

Similarly, Resolution 40223 of 2021 defines the charging service provider for electric and plug-in hybrid vehicles, establishes a minimum connector standard for charging stations, indicates the minimum information that must be available to the public at charging stations, and establishes the market conditions to continue promoting the deployment of charging infrastructure in Colombia.

The Ministry is also working with ICONTEC on a consultancy that will provide a package of Technical Standards for electric vehicles, to be published in October 2021. In addition, regulatory requirements related to interoperability issues and communication protocols for electric vehicle charging infrastructure are being analyzed with the support of the IDB.

Another initiative underway, with the support of Euroclima+, ECLAC and FIIAP, is the development of a strategy on energy efficiency standards for new light vehicles, which is expected to be completed in the second quarter of 2022.

High-quality fuels, a key element

Given the high energy consumption of the transportation sector, providing the country with better quality gasoline is crucial. Throughout this century, a set of regulations has focused on reducing polluting and harmful materials for health, as well as encouraging the use of cleaner engines, especially for passenger transportation.

Law 1972 of 2019 determines that the Ministry of Mines and Energy will carry out the necessary actions to guarantee the production, import, storage, addition and quality in the distribution of fuels needed to comply with the emission standards². Similarly, the aforementioned Resolution 40177 defines deadlines for diesel, biodiesel and their blends under the consideration of classifying them as low-emission fuels³.

Particulate matter is the main contributor to urban air pollution in Colombia, and is produced primarily by fossil fuel combustion, especially diesel. Science has determined that emissions from vehicles that use this fuel are carcinogenic.

2 | As of January 1, 2023, the sulfur content of diesel will be set at between 15 and 10 ppm, and as of December 1, 2025 it will be 10 ppm.

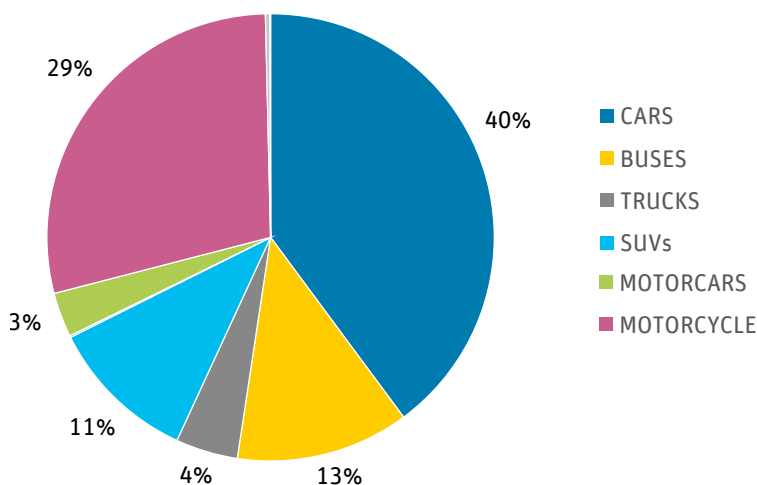
3 | Up to December 30, 2020, the sulfur content will be a maximum of 50 ppm. As of December 31, 2020 until December 31, 2022, the sulfur content will be set at a maximum of 20 ppm. In the case of gasoline, fuel alcohol and their blends, they will be considered low-emission energy sources and their sulfur content will be set at a maximum of 50 ppm up to December 30, 2030, and at a maximum of 10 ppm as of this date.

On July 3, 2020, Resolution 40178 was issued, establishing the procedure for the approval and implementation of programs for higher biodiesel fossil fuel blends, in order to further the study on the impact and feasibility of these higher levels of blends.

This resolution opened the way for the first blend pilot above the current regulatory level of 10%, testing a 20% blend of biodiesel with diesel-type fossil fuel. The experiment will be carried out over a 36-month period and involves 699 heavy-duty vehicles in the Aburrá Valley. The second project is expected to be developed in 2021 with a 20% blend for courier and package fleets. The purpose of these pilots is to evaluate the impact on the reduction of particulate matter emissions and on the performance of heavy-duty vehicles.

However, fuel improvement must be accompanied by requirements for technologically advanced vehicles. Stringent standards can force their introduction. Heavy-duty trucks and buses, most of which run on diesel engines, currently account for more than 80% of PM_{2.5} emissions from on-road vehicles, making them prime targets for such regulations. According to the RUNT, as of August 31, 2021, about 4,849 electric vehicles have been registered in Colombia, including cars, motorcycles, vans, buses, trucks, among others.

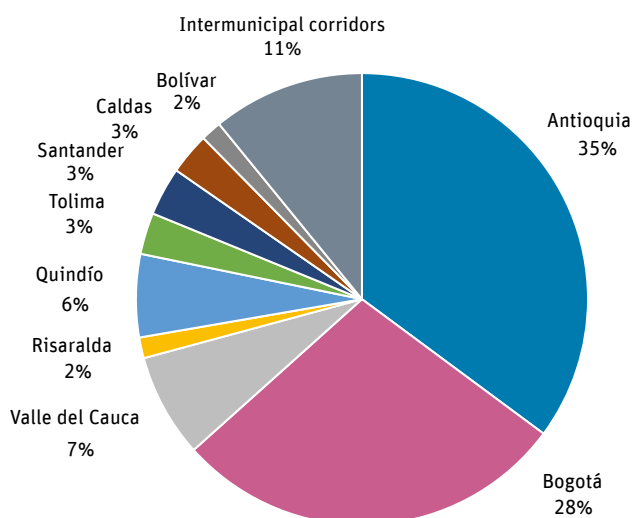
Figure 13. Electrical vehicles registered in Colombia, as of December 2020



Source: Own elaboration based on data from RUNT 2020

In 2020, a public charging infrastructure information survey was conducted in Colombia, estimating approximately 202 fast and semi-fast charging outlets, distributed throughout approximately 74 charging stations. Antioquia and Bogotá D.C. have the largest number of charging outlets, with 63% of the overall total, followed by Valle del Cauca, Quindío, Tolima, Santander, Caldas, Risaralda and Bolivar, as shown in Figure 14.

Figure 14. Distribution of charging stations for electrical vehicles in Colombia



Source: Own elaboration based on data from RUNT 2020

Rapid changes are also taking place in this area. At the beginning of 2021 and after a bidding process, the number of electric buses in Bogotá will reach 1,485 units, making it the city with the largest electric bus fleet outside China.

In this regard, the government is working on the adoption of technical standards on specifications, safety and interoperability requirements, as well as the charging infrastructure and components used in electric vehicles. The institutional framework must also be determined along with a toolkit allowing

decision-makers to identify zero and low-emission vehicles that meet the goals set out in Law 1964 of 2019, based on a cost-benefit analysis that incorporates gains in energy efficiency and environmental benefits.

Thanks to the efforts undertaken, explained in this chapter, Colombia led regional electric vehicle sales in 2019 and 2020, registering higher sales figures than countries such as Brazil, Chile, Costa Rica, Mexico and the Dominican Republic. Likewise, in terms of plug-in hybrid vehicle sales, Colombia is ranked among the top-selling countries, together with Mexico and Brazil.

Figure 15. Vehicle registrations, electrical and hybrid vehicles in Latin America

COUNTRY	BPV			PHEV			HEV		
	2019	2020	VAR %	2019	2020	VAR %	2019	2020	VAR %
Argentina	45	39	-13,3%				1.505	2.344	55,7%
Brazil	167	182	9,0%	437	619	41,6%	11.924	18.921	58,7%
Chile **	521	967	85,6%	85	73	-14,1%	850	671	-21,1%
Colombia	923	1.314	42,4%	442	467	5,7%	1.769	4.230	139,1%
Costa Rica	346	593	71,4%	53	81	52,8%	728	761	4,5%
Ecuador	103	105	1,9%		42		1.367	1.088	-20,4%
Mexico*	305	406	33,0%	1.339	1.770	32,2%	23.964	19.087	-20,4%
Peru	20	25	25,0%	7	9	28,6%	339	541	59,6%
Dominican Rep.	370	407	10,0%	40	48	20,0%	334	246	-26,3%
Total	2.800	4.038	44,2%	2.403	3.109	29,4%	42.780	47.889	11,9%

Notes: Dominican Republic includes used vehicles *Mexico, ANDEMOS projections based on estimated INEGI **Chile, preliminary information BPV: Battery powered vehicle PHEV: Plug-in Hybrid Electric Vehicle HEV: Hybrid Electric Vehicle

Source: ANDEMOS, 2020

Energy efficiency

This is one of the most cost-effective strategies for climate change mitigation, in addition to encouraging the productivity and competitiveness of the sectors and contributing to the country's energy security. Advances in this field will make it possible to comply with the environmental commitments

that Colombia acquired within the framework of COP21. The implementation of good practices, the adoption of new technologies and integrated energy management systems can represent consumption savings ranging from 5% to 50%.

In Colombia, the Useful Energy Balance (BEU for its Spanish acronym) was performed to identify potential energy efficiencies. According to this analysis, the country can improve 1.6 to 2.2 times compared to the best available domestic or international technologies. The cost of inefficiency ranges between USD 6.6 and 11 billion.

Law 679 of 2001 declared the rational and efficient use of energy (URE for its Spanish acronym) as a matter of social, public and national convenience interest, which is essential to ensure complete and timely energy supply, the competitiveness of the Colombian economy, consumer protection and the sustainable use of environmental and natural resourced non-conventional energy sources. Colombia implemented the Indicative Action Plan for the Rational and Efficient Energy Use Program (PAI-PROURE for its Spanish acronym) 2017 - 2022, adopted by the Ministry in 2016, which defines energy efficiency goals and sectoral lines of action.

Resolution 40808 of 2018 adopts the Climate Change Management Plan for the Mining and Energy Sector - PIGCC and through strategic Energy Efficiency track, established that activities to strengthen the Rational and Efficient Energy Use Program (PROURE for its Spanish acronym) must be undertaken.

Furthermore, the National development instructs public entities to conduct energy audits of their facilities and establish energy savings targets to be achieved through energy efficiency measures and changes and/or adjustments to their infrastructure. The consumption savings goal for this sector is a minimum of 15%.

Additionally, non-conventional renewable energies and energy efficiency are being encouraged, including actions such as: regulations and energy labeling schemes for vehicles; hourly rates; evaluation of the potential for thermal districts; strengthening the Commission for the rational and efficient use of energy; establishing mandatory PROURE goals; industry reconversion; energy management within the industrial sector; technological changes in the use of lighting and household appliances for low-income users with the EE program in the Caribbean; programs to replace firewood and coal with LPG.

Furthermore, Colombia is part of the 3% Club, which promotes annual energy savings of 3%. This initiative seeks to strengthen energy efficiency capacities in the country and support early adoption. Additionally, it is in line with the goal set in the National Development Plan 2018-2022, which seeks to reduce energy intensity from 3.7 (TJ/ billion pesos from 2005) to 3.43 (TJ/ billion pesos from 2005).

Green incentives are of great importance as a means to finance and achieve potential efficiency savings. Colombia has made progress with incentives such as VAT exemption and net income discounts or deductions, the creation of specific funds such as FENOGE, and the use of resources captured by the national carbon tax to promote energy efficiency projects. In this context, Resolution 196 of 2020 was issued by UPME to obtain an income tax deduction. Those who apply for this incentive no longer have to submit the application to ANLA, which reduces the application process by more than three months.

Two other strategies are worth highlighting. The first is the energy efficiency project in San Andres, Providencia and Santa Catalina, which specifically aims to improve energy sustainability through improvements in electricity demand management, such as energy efficiency measures and the use of local energy resources, with the ensuing reduction of greenhouse gas emissions and savings in government subsidies (see box).

Likewise, the Caribbean Energy Efficiency and Sustainable Energy Program (PEECES for its Spanish acronym) focuses on the replacement of domestic refrigeration, lighting and architectural retrofitting for the residential sector, as well as on renewable energy generation, replacement of air conditioners and lighting for the official sector. Two of the proposed goals are to reduce consumption and subsidies, with positive effects for both users and public finances (see box).

Sustainable Energy and Energy Efficiency Program in the Caribbean (PEECES), a comprehensive program

PEECES is a large-scale comprehensive program that operates in the seven departments of the Caribbean region (Atlántico, Bolívar, Cesar, Córdoba, La Guajira, Magdalena and Sucre), benefiting the most vulnerable low-income socio-economic strata 1 and 2 residential users, by reducing their energy bill costs and using efficient technologies in their households.

The measures include the replacement of cooling, lighting and air conditioning appliances, architectural retrofitting and generation with non-conventional renewable energy sources for low-income socio-economic strata 1 and 2 residential and official users, which represent a large pool of beneficiaries:

- 1,930,803 low-income socio-economic strata 1 and 2 residential users from the seven Caribbean Region departments, representing 83% of the segment.
- 3% reduction in subsidy costs for residential users within the scope of the program, which for 2017 amounted to COP \$741,600 million, allowing for these resources to be allocated to new programs that contribute to the improvement of the quality of life and living conditions of the country's population.
- COP \$24,500 of estimated monthly savings per beneficiary on their energy bill, and of approximately COP \$25.2 billion per year in State subsidies.
- 1,600 gigawatt-hours/year in energy savings, resulting from the replacement of low-efficiency equipment with efficient RETIQ*-labeled equipment and architectural retrofitting.
- 202,349 tons of CO₂ equivalent in the 10-year lifespan of a refrigerator, thanks to energy savings and the substitution of less polluting refrigerants.

On February 5, 2020 the implementation of Component 1 of PEECES began, known as “Caribe Eficiente” (Efficient Caribe), an initiative executed and financed by FENOGÉ, which seeks to replace 54,619 cooling appliances in residential strata 1 and 2 in the departments of Atlántico,

Bolívar and Córdoba, with which it expects to obtain benefits during the useful life of the cooling appliances, such as reduction of energy consumption, savings in subsidies, reduction of emissions and savings in service billing for the beneficiaries.

During this first year, Caribe Eficiente carried out the pre-operational stage in which the technical, financial, legal, environmental, social, administrative and logistical needs were mapped out, as well as the control and follow-up requirements needed for the proper operation of the project.

The project currently has seven retailers, three environmental managers, and nine refrigerator references that meet the program's participation requirements. During the first year of operation it has reached 6,001 registered participants, 2,221 replaced, and more than 1,900 old refrigerators delivered to the environmental managers for their correct final disposal; this number of replacements represents, over the useful life of the refrigerators (10 years), an estimated total of 436 tons of CO₂ emissions reduction, COP \$135 million of annual average subsidy savings, and 68,000 kilowatt-hours/month of annual average energy consumption reduction.

Efficient energy demand management pilot program in non-interconnected areas: San Andres, Providencia and Santa Catalina archipelago.

- With a reduction goal of 26,534 tons of CO₂ as a result of reduced energy consumption calculated at 40 gigawatt-hours, the program has achieved the following results:
- Installation of solar photovoltaic systems, with a total capacity of 51 kilowatt-peak, in seven public offices located in the archipelago. In 2021, they will be installed in three additional public offices, achieving an installed capacity of 66.6 kilowatt-peaks.
- Energy audits and partial replacement of appliances, including air conditioners, energy-saving light bulbs, cooling equipment and motion sensors for offices in 14 public offices located in the

archipelago.

- Replacement of 76,654 light bulbs for part of low-income socio-economic strata 1 and 2 users. The total number of beneficiaries is 13,278 residential users, including 7,127 users from the islands.
- Subsidy for the replacement of air conditioners, refrigerators and lighting fixtures for 3,486 users.

Actions to be developed within the framework of the reconstruction of the islands:

- Installation of photovoltaic solar solutions, which contribute to the generation of energy for 450 households built by the Ministry of Housing.
- Delivery of efficient refrigeration equipment in Providencia, with a benefit that covers up to 100% of the value of the equipment. After the hurricane, 1,179 refrigerators have been delivered.
- Free delivery of light bulbs in the residential, commercial and public sectors in Providencia and Santa Catalina. It will begin with the residential sector and will continue until stocks are exhausted in the other two sectors. To date they have delivered up to 7,000 light bulbs in the islands.

Progress on the Energy Cities initiative

In 2018, the Swiss Embassy, Economic Cooperation and Development and UPME joined efforts to develop the Energy City initiative^{xxiii} aimed at introducing a tool implemented in other countries, in order to improve the quality of energy management in the Colombian cities chosen as pilots. Fusagasugá, Montería and Pasto were selected based mainly on institutional leadership, territory (population, diversity of thermal floors), environment and sustainability (potential for renewable energies) criteria.

These cities developed a participatory process for the construction of a Local Energy Strategy (EEL for its Spanish acronym) based on the international methodology used by Energiestadt and the EEA. This participatory process involved the contribution of local governments, the private sector -including business associations- and academia.

The construction of the EEL, as a participatory energy diagnosis, allowed for the structuring of an action plan that identified demonstrative and scalable priority projects that respond to the particular energy needs of each municipality. These projects aim to foster the use of renewable energy and energy efficiency in cities, and the monitoring of results and impacts. Within these projects, the initiative identified early-win projects, which were 100% financed in their execution to guarantee a representative effect in the medium-term that would contribute to maintaining the municipality's increased interest in undertaking other projects identified within the EEL.

As a result, the initiative also provided assistance to the municipalities in strengthening their knowledge regarding project management and in raising additional resources to develop other projects.

The process carried out with these pilot cities has consistently tried to encourage concrete energy actions and provide local governments and their partners with the means to carry out an integrated, participatory and sustainable energy policy.

Fusagasugá pilot project

The early victory project in Fusagasugá consists of the installation and operation of photovoltaic solar panels to reduce billing costs for public and private users through a demand aggregation model, which consists of an associative purchase. The 2019 tender process for the acquisition of these systems reduced costs by approximately 20%, with a price of USD \$1200/kilowatt-peak. This is a replicable business model that could be implemented in other municipalities in Colombia.



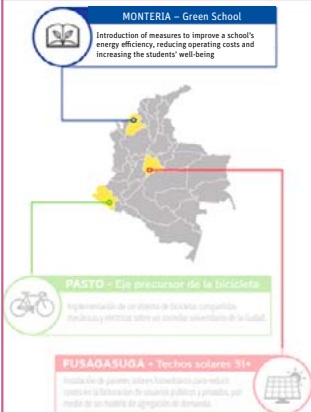
Source: Progress Report: Energy Cities - UPME-SECO-AI

This project will involve the installation of approximately 200 to 250 kilowatts and at least 51 installations in both residential and public buildings, as well as in other users such as private businesses. In addition to the cost reduction brought about by demand aggregation, this program will grant users partial financing depending on the sector and the socioeconomic level of urban households. The expected results of the implementation of this project are the following: a reduction of greenhouse gas emissions of 20.6 tons of CO₂ equivalent per year and the generation of 125.6 megawatt-hours of energy per year.

Monteria pilot project

The early victory project implemented in the city of Monteria, consists of the introduction of measures to improve a school's energy efficiency in an effort to reduce operating costs, maintaining temperatures inside the classrooms at 27°C using solar self-generation to increase the well-being of students and staff. This project has taken into account passive and active measures that can be implemented to improve the comfort of those who attend the educational institution without increasing operating costs.


The expected results of the implementation of this project are the following: the reduction of greenhouse gas emissions by 5.8 tons of CO2 equivalent per year, the saving of 35.5 megawatt-hours of energy per year through the energy efficiency measures applied, and the generation of 55.6 megawatt-hours of energy per year.





MONTERIA - Green School
Introduction of measures to improve a school's energy efficiency, reducing operating costs and increasing the students' well-being.

PASTO - Eje precurser de la bicicleta
Implementación de un sistema de bicicletas compartidas, mecánicas y eléctricas sobre un corredor universitario de la ciudad.

FUSAGASUGÁ - Techos solares 51+
Instalación de paneles solares fotovoltaicos para reducir costos en la generación de energía pública y privada, por medio de un modelo de agregación de demanda.



Juan XXIII School

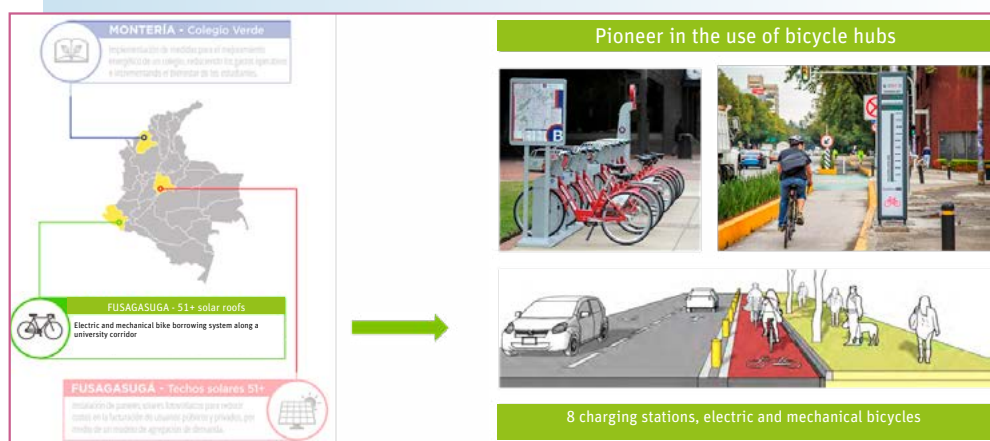



Estimated investment: COP 1.4 Billion

Source: Progress Report: Energy Cities - UPME-SECO-AI

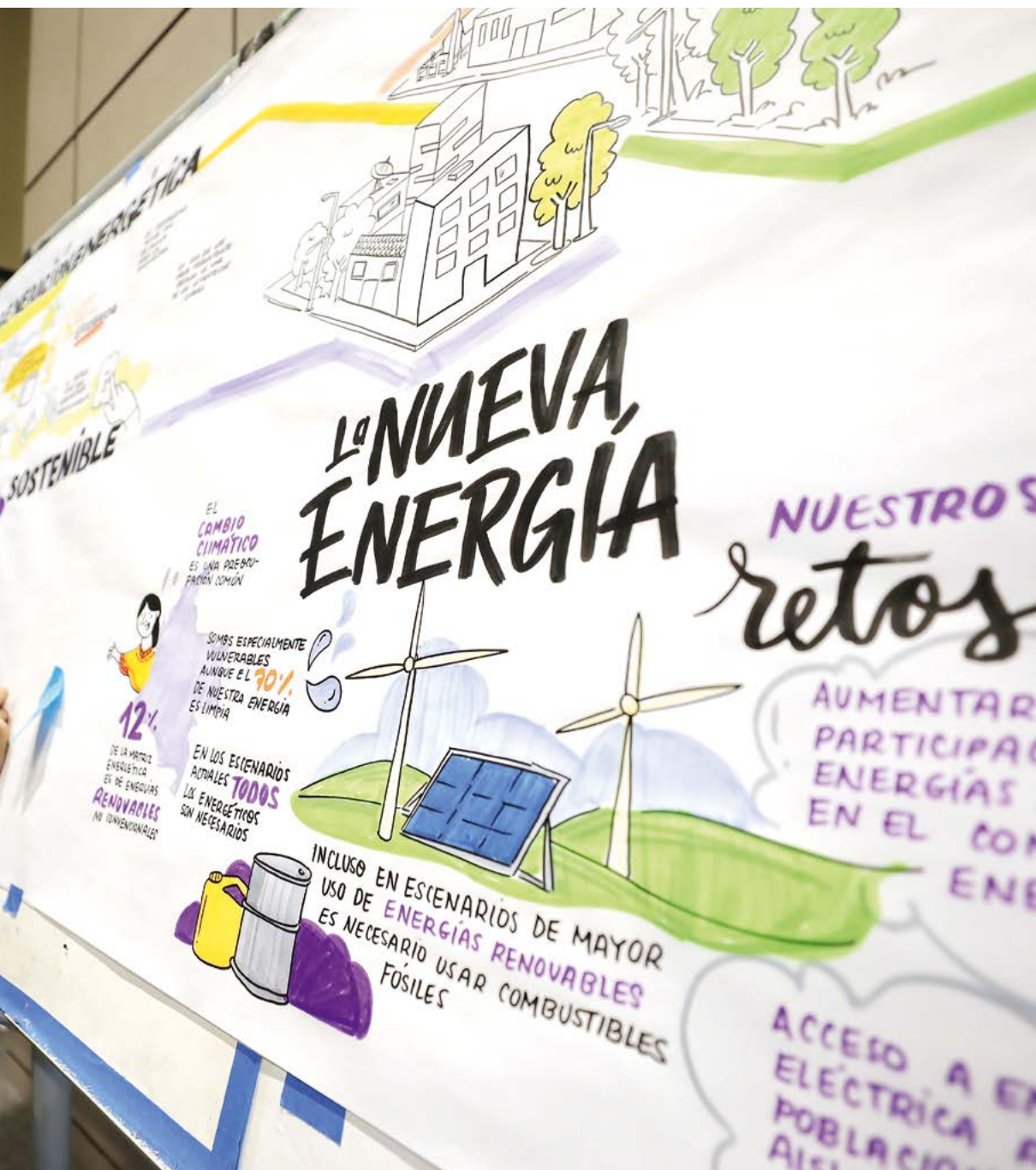
Pasto pilot project

The early victory project being implemented in the city of Pasto consists of a bicycle hub with eight bicycle charging stations along a university corridor and a fleet of electric and mechanical bicycles. The bicycle borrowing stations will be managed by each of the institutions wherein they are located, which will also be responsible for their ensuing operation.



Source: Progress Report: Energy Cities - UPME-SECO-AI

The project serves as a model to be replicated in other cities in the country based on their specific needs and aims to generate a sense of ownership and recognition by the communities where it is implemented. The expected results of the implementation of this project are the following: the reduction of greenhouse gas emissions by 85.1 tons of CO₂ equivalent per year, the saving of 312 megawatt-hours of energy per year through the energy efficiency measures applied, and the generation of 28.6 megawatt-hours of energy per year.



CHAPTER 5

The user at the center of the transformation

It is not an overstatement to assert that distribution and commercialization are key links in the electricity chain because, in spite of their final position, they provide the end-user a wide range of benefits, from operating their business to using their electrical appliances at home. They are the connectors between the electricity market and the end consumer.

In order for the system to function properly, these links must meet certain requirements, including reliability, competitive pricing and prompt response to user needs and complaints. The available scorecards indicate that Colombia has made significant progress in these areas. However, there are large indicator disparities among the companies that perform this work throughout the national territory.^{xxiv}

For example, in 2019 the average aggregate hours of interruptions was 39.5. However, while for a dozen companies this indicator was below 20 hours, in a few it exceeded 100 hours. Similar extremes are found in the indicator gaging the number of power outages, clearly confirming that the residents of the Caribbean area are those most affected by this situation.

Nationwide, the incumbent market of Network Operators coincide with the geographical departments. Each company manages the distribution networks and is the energy services provider for one or more territorial entities. The companies are compensated for their distribution activity according to the methodology established by CREG^{xxv} based on their existing and new asset base along with their investment plan. In other words, network operators are required to invest in the networks and strive to provide the best quality service as critical characteristics of their activity.

Distribution and commercialization play a fundamental role in energy transition because they are the links that will foster and encourage the upgrading of the network and provide opportunities for the involvement of end-users in the electricity markets. This latter point is essential to create the role of prosumers. The evolution of network operators, transforming themselves into service providers, will allow users to fully take advantage of their participation, which will in turn impact the market's efficiency.

Bearing in mind the importance of distribution, the recommendations offered by the Energy Transformation Mission focused on analyzing conduits to modernize the distribution network, increase its visibility in order to host distributed energy resources more efficiently, update the role of the distributor and propose opportunities for more efficient demand participation in the country. The foregoing is explained in depth in Chapter 7.

Competition in commercialization and efficiency for end-user pricing

Bilateral agreements are mechanisms whereby generators in Colombia sell power in the short and medium-term, establishing a fixed and indexed price for a certain amount of electricity for the duration of the agreement. This allows generators to obtain a stable income that helps them achieve financial feasibility when the plant is new and, in the case of an existing plant, reduces their exposure to uncertain future spot market prices, offsetting their volatility from energy sales income. The agreements complement the income obtained from the reliability charge mechanism and also recently from long-term contracts auctions.

As part of their activities, retailers have the duty of structuring a power purchase portfolio that balances their spot market purchases and their purchases in long-term agreements or auction mechanisms, seeking to optimize the resources and prices with which they satisfy their demand.

In a concentrated market such as Colombia, wherein many generators are integrated with retailers the shortcoming of said negotiations is that the prices agreed are not publicly available, which favors the dominant position of the integrated incumbents, and creates a barrier for other parties interested in the negotiation. Consequently, prices depend on the counterparty with whom the contract is negotiated, resulting in inefficiencies from this partiality and ultimately affecting end-users.

To correct the inefficiencies in bilateral agreements, it was determined that a transparent, anonymous and standardized market is necessary so that new agents may compete, and an efficient price is guaranteed to the end-user. Therefore, CREG Resolution 114 of 2018 was issued inviting agents to design, recommend and administer the market mechanism for negotiating bilateral contracts based on their own risk profile, with the incentive that the transaction prices between retailers and generators can be transferred directly to the demand.

The mechanism designed must comply with plurality, standardization, simplicity, availability of information, accreditation and anonymity characteristics, among others, striving to achieve the objectives of plurality, transparency, fairness and reliability. The proposals must include indicators to monitor the mechanism and evaluate its effectiveness, as well as confirm their price setting method, the administrator and executor of the mechanism, the risk manager, among others.

Thus far, two candidates have been announced which have submitted proposals for the development of standardized anonymous markets for power purchase agreements. One is the Bolsa Mercantil de Colombia (BMC for its Spanish acronym), which currently fulfills the role of gas market manager, and the other is Derivex, whose proposal was assessed by CREG and published for comments during 2020. Accordingly, there is much being done to encourage competition and efficiency in power purchase agreements.

Additionally, market behavior rules were established in 2019 for the public utility agents providing residential electricity and gas delivery services,^{xxvi} establishing guidelines to guarantee transparency, best practices in user information management and to ensure customers' interests were looked after. They specify behaviors that endorse the provision of free access to essential goods, competition, fair and nondiscriminatory treatment of consumers and agents and, in general, the actions required for the adequate provision of services.

Simultaneously, the principles, behaviors and procedures that retailers must comply with when entering into energy agreements for the regulated market were defined.^{xxvii} One of these provisions determines that retailers must design unbiased and transparent terms of reference, which will be published on an

internet-based platform set up for this purpose, specifying the quantity of energy, target term and other required conditions.

Thus, the buyer will purchase the energy from the provider who offers the lowest price and meets the conditions established in the terms of reference. In this way, fairness and competition are encouraged in these negotiations.

The second fundamental feature consists in the creation of a centralized public tendering system (SICEP for its Spanish acronym) to provide access to information on the energy trading process, giving way to greater transparency in the processes, reducing associated transaction costs, promoting competition and protecting the end-user.

It is noteworthy that, since the SICEP's inception, the platform has been used for 131 energy public tender processes, of which 76 have been awarded, 16 are open, 9 were canceled and 29 were abandoned.

The third important feature is the limit placed on the percentage of purchases that the marketer can make to agents with which it is integrated or wherein it has a controlling interest, i.e., related parties. The percentage allowed gradually decreases, starting at 50% in 2020 and concluding at 20% in 2027.

Finally, it is worth noting that as part of the energy transition process, it is considered essential for the end-user to be informed and have access to information that allows them to make better decisions, which is why a regulatory framework for the massification of Advanced Metering Infrastructure (AMI) has been developed. The Government has established the goal that, by 2030, 75% of SIN (National Interconnected System for its Spanish acronym) users will have advanced metering infrastructure. Consequently, CREG published in 2020 two draft resolutions to establish the responsibilities of network operators, retailers and users regarding AMI massification, as well as the deadlines, stages and conditions for its deployment. In addition, the Energy Transition Law set conditions about the smart metering infrastructure impact on the users' tariff, which may imply certain modifications to the previous proposals. It is expected that the final resolution by CREG will be published in 2021.

The importance of good behavior

In Colombia, the Government and CREG have established command and control tools and operational guidelines governing agents that provide public energy services. Additionally, regulation by incentives, is implemented a (revenue cap) which provides an explicit signal to reduce costs and consequently translates into increased profits.

However, regulation faces a natural difficulty in not being able to foresee all possible market situations that may arise. This in addition to the fact that the operation of the networks is by nature a monopoly which provides a competitive advantage to the retailers which are integrated with the Network Operator, who, in turn, maintain a relationship of control with the main generators nationwide. Therefore, an adaptive and clear regulation is required to encourage social well-being.

In response to the above, the rules governing the behavior of market agents were published through CREG Resolution 080 of 2019, in order to guarantee free access to the networks, the choice of service providers and the possibility of user migration. Likewise, transparency, fairness, economic efficiency, free competition and the non-abusive use of the dominant position were endorsed.

This resolution specifies that retailers must manage their conflicts of interest in such a manner as to ensure that their commitment to the well-being of end-users prevails. In the same way, it addresses the requisite principles of fairness and transparency that should govern access to networks and other goods necessary for the adequate provision of services, the proper handling of user information and data, and the veracity and clarity that must characterize all information delivered to users and other agents. In conclusion, the guidelines that govern the actions of agents are established so that their performance is transparent and there are no distortions in relationships between agents.

An additional scope of action consistent with the above is the visibility of the distribution network for users who require access. CREG Draft Resolution 002 of 2021 clarifies the previously established standards ^{xxviii} regarding small-scale self-generators and distributed generators. It specifies the conditions so that any user may access the network visualization system and foresees the possibility for connection requests and consulting costs to be done online.

This intends to guarantee access to information and eliminate existing barriers and restrictions thereon.

In addition to the abovementioned, the draft resolution establishes the acceptable response times by Network Operators to requests for information and connections from self-generators and distributed generators, in addition to standardizing the connection process according to the size of the project so as to guarantee uniform conditions for the interested parties. In order to ensure compliance with these conditions, CREG recommends carrying out an audit twice a year whose results are sent to the Superintendency for Residential Public Services to serve as an input in its oversight activities. The final resolution for small-scale self-generation and distributed generation is expected to be published during the first half of 2021.

Outlook for distributed energy resources

As part of its initiatives to transform the energy sector, the Ministry of Mines and Energy has included in its agenda the issuing of policy guidelines to incorporate distributed energy resources (DER) into the power grid.

Consistent with the recommendations of the Transformation Mission, it is worthwhile to open the door so that demand, distributed generation and storage can participate in the spot market and the reliability market. When Colombia attains a market for complementary services, these resources can participate and be compensated under equal conditions vis-a-vis other agents.

One modification that is considered necessary to achieve a flexible and dynamic participation of distributed energy resources in energy markets is the creation of an aggregator of these resources. Therein lies the challenge of evaluating whether a new agent is required, or this function can be included within the services offered by retailers.

Another component of this prospective scenario for the sector is to provide an open-access distribution network and for Network Operators to be able to use the distributed resources installed in their market to optimize their operations. The Transformation Mission emphasizes the migration to a Distribution System Operator (DSO) arrangement. This would require updating the compensation structure for the distribution activity in order for the distributor to encourage the installation of DERs and to provide services at the distribution level.

To the same extent that this seeks to advance a new role for the distributor, it also aims to encourage innovation and the emergence of new regulatory structures more responsive to the modern and shifting system that is being constructed. Regulatory sandboxes provide a mechanism to this end, and international references exist that can be employed in their implementation. For example, countries such as the United Kingdom, Canada and the Netherlands have already implemented such mechanisms.

Service on the Caribbean Coast

Electricaribe was the company that provided electric power services to the northern region of the national territory, covering seven departments: Atlántico, Magdalena, La Guajira, Córdoba, Cesar, Sucre and Bolivar. Its number of users was close to 2.7 million in 2018, which represents approximately 25% of national demand.

Service quality was considerably lower than that of other areas of the country, with a System Average Interruption Frequency Index (SAIFI) of 115, which indicated that users suffered an average of 115 power interruptions per year, and a System Average Interruption Duration Index (SAIDI) of 120, which indicates that on average users sustained outages of 56 hours per year, for 2019.

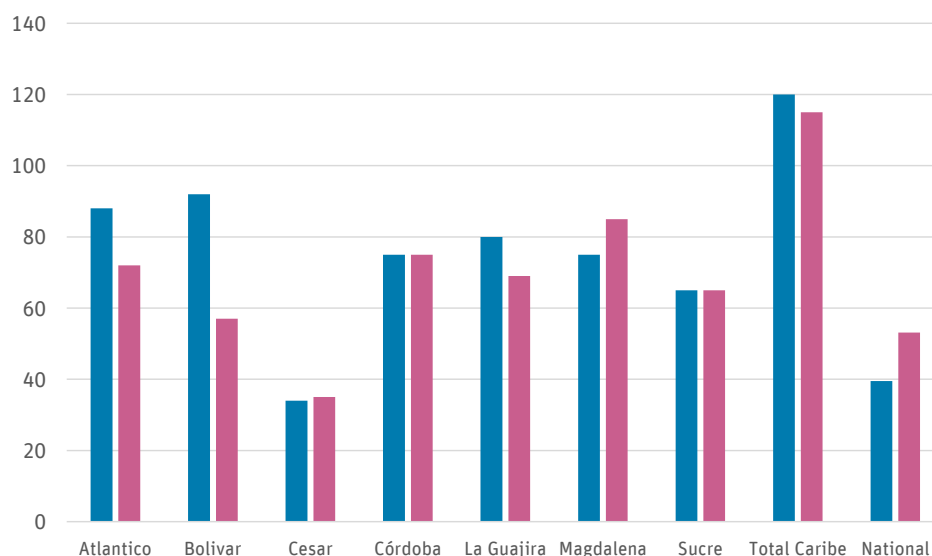
Various assessments have shown that the main reasons behind this issue were that they failed to complete the investments needed to replace obsolete equipment or did not perform adequate maintenance because of the profitability and financial solvency problems faced by the company. They noted Electricaribe's networks required annual investments of between 800 billion and a trillion pesos, far from the average 130 billion pesos invested annually over the past decade.

Additionally, Electricaribe had acquired a debt with generators that reached 300 billion pesos due to their failure, over various years, to pay off their obligations to the wholesale energy market. Their low investment levels resulted in energy losses that reached levels of over 30%, which far exceeded the value of efficient losses paid to companies. In this fashion, the Caribbean region suffered from a vicious cycle of underinvestment that resulted in low service quality, high losses and a low level of collection, which in turn meant

that the rate charged by the company was insufficient to leverage additional investments, exacerbating difficulties in the provision of services.

Over more than two decades, the Caribbean region was provided a service that did not meet the continuity and quality required by regulations, and for over 10 years the company experienced a negative net present cash flow value, which hampered its ability to access new sources of financing.

Figure 16. SAIDI and SAIIFI indicators for the Caribbean Coast in 2018



Source: Superintendency of Residential Public Services

In the exercise of its control duties, the Superintendency of Residential Public Services (SSPD for its Spanish acronym; also referred to as Superservicios) took possession of the assets and businesses of Electricaribe on November 15, 2016 in order to ensure the provision of electric power service to the departments supplied by this company. The main purpose of said intervention was to guarantee its customers a continuous provision of services and find comprehensive solutions to the problems afflicting electric power service in the Caribbean region.

After a rigorous evaluation carried out as of August 2018, the Superintendency concluded that the extremely grave financial situation faced by Electricaribe presented an imminent risk of a general cessation of payment of its obligations, including those for the wholesale market agents that provide the energy services required by users, thereby generating a risk that the company would not be able to provide the requisite service.

A solution to the problem experience by users in the Caribbean departments was an outstanding debt that persisted during three national administrations, and hence one of President Iván Duque's priorities was to provide a structural and definitive solution to this problem.

The National Development Plan of the Duque administration authorized a financial contribution by the service provider companies in order to raise approximately 620 billion pesos for the financial sustainability of the Business Fund that guarantees the provision of the service to the companies intervened by the Superintendency of Residential Public Services, including Electricaribe. In addition, it increased limits to vertical integration in order to provide existing agents the opportunity to participate in the Caribbean market auction.

CONPES Document 3933 of 2018 approved the Nation's guarantee on the Business Fund of the Superintendency of Residential Public Services in order to access a credit line of 735 billion pesos, used to ensure the investment and recovery plan regarding Electricaribe losses during 2019. These resources were employed to complete works to improve quality, reduce losses, expand infrastructure capacity and upgrade technology while the auction process was being structured.

With the Government's support and as part of its duties, the Superintendency of Residential Public Services established that the business solution for Electricaribe consisted in finding one or two investor-operators that could provide the electric power serviced by Electricaribe. At the beginning of President Duque's term of office there was a process under way contemplating a single bidder, which was canceled in order to structure an auction that would include more participants and foster competition.

The auction design to select investors, directed by the Ministry of Mines and Energy, the Ministry of Finance, the National Planning Department and the Superintendency of Residential Public Services, included the option of

dividing Electricaribe's market into two smaller regions. This structure was determined to be advantageous for the following reasons:

1. Guarantees a definitive solution for the provision of service to nearly 10 million residents
2. Ensures the execution of investments
3. Adapts the network to current and future demand growth.
4. Significantly improves service quality and continuity indicators
5. Market segmentation implies lower initial capital needs per investor
6. Distributes the existing company risks
7. Allows for smaller companies that are easier to manage

In this manner, the market segmentation process was finally carried out, creating Caribe Sol and Caribe Mar. The first covers the departments of Atlántico, La Guajira and Magdalena, and the latter Bolívar, Sucre, Córdoba and Cesar. In addition to the creation of these new markets, it was necessary to design a special rate regime for the Caribbean zone that considered the special needs of this region. CREG Resolution 010 of 2020 establishes the recognition of retroactive losses, in order not to perpetuate the deficit by recognizing losses while the new companies make the necessary investments to recover the service quality. Likewise, this resolution established the pathway towards a quality improvement in line with the reality faced by the Caribbean markets and an adjustment to reimburse Administration, Operation and Maintenance (AOM) expenses. These efforts sought to ensure the financial viability of the provision of service in the Caribbean region and attract investors to the selection process.

Consequently, during 2020 and within the framework of the business solution designed and headed by the administration of President Duque, an auction was held to select new service providers for each market. As part of the process, the Government committed to assuming liabilities totaling 1.4 trillion pesos in order to attract investors.

In this auction, Aire and Afinia were awarded the Caribe Sol and Caribe Mar markets, respectively. Aire is a consortium led by Empresa de Energía de Pereira, and Afinia is a subsidiary of Empresas Públicas de Medellín, which began operating in their particular markets in October 2020.

These new companies guaranteed the implementation of the employer substitution model for the 1,410 direct employees and the realization of timely investments in the networks of the magnitude required to repair the deficient state of the network's assets and improve the quality of user service. In the Caribe Mar market, the investment foreseen over the next five years is 3.2 trillion pesos and for Caribe Sol totaling 2.6 trillion pesos, which will benefit the users living in the corresponding departments, amounting to almost three million in each case.

The aforementioned activities are complemented with the execution of the "Plan 5 Caribe" that includes contracted investments for 2.97 trillion pesos targeted towards improving the reliability of the electric power system in this area of the country. To date, the Government has begun operations in 13 works of the 22 completed to date, which include substations, new lines and transformers.

The electrical strengthening of La Guajira deserves special mention within this body of works, inaugurated in November 2020. This project will improve the reliability of the department's regional transmission system by adding an additional line from Cuestecitas to Riohacha, and closing the electrical ring between Riohacha and Maicao. The initiative directly benefits 50,000 families in the municipalities of Riohacha, Maicao, Uribia and Manaure, and indirectly benefits the entire region.

In addition to the foregoing, there are another fifteen projects in progress amounting to nearly 3.8 trillion pesos. Said expenditures, along with those being completed by Afinia and Aire, will lead to a significant increase in the quality of service received by the almost ten million inhabitants of the country's northern region.

The structural solution to the Caribbean Coast's problem and the advancement of activities focused on improving the reliability of the network's transmission, along with the sponsorship of a greater number of possibilities to encourage participation by market agents, clears the way for the electricity market of the future, which has at its center the best interest of the users.



Image: Ministry of Mines and Energy of Colombia/ César Nigrinis Name

CHAPTER 6

Commitment to equity and the power to transform lives through energy

Although Colombia has made significant efforts towards increasing the coverage of public services, much remains to be done. Both sector indicators as well as poverty multidimensional measurements reveal that there is an important group of citizens, mainly located in isolated rural areas, that lack the same levels of access as their counterparts.

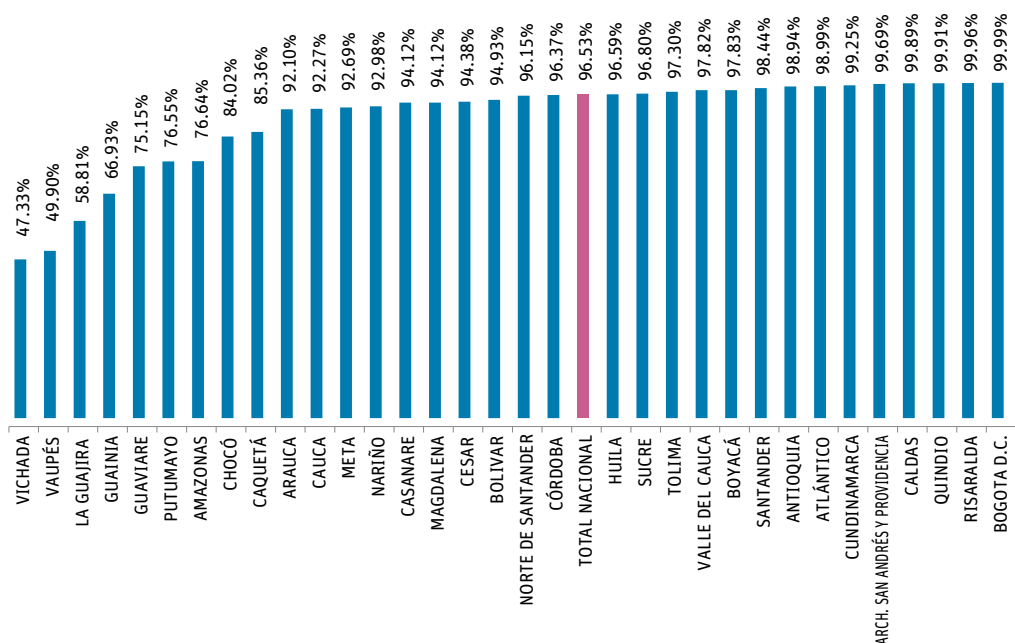
The consequences of this reality are clear: fewer progress possibilities for those who are born and live in a home where there is limited access to nighttime light or to drinkable clean water. Such a situation in an unequal country like ours is a clear call to action for the State to do whatever is within its power to close the existing gaps.

In 2018, the Mining and Energy Planning Unit, using information provided by different sources, determined that the total number of households in the national territory was 14,294,753, of which 13,798,765 had electric power service. In other words, the coverage indicator reached 96.5% for that year. Providing electricity to the remaining half-million families is an objective included within the energy transition and the national sector strategy.

One of the reasons for this is that energy transition has enabled new technologies to provide solutions that differ from a traditional connection to the national grid.

A simple glance at the map confirms large regional imbalances. It can be observed that the departments of Vichada and Vaupés have the lowest coverage rates of the entire country (below 50%). In contrast, Cundinamarca, San Andrés y Providencia, the coffee growing axis departments and Bogotá have rates that exceed 99%.

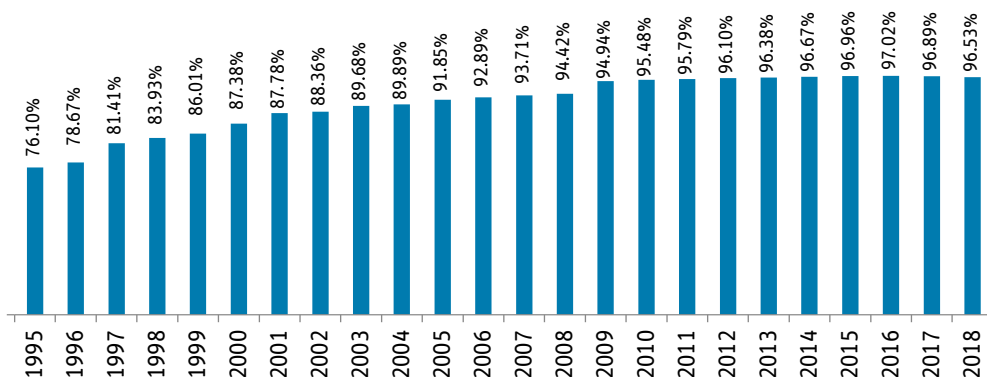
Figure 17. Departmental Electric Power Coverage Index (ICEE for its Spanish acronym), 2018



Source: Mining and Energy Planning Unit (UPME)

This impression does not dismiss the progress made, especially when comparing these figures with the snapshot at the end of the last century. However, it is obvious that a sort of stagnation has occurred in recent years, attributable to the difficulty of accessing those more remote places with a permanent and sustainable solution.

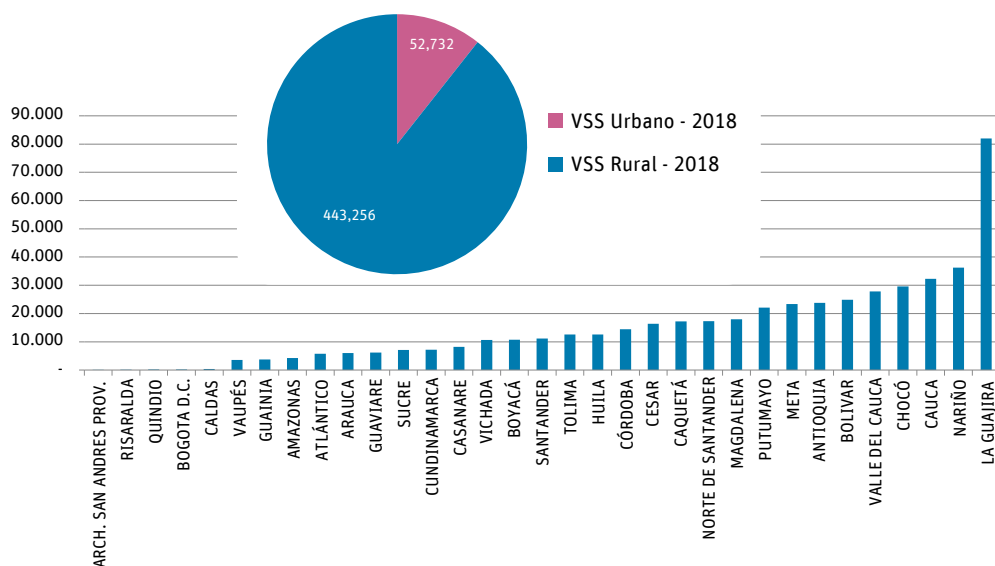
Figure 18: National Electric Power Coverage Index (ICEE), 1995 - 2018



Source: Mining and Energy Planning Unit (UPME)

To complete this diagnosis, it is important to consider the number of households without service by department (Figure 19). Here, too, the differences and delays are clearly visible, which must be overcome in order to guarantee everyone the same opportunities.

Figure 19. Households without service by department, 2018



Source: Mining and Energy Planning Unit (UPME)

The commitments

In light of this reality, President Duque's government defined as one of the National Development Plan's goals to expand the coverage of the electricity supply to 100 thousand new households (about half a million people) through the use of public funds. Of this total, 40,000 households are located in the municipalities prioritized by the Territorially Focused Development Programs (PDET for its Spanish acronym). Likewise, it is estimated that around 45,200 new users will receive electricity for the first time through individual photovoltaic solar solutions, thus guaranteeing an energy supply to isolated or difficult-to-access users, whose operation does not generate greenhouse gas emissions in regions of the Colombian geography that have difficulties connecting to the national grid.

The responsibility for reaching this target rests with the Ministry of Mines and Energy, along with its affiliate agencies. In regulations, notable progress has been made, which has translated into virtual or logistics networks that allow incumbent operators to carry out projects with individual solutions or microgrids and be compensated by established rates. Transitory rates resolution that authorize compensation to individual solar systems, public-private partnerships for Non-Interconnected Zones (ZNI, for its Spanish acronym) or new multidimensional arrangements have been implemented.

In order for these initiatives to become viable, the resources from the Financial Support Fund for the Electrification of Interconnected Zones (FAER for its Spanish acronym) and the Financial Support Fund for Electrification of Non-interconnected Zones (FAZNI) are available. Likewise, resources have been allocated from the General Royalties System (SGR for its Spanish acronym) and from the development plan for the pacific region *Plan Todos Somos Pazcífico* (PTSP for its Spanish acronym) to develop the projects. Finally, the electricity provision activities are complemented with solutions financed with resources from the Institute for Planning and Promotion of Energy Solutions for Non-Interconnected Zones (IPSE for its Spanish acronym).

The efforts to date can be classified according to two different progress stages as of September 30, 2021:

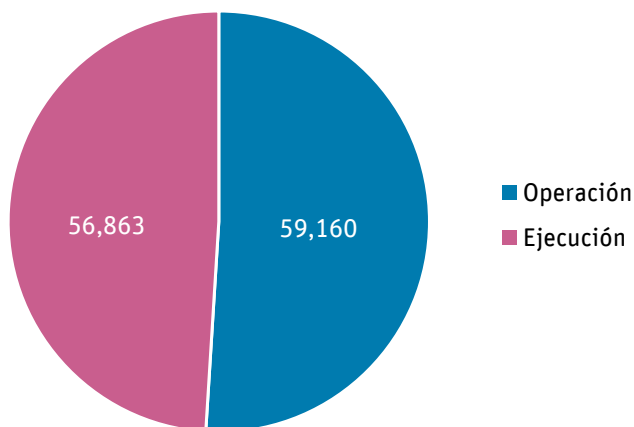
- Projects in operation: are completed works that have provided electricity to new families since August 2018. Here we can find projects financed

with resources from the FAZNI, FAER, IPSE, the SGR and the PTSP. At this point in President Duque's administration, electricity has been supplied for the first time to 60,185 households through the entry into operation of more than 150 projects in 25 departments

- Projects in execution: are works underway, meaning the contracting process has been completed with the corresponding operator. There are currently 193 electrification projects in execution in 25 departments that will benefit 51,872 new users. In this case, the resources come from the FAER and FAZNI funds, as well as from the PTSP and the SGR.

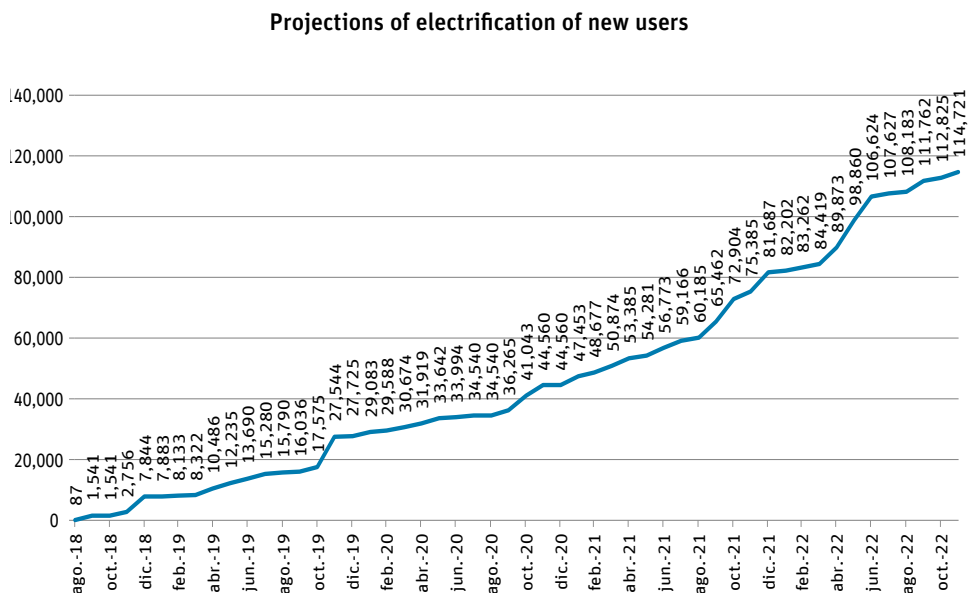
When the reports are jointly evaluated, it is clear that the target will be effectively achieved by July 2022, which should serve as encouragement to stay on this course.

▼ Figure 20. Users benefitting from electrification projects – Goal 100,000



Source: Own elaboration

Figure 21. Projections of new users connected during the current administration's 4-year term, 2018-2022



Source: Own elaboration

Lessons learned

The work carried out has provided important lessons. Various difficulties have been evidenced in different stages during the development of new user electrification projects. A review of the solutions provided thereto found these can be affected by issues such as very long structuring times that affect the initial assumptions or alter the financial projections due to exchange rate fluctuations or commercial factors.

In the construction stage, some of the projects have been affected by variables whose contingency is difficult to predict, such as weather events or public order issues, particularities of the communities and/or delays in the import of equipment (logistics). These inconveniences affect in turn the execution schedules and consequently the completion delivery date.

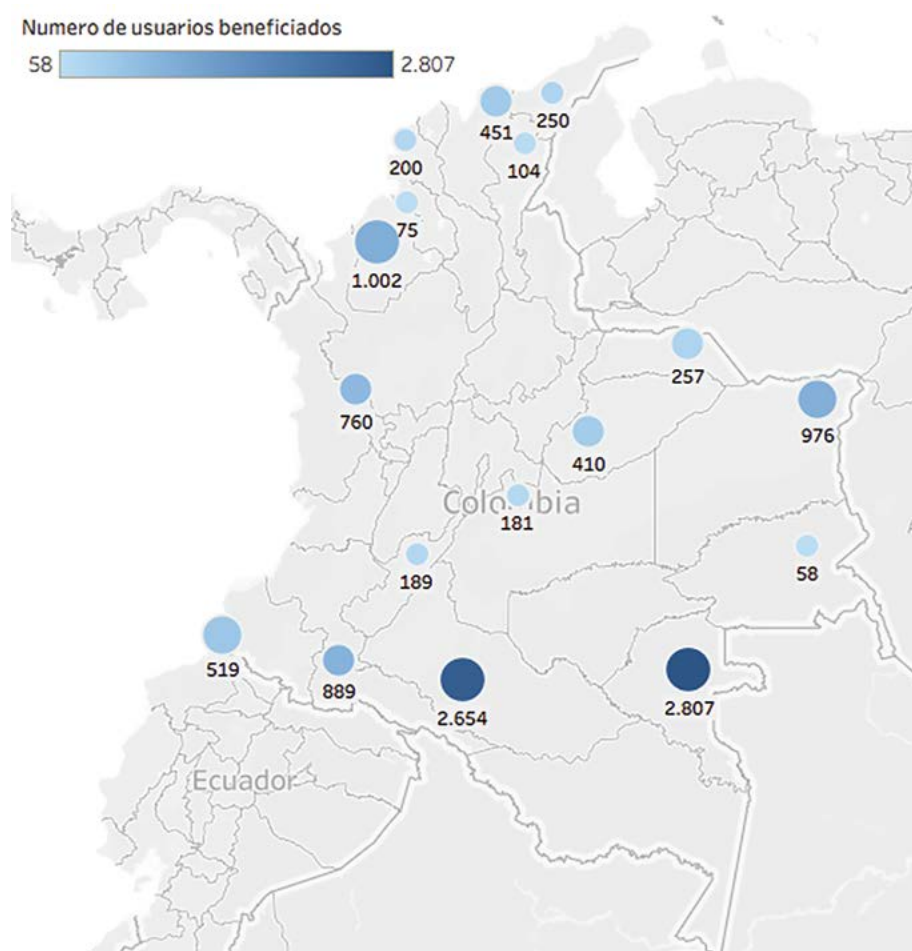
Finally, the operation stage has encountered difficulties associated with AOM and guarantees, user training and financial sustainability of the solutions provided. In general, few projects are exempt from such obstacles or other sorts of difficulties, but what is most worth salvaging from the experiences is the importance of working with the community or including sustainability designs. From this experience, the Electric Power Directorate of the Ministry of Mines and Energy has found that it is the Networks Operators who can best testify to such instances since they are the ones in direct contact with the builders and know the specific characteristics of the communities where each of the new facilities are built.



Image: Ministry of Mines and Energy of Colombia/ César Nigrinis Name

The rural electrification initiatives currently in the various development stages are divided into two electrification categories. The first is to provide a supply through an interconnection to existing systems and the second are isolated solutions through photovoltaic systems. The latter are present in a third of the households that have electricity as a result of these accomplished endeavors (41 projects in 18 departments).

Figure 22. Distribution of new users electrified with photovoltaic solar solutions, 2018-2020



Source: Own elaboration

The implementations of these solutions throughout the national territory have had an average cost per user ranging between USD \$5,500 and USD \$8,000, while the national average is around USD \$ 6,800. Given the rate of technological advances, it is foreseeable that this category will continue to grow, contingent on its consolidation and efficiency, while technology costs will decrease hand in hand with technological progress.

A life changer: The transformative power of renewable energy

For Nevis Troncoso, resident of Crucito, a village in Tierralta in the department of Córdoba, solar panels changed her life. Instead of moving around in the dark or relying on the light of a flashlight after the sun sets, her nighttime routine has changed dramatically. “We have light all night long. We can no longer hear the noise of the plants and we put a fan in the room. Now we can finally sleep comfortably and peacefully!” affirms her husband Luis Carlos López.

That improvement is noticeable in large and small details. Before, in order to charge their cell phone, they had to go to the store and pay a thousand pesos. Before, Shaira, their youngest daughter, had to complete her homework by candlelight. Before, a television was a dream that seemed unachievable. Today everything has changed, and not just because of the device installed in their living room.

A similar impression runs through the mind of Elías Ramos, several hundred kilometers to the north of the country in the department of La Guajira. After working for 35 years in Cerrejón, at the end of 2019 he decided to dedicate himself fully to the farm, which had lain abandoned for years in the village of Las Dudas - Aguas Arriba village, in the municipality of Urumita.

“Because we didn’t have light, we couldn’t live here. So, we came over very early in the morning, worked in the tomato field, with the chickens, with the animals, and at five or six in the afternoon it was vacant once more, we all left again,” he recalls. In February 2020 he received the single solar panel that qualifies as a blessing.

Thanks to this power he decided to undertake a new project: four tanks in which he is realizing a fish farming project. Currently, his first batch of over 1,500 tilapias is very close to completing its growth cycle. “For me, the sun is life, and the power is the blessing that allowed us to come back and fall in love with our country life,” he says.

To the south of the national territory, in the jurisdiction of San Vicente del Caguán, lives Alba Nelcy Pinzón, better known as “Doña Chela”, whose livelihood depends on the sale of milk. 57 years old, she is a recognized community leader in La Granada, where she lives with her husband and 16-year-old grandson.

After installing a solar panel in their home, the family was able to light up the barn with LED bulbs, making tasks such as getting up to milk the cows at dawn much easier. A thousand families in the area, who have seen their productivity improve because of the same technology, today recount similar stories of progress.

Necessary substitution

The image may be anachronistic for the millions of Colombians that reside in the big cities, but in numerous localities nationwide cooking with firewood is a reality, as corroborated by available data. According to the Quality of Life Survey for 2018, 1.77 million households are still using solid fuels for cooking.

That is why the National Development Plan determined that the Ministry of Mines and Energy would launch a program to replace firewood and charcoal with LPG in a target 100,000 households. Accordingly, monitoring has been carried out in various departments, supported by data from the subsidy system. A preliminary assessment indicates that since August 2018, a total of 68,250 households have switched to gas purchases.

Such an improvement complements an obvious truth. Gas is an essential service in the life of Colombians, not only because eight out of ten households use it on a daily basis, but because it contributes towards protecting the environment and closing existing gaps. Additionally, it is considered an energy transition fuel: it reduces carbon emissions by 40% and particulate

matter by 96%. In the five-year period from 2015-2019, sustained growth in its consumption was notable. During this period, residential sector demand increased by 20 million cubic feet per day as a result of the entry of 1.8 million users into the system.

This growth is ongoing. While by the end of 2018 there were 9,595,597 users to connect to gas distribution networks, by the second quarter of 2021 this number amounted to 10,610,568 users from which 10,414,232 are residential. Thus, effective residential coverage reached 98%.

Among the factors that have streamlined the provision of gas services (natural gas and LPG distributed through networks), is a distinct State policy expressed through suitable regulation, as well as a subsidy arrangement that involves infrastructure construction and coverage for the low-income demographic. Beyond the foregoing, measures have been put in place aimed at fostering the competitiveness of natural gas, the union of private and public investment for the execution of projects and the development of a gas culture publicizing the advantages of this energy source.



Image: Ministry of Mines and Energy of Colombia/ César Nigrinis Name

The institutional offer by the Ministry of Mines and Energy is summarized as follows:

Investment Project	Program	Objective	Regulatory Framework	2021 Resources
Assist the financing of projects geared towards the development of infrastructure and connections for the use of natural gas at a national level.	Co-financing of transport, distribution and connection infrastructure through the Special Fund for the Promotion of Natural Gas (FECFGN for its Spanish acronym)	Promote and co-finance transport, distribution and connection infrastructure projects to provide low-income users access to public natural gas services	Single Regulatory Decree of the Mining and Energy Administrative Sector No. 1073 of 2015; UPME Resolution 0417 of 2010	COP \$17,178 million countrywide
National allocation of resources for cylinder consumption and infrastructure projects for LPG	Assistance to the co-financing of projects for the development of distribution and connection infrastructure for the use of liquified petroleum gas (LPG) through networks nationally	Promote and co-finance projects for the provision of LPG services through networks	Ministry of Mines and Energy Resolutions 90032 and 90033 of 2014	COP \$101,591 million countrywide

Investment Project	Program	Objective	Regulatory Framework	2021 Resources
Allocation of resources to users of fuel gas by network for low-income socio-economic strata 1 and 2 nationally	Allocation of resources to users of fuel gas by network for low-income socio-economic strata 1 and 2 nationally	Subsidize basic subsistence consumption (20m ³) for low-income socio-economic strata 1 and 2 users for fuel gas delivered by network (natural gas and LPG by networks)	Solidarity Fund for Subsidies and Income Redistribution (FSSRI for its Spanish acronym); Single Regulatory Decree of the Mining and Energy Administrative Sector No. 1073 of 2015	COP \$623,634 million countrywide

Source: Own elaboration



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

CHAPTER 7

*Energy Transformation Mission: roadmap for the modernization and inclusion of new technologies in the electricity sector*⁴

Cognizant of the challenges of adopting a cleaner generation and consumption matrix, in 2019 the Government of Colombia, through the Ministry of Mines and Energy, convened a Mission of Experts to recommend modifications aimed at fostering the energy transition. It expected this mission would provide a proposal to modernize the institutional and regulatory framework so as to facilitate the inclusion of new agents, technologies and a new transactional framework in the electricity market.

Advancements in information, telecommunications, control and oversight technologies and the trend towards greater decentralization of energy production activities and associated transactions require a framework conducive to innovation and technical change.^{xxix} Electricity markets have been adjusting to support these trends, exploiting in this way the mounting benefits they convey, thanks in part to the reduction in the costs of associated technologies.

In Colombia, Laws 142 and 143 of 1994 established a suitable operating framework, which deserved a much need comprehensive review after almost three decades. Market liberalization, the introduction of competitive price-setting in generation, incentive regulation in transmission and distribution and institutional progress have made it possible to have a reliable supply, even in periods of reduced or variable water provision, with an internationally benchmarked management model over the years.

4 | Special thanks to Dr. Ángela Inés Cadena, mission coordinator, and to the experts who assisted in developing and analyzing the recommendations.

Even so, from the beginning it was clear efforts were still needed to guarantee a supply with efficient pricing, achieve higher service quality and providing wider coverage, and to increase resilience to climatic phenomena. In addition, industry changes offer opportunities to boost competition, diversify the generation portfolio, increase the participation of the demand, automate distribution networks, leverage local resources embedded in distribution networks and modernize the market's architecture and regulation.

For its part, the Ministry considered “the high level of concentration in certain segments of the electricity market, the vulnerability of the sector to hydro-climatic events and their increasing intensity and frequency, the low participation of the demand, the need for better quality conditions in the service supply and the need for a better rate structuring to benefit the end-user.” Thanks to the support of the Inter-American Development Bank and the World Bank, it was possible to assemble a group of 20 national and international experts focused on five areas.

Specifically, the panel sought to resolve two central questions: How to ensure that regulation allows for innovation or the introduction of new technologies quickly enough without jeopardizing reliability? and, what should be the institutional and regulatory framework that ensures that the market is disposed towards benefitting the user and generating efficient pricing outcomes for the demand?

As a result of the Mission's first phase, about a hundred proposals on the previously listed points were received. Accordingly, the Ministry, jointly with the entities comprising the Technical Secretariat of the Mission,⁵ focused on furthering a review and discussion process on the submitted initiatives in order to prioritize the various issues. These inputs were used to construct a roadmap for updating the sector over the next 30 years.

In september 2021, the Mission's roadmap was published, which contains the proposals that will be implemented in the short, medium and long-term. The magnitude of the work can be understood more clearly in light of the recommendations offered. In summary, proposals were provided to improve

5 | Entities participating in the Technical Secretariat of the Mission: Mining and Energy Planning Unit (UPME), Commission for Electricity and Gas Regulation (CREG), Institute for Planning and Promotion of Energy Solutions for Non-Interconnected Zones (IPSE), National Hydrocarbons Agency (ANH), Superintendency for Residential Public Services (SSPD), National Planning Department (DNP) – all acronyms in Spanish.

the electricity and natural gas sector which, in the interest of clarity, are grouped here under five main topics:

Recommendations for the wholesale market

- *Short-term market design.* The implementation of a nodal pricing structure that considers efficient energy payments and charges for congestion and losses is recommended. It seeks to provide consumers and agents with price and locational signals that support efficient consumption and locational decisions. Additionally, it recommends continuing with the initiatives that CREG has been carrying out: intraday markets, balancing mechanisms.
- *Improvements in the design of bilateral contracts and markets.* The recommendation is to continue progressing with the development of standardized markets in view of improving the credit security of transactions. Another key issue is to align incentives between the retailer and the end-user, seeking the best way to share the risks, and for the



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

retailer to make decisions considering the best interest of the user. Similarly, it recommends allowing unregulated users to negotiate directly with generators.

- *Long-term sufficiency and resources: energy contracts and reliability charges.* This proposal seeks to guarantee reliability in the supply of a hydrothermal system, such as the Colombian one, with an accelerated increase of non-conventional renewables. Initially, improvements are recommended to correct the shortcomings in the current reliability charge mechanism and complement this arrangement with a long-term contracts system.
- *Participation of distributed energy resources.* The recommendation is that demand and other resources such as distributed generation and storage take part in the spot market and the reliability market, represented by aggregators or retailers. To play an active role in price structuring and the system's flexibility, it is necessary to guarantee a level playing field with regard to other agents, and to encourage competition. To the extent allowed by the equipment, demand must be allowed to provide all those services that it is technically capable of providing (including congestion management, maintenance frequency services, etc.). Consideration should be given to the creation of active demand response programs.
- *Improvements in transmission planning and expansion.* It is advised to include new criteria in network planning, as well as to modify the definition of the National Transmission System (STN for its Spanish acronym), including the Regional Transmission System (STR for its Spanish acronym), to improve competition in the development of new projects, reduce barriers relating to storage systems and new renewable and distributed energy resources.
- *International interconnections.* To augment the benefits of international interconnections, it is necessary to: (i) define in the energy policy the creation of an energy hub to trade energy; (ii) have regulatory harmonization schemes; (iii) create the figure of International Agent that can freely negotiate in the different markets; (iv) develop a liquid contract market that guarantees the creation of low-risk portfolios for the parties; (v) allow free access to interconnections; (vi) include within the network

expansion plan those interconnections with a positive social benefit; and (vii) allow the development of at-risk interconnections.

Recommendations to update the distribution network

- *Incorporate distributed energy resources (DER).* National experts find that, in order to eliminate the discretion inherent in the requirements, it is necessary to facilitate connections with gravity, security and reliability, and to accelerate the inclusion of DERs. They also suggest reformulating the backup charge for self-generation, for which they recommend: (i) associating the penalty to congestion; and (ii) redesigning the arrangement to signal congestion contingent on the network capacity used. Likewise, the recommendation is to incentivize the penetration of electrical mobility alternatives.
- *Design of flexible regulated rates for end-users.* In the short-term, the rate structure must become gradually more sophisticated to allow the sending of efficient consumption signals (and distributed generation) to motivate network users to reduce their energy consumption during the hours with the highest market pricing.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

- *Increased visibility and transparency for distribution systems.* It is important to compute hosting capacity maps, including a list of descriptive and performance indicators (along with spatial and temporal granularity) to encourage transparent and efficient investment in distributed generation. CREG must establish criteria for what kind of data should be handled confidentially and what should be the format and channel arrangement as well as the agent authorized to handle such data. The role of aggregator has been revised.
- *Planning and compensation for the distribution systems.* The recommendation foresees carrying out regulatory reform in the long-term, leading to a compensation based on total expenditure (TOTEX) output-based (common supply quality objectives, and others aligned with the country's energy policy, efficiency, client satisfaction, penetration of distributed resources, etc.), with a longer regulatory period (between 5 and 10 years) and with a flexible compensation that can help to effectively mitigate the risk associated with the distribution activity.
- *Creation of distributed platforms to purchase network services.* In order for the distribution network to become an efficient platform with open access for different services, CREG's proposal to regulate the installation and operation of Energy Storage Systems with Batteries in the SIN is a good first step. It should be clear that the distributor should never have ownership over the asset (generation or storage) that provides network services. The asset investor should be able to, for example, simultaneously sell energy on the exchange, complementary services to XM and network services to the distributor.
- *The new role of the distributor.* It is suggested for the distributor to become a network operator and for there to be a structural separation between the distribution and marketing (sales) businesses. Failing that, prevent the marketer from competing for users of its distribution networks. If these alternatives are not selected, strict oversight mechanisms must be designed by the regulator to prevent the distributor from conditioning competition in its distribution networks, minimizing entry barriers.

Natural gas market recommendations

- *Reliability and security of supply:* A new planning structure is proposed to guarantee an extensive supply of natural gas with a flexible horizon of 10 years. The offer must consist of production declarations for the projected horizon and the capacity of the regasification plants. The demand must be estimated taking into account the total potential demand of the thermal plants. In addition, it is suggested to apply an open access or open access with exemption regime to the regasification plants. Furthermore, the criteria for selecting the developers of these plants should be the minimization of the Annual Income offered, which will cover their capital expenditure, the profitability thereon and the annual operating expense over a 10-year horizon.
- *Expansion of the gas transportation system and reliability projects.* It is recommended that the planning of the system expansions adopt a 10-year outlook. New infrastructure projects identified will be classified as: strategic, characteristic, or reliability related. The strategic ones are network extension projects that the Government deems necessary and would be developed through public tenders. Characteristic projects would be those identified by the company and which the existing sectoral agents consider they can develop profitably. Reliability related projects would be defined through a hybrid mechanism, where coordination between the agents involved in decision-making is facilitated.
- *Transport service compensation and rate methodology.* Adopt the “Common Carrier” model in the National Transportation System (SNT for its Spanish acronym) that would replace the “Contract Carrier” model currently in force. This change essentially consists of transforming the scope of action from vertically integrated industries into industries that separately develop monopolistic activities and competitive activities. This model would imply an adhesion contract and a compensation methodology under the “Revenue Cap” method (regulated income). As a rate methodology, the Entry-Exit model would be adopted, in which entry charges (injections) and exit charges (withdrawals) are established. Regulated revenues that compensate carriers will be distributed 50% / 50% between the entry and exit charges.

- *Market operation.* Create a new institutional agent for the sector called Independent Technical Manager for the Transportation and Storage System and a Virtual Transactions Center (HUB). The Technical Manager must guarantee open and unbiased access to gas transportation for all users, enforce operational discipline among retailers and end-users, facilitate the attainment of a daily operating balance that does not place the system at risk, and create a liquid market of gas pipeline capacity.
- *Gas-electricity coordination.* Thermoelectric gas organization and involvement is achieved through: (i) a modified approach through the recommended delivery and transport planning, which avoids resorting to gas rationing and limiting the supply of gas and/or transportation; ii) eliminating the gas supply nomination term (6 hours), allowing the thermoelectric plants to take gas from the transportation network whenever the National Dispatch Center (CND for its Spanish acronym) requires it; through real-time communication between the CND and the Technical Manager; (iii) by allowing, in an agile and timely manner, for the thermoelectric plants in the intraday market to acquire gas in the primary



Image: Ministry of Mines and Energy of Colombia/César Nigrinis Name

or secondary market through physical or virtual transactions; (iv) timely and transparent information from the Technical Manager; (v) Entry-Exit charges would reduce the dispersion of transportation rates.

Coverage and subsidies recommendations

- *Electric power coverage.* Continue with the implementation of integrated planning to identify investments and projects in order to achieve the targets at the lowest cost possible and establish priorities and reference costs. A minimum cost electrification plan must be able to provide a comparison regarding the option of electrification with networks, microgrids and individual systems to achieve savings in service costs, guaranteeing adequate quality levels in each situation. The recommendation is to analyze the territorial concession model with responsibility for universal service in the assigned area through an auction process, both as a default and as a last resort supplier (in the event another supplier exists in the area and abandons it), but only exclusively for the supply by extension of the interconnected network. Ownership and responsibility for the maintenance of the equipment lie in the service provider, which relates to its customers through a utility-like format.
- *Institutional and electrical governance framework.* UPME should be the exclusive sectorial planner with responsibility for the feasibility of projects therein. Additionally, it is necessary to strengthen institutional capacities to structure projects, carry out contracting processes and monitor execution, which are tasks that would be assigned to the IPSE. Likewise, the recommendation is to improve collection and access to information in order to support the assessment of the impact and efficiency of processes relating to the allocation of funds.
- *Quality of the service Improvements.* Define and set differentiated quality goals between rural and urban areas as well as quality goals for the different development levels, for example, by establishing acceptable quality levels in the, accepting targets for gradual improvements and having a review and evaluation system regarding target compliance. Additionally, recommendations include to continue furthering the technological improvement of the networks (installation of telemetry systems in the SIN and ZNI; updating of the portfolio of construction units managed by CREG to include isolated solutions; standardize definitions

so that distributed generation systems ensure the voltage or wave quality injected into the network will not cause disturbances in the system).

- *Natural gas, LPG coverage and reduction of firewood consumption.* Establish conditions of suitability of the distributors in charge of the projects of the Special Fund for the Promotion of Natural Gas (FECFGN), which guarantee the medium and long-term provision of the service. Second, prioritize FECFGN resources to co-finance connections for low-income socioeconomic strata 1 and 2 users. Finally, once the expansion targets have been met, FECFGN should be eliminated. In addition, UPME and the IPSE should prepare Sustainable Rural Energization Plans (PERS for its Spanish acronym) for each department. IPSE must structure integral energy solutions for the cooking and electricity requirements of the population in ZNI areas and other isolated and rural areas. UPME must set up an information system with projects and programs to expand the coverage of fuel gas and efficient electric cooking.
- *Funds.* Unify the FAER and FAZNI funds. In terms of targeting, the resources of the energy funds should be used exclusively for those solutions that are not profitable for non-governmental entities. IPSE must structure or identify strategic projects. Regarding the PRONE, the following are proposed: (i) a gradual dismantling of the subsidies financed with the Social Energy fund (FOES for its Spanish acronym) as a result of the strategic execution of the Electricity Networks Standardization program (PRONE for its Spanish acronym) in areas identified as subnormal. Once this objective is fulfilled, these subsidies should be dismantled to help discourage illegal connections; (ii) include the source of the resources that nourishes the PRONE in the Fund that would unify the FAZNI and the FAER.
- *Design and structuring of subsidies.* The current division through the strata system is not an effective targeting tool. The Mission recommends the following: (1) Condition the receipt of the subsidy by demonstrated need according to the information contained in the SISBEN (Identification System for Social Program Beneficiaries, for its Spanish acronym) in addition to the requirement to be located in the 1, 2 or 3 strata. The implementation of this alternative entails logistical changes in terms of the distributor's verification systems, or a centralized method administered by the State to assign the subsidies. For these reasons, this would be a medium-term



Image: Ministry of Mines and Energy of Colombia/César Nigrinis Name

target restructuring scenario. (2) The most effective and implementable short-term alternative regarding electricity is to restrict the delivery of subsidies to households whose consumption does not exceed a limit level of subsidized consumption (using a moving average of several months, to prevent a household from large fluctuations in its power bill because they might meet eligible consumption levels regarding the subsidy only in certain months). Nevertheless, any alternative targeting scheme should include a timetable to progressively implement such a restructuring.

Adjustments to the institutional and regulatory framework

- *Limits to horizontal and vertical integration.* The recommendation entails an analysis of whether companies in a competitive sector should be integrated with regulated activities, since in a mature sector there should not be major advantages to integration because the market offers similar advantages thereto.

- *Governance of the sector.* The Ministry must set the energy policy objectives through the National Energy Plan and these should be defined through CONPES documents, which should be reviewed at least every 10 years. National development plans should be explicit regarding the advances they are seeking to achieve in relation to those targets.
- *UPME should continue to oversee planning.* This entity must be strengthened, starting with improving the remuneration of its employees. In addition, it deserves an environmental department and greater human resources for the timely structuring of the tendering processes. Finally, the recommendation anticipates it should withdraw from certain activities in the mining sector (which must be identified) and assume the role of Chief Information Officer thereof, in coordination with the Superintendency for Residential Public Services and XM. IPSE should focus on the promotion, structuring, and execution of projects in the ZNIs. The National Monitoring Center should be strengthened and have a suitable body of project auditors.
- *Regulation of energy sectors.* Would be legally assigned to CREG (including gas and liquid fuels). Regarding liquid fuels, the recommendation envisages that the regulation of the entire chain remains in the hands of CREG, despite the tax implications, with the exception of regulating the producer's income. Additionally, the commission would be restructured in the following way: i) move from eleven members to seven (one government representative and six full-time); ii) the Ministry of Finance and Public Credit and the National Planning Department should cease to be permanent members thereof, although issues with fiscal implications must be coordinated with these entities; iii) the full-time members must include among them not only experts in electrical, gas and liquid fuels issues, but also in economics-regulation, finance and law. Additionally, it is recommended to include an Administrative Director in CREG, exclusively responsible for administrative matters. Regarding the terms of the experts, it is suggested that they serve for a maximum of two periods without the option of extending the term. In the same manner that the regulatory agenda is publicly available, the agendas of the meetings should also be made public in a timely manner along with their respective minutes. The presence of the Minister of Mines and Energy would be required in each meeting. To encourage innovation, supported by compliance with regulatory deadlines, mechanisms such as the so-called sandboxes used

by British regulators and recommended by the Mission of the Wise (2019) can be employed.

- *An appeal proceeding must be created to address appeals on rate resolutions.* This would be comprised of a shortlist selected from a list of renowned experts constituted by the CREG for this purpose, which could also serve to rule on similar cases derived from resolutions issued by other regulatory commissions.
- *Oversight.* The Superintendency for Residential Public Services must improve preventive oversight, periodically carrying out stress tests on agents and publicizing their results. The Business Fund should be strengthened to guarantee the availability of resources to ensure continuity in the service provision of an intervened company. The Superintendency to have a National Wholesale Market Monitoring Center. To develop its work, the Superintendency of Industry and Commerce should ideally be provided the information generated by the Superintendency of Residential Public Services. Similarly, it is ideal for the Superintendency needs for Residential Public Services to have a collegiate advisory body for certain issues, such as the imposition of fines that exceed a certain amount or the takeovers of service providers in difficulties, which require the use of resources from the Business Fund. In relation to XM, this entity should be spun off from the ISA group and continue as a for-profit company. The new XM would have the State as the majority shareholder and could have other shareholders. The main duties of the Board of Directors of this new XM would include providing non-binding proposals to: (i) the Ministry on policy; (ii) CREG on regulation; and (iii) UPME on planning.
- *Sector coordination mechanism.* The cross participation of Board of Director members of the sectoral entities in the Boards of other entities must continue. A similar entity as the Coordination Committee for the Monitoring of the Financial System (created in Law 795 of 2003) is desirable, which must meet at least once a quarter and include the Vice Minister of Energy as Technical Secretary. Its members must be the Ministry of Mines and Energy, CREG, UPME, the Superintendency for Residential Public Services and the new XM.



Image: Ministry of Mines and Energy of Colombia / Edward Barragán Ortíz

CHAPTER 8

Energy sector climate change plan

The Ministry of Mines and Energy is the first ministry in Colombia to adopt an integral sectoral climate change management plan,^{xxx} which includes reducing carbon dioxide emissions by 11.2 million tons by 2030. This not only follows the dictates of national policy and climate change legislation,^{xxxi} but is also a tangible intent by the energy and mining sector to address the challenges and threats generated by global warming.

The document in question (Integral Climate Change Management Plan for the Energy and Mining Sector or PIGCCme for its Spanish acronym) constitutes an instrument whose main objective is to reduce the nation's vulnerability to climate change and promote the development of low-carbon strategies, strengthening and protecting the sustainability and competitiveness of the extractive industry. Through this instrument, the Ministry identifies, evaluates and guides the inclusion of strategies with the stated objective. The plan was formulated to achieve the national climate change goals by 2030 through three components: mitigation, adaptation and governance. Its general structure and defined strategic lines are the following:

Figure 23. Structure of the Integral Climate Change Management Plan of the Ministry of Mines and Energy

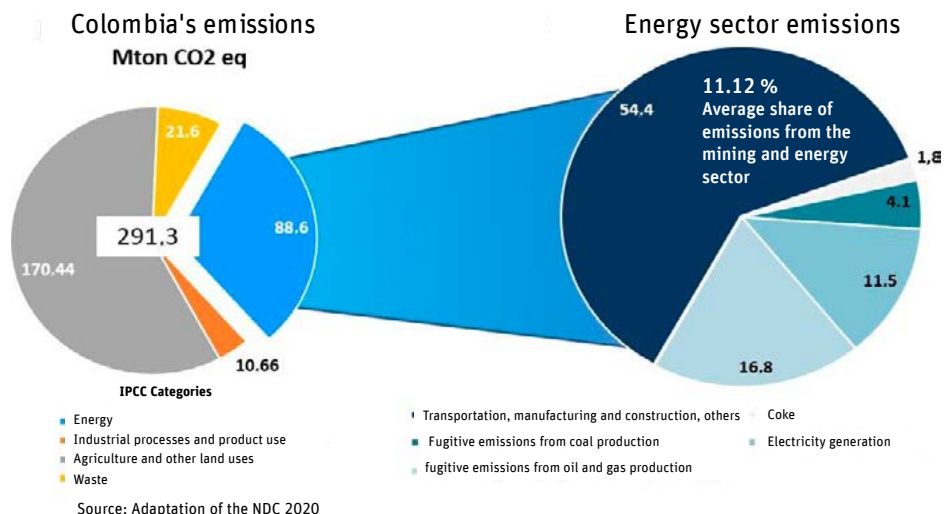


Source: Ministry of Mines and Energy, 2019

Progress in reducing greenhouse gas emissions

Colombia exhibits a fundamental asymmetric condition because, while its greenhouse gas (GHG) emissions represent only 0.46% of total global GHG emissions, it is one of the most vulnerable countries to climate change given its geography and location. The share of GHG emissions originating from the energy and mining sector is approximately 11% of the country's total emissions (Figure 24). Nationally, the energy and mining sector has set itself an emissions reduction target of 11.2 million tons of CO₂, corresponding to 18% of the goal set by Colombia, which is ambitious taking into account that its emissions currently account for close to 10% of total national emissions.

Figure 24: Share of emissions of the mining and energy sector in total national emission, 2019



Source: Own elaboration, adapted from Nationally Determined Contributions (NDC) data

In 2019, the emissions recorded by the monitoring system of the Ministry of Mines and Energy showed values between 32 and 34 million tons of CO₂ equivalent, of which 12% are associated with the extraction of coal, 5% with the coke production process, 32% with power generation in the SIN, 1% to power generation in ZNI, and 49% to hydrocarbon extraction, storage, transport and treatment processes.

The Monitoring, Reporting and Verification system of the Ministry is the sole instrument of its type nationally that provides information on emissions at both department and national levels (Graphs 25 and 26)

Figure 25. Map of the total GHG emissions of the mining and energy sector by department

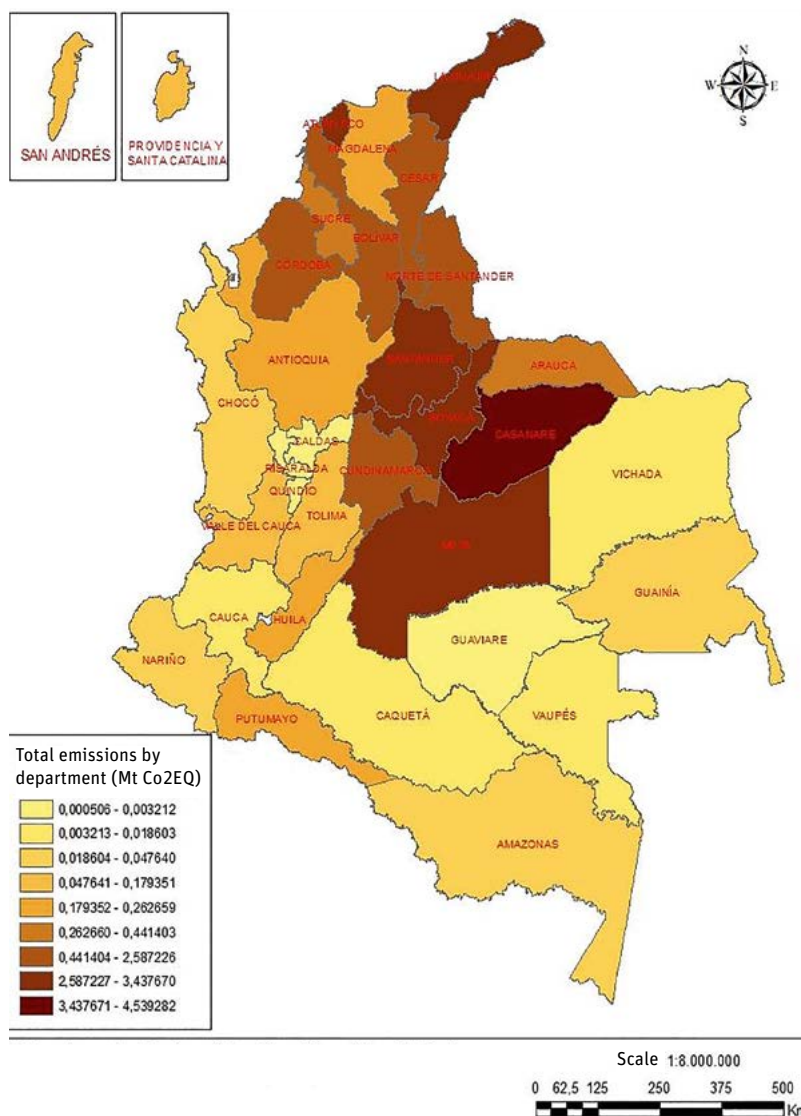
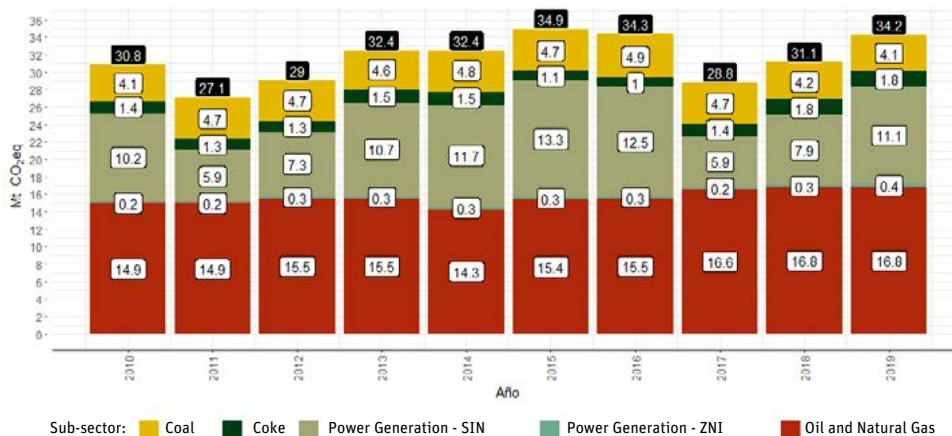


Gráfico 26. National historic emissions of the mining and energy sector



- The white labels are the emission amounts for each of the subsectors in Mt CO₂e, while the black labels at the top of each bar are the total emission amounts for the sector in Mt CO₂e

Source: Ministry of Mines and Energy, 2020

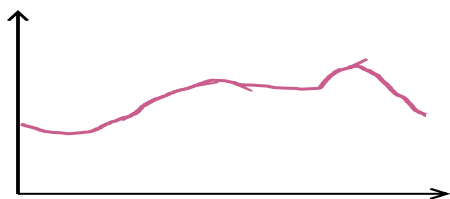
The indicators have been greatly influenced by thermal generation and by the oil and gas sub-sector, the latter being the one with the highest share of emissions since 2010. The historical series shows an increase in emissions of ~27 million tons CO₂ equivalent in 2011 to ~35 million tons CO₂ equivalent in 2015 with an average increase of ~2 million tons CO₂ equivalent per year. However, between 2016 and 2017 emissions fell drastically to ~29 million tons CO₂ equivalent mainly due to hydroelectric generation. As of 2017, GHG emissions have increased at a rate of ~2.5 million tons CO₂ equivalent per year until reaching emissions of ~34 in 2019. This growth in emissions is mainly tempered by electricity generation.

Progress in climate change management

The implementation of the PIGCCme has contributed and/or made it possible to achieve progress in the following different strategic areas:

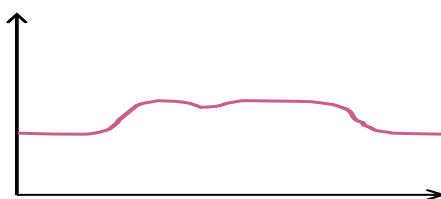
- Mitigation component: strategies and actions that generate adequate conditions to efficiently encourage the reduction of GHG emissions.
 - *Energy efficiency*: The energy consumption baseline and the possible energy efficiency improvement of the thermoelectric sector were established. Energy consumption required for the operation of eight (8) thermal power plants was evaluated and it is estimated that the average potential savings resulting from operation and maintenance management are 3.6 % for those plants assessed operating a regenerative Rankine Cycle and 2.7% for those with a Combined Cycle system. Using these values as a reference, annual savings of 2,604,648 MBTU are estimated with a possible emissions reduction of 209,742 tons of CO₂ equivalent per year.
 - *Demand-side management*: a characterization of the electricity demand of the country's regions was carried out (Figure 27) which established six possible types of consumption curves that classify users according to their daily electricity consumption behavior and potential to mitigate gas emissions by subsector. Based on these behaviors, consumption was typified to target demand-side programs. In total, a reduction of 2,087,303 tons of CO₂ equivalent is estimated for 2030. The Ministry has prepared a proposal incorporating this information to encourage the empowerment of users.
 - *Power generation*: since 2019, the Ministry has measured Scope 1, related to direct emissions (consumption of fuels and cooling fluids, among others) and Scope 2, associated with indirect emissions (consumption of electrical power) to identify the carbon footprint of its administrative operations. Thus, 191 tons of CO₂ equivalent were identified, which were compensated with the acquisition of national carbon certificates from the "El Viento" forestry project, located in the department of Vichada, which provides biodiversity conservation and supports the development of small reforesters in the country.

Figure 27: Consumer consumption curves



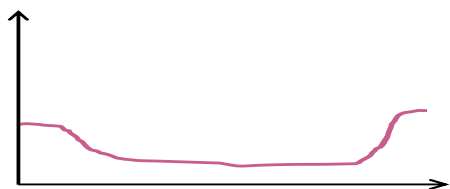
1. Pink Dolphin:

consumption is constant with at least three increases associated with morning, noon and night peaks



2. Turtle:

consumption associated with daytime work activity (commerce or industry).



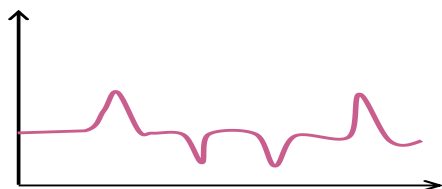
3. Possum:

mainly nighttime consumption (social, lighting, non-daytime processes)



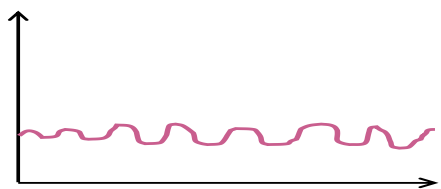
4. Manatee/Cayman:

consumption associated with a production process and exhibiting no significant variations throughout the day. variaciones representativas en todo el día.



5. Sloth:

consumption with 1 or 2 changes a day (2 or 3 hours, residential at home or temporary closure of the place of business).



6. Frog:

consumption exhibiting no defined pattern, semi-aleatory and unrelated to time of day.

Source: Own elaboration

By 2020 this amount reached 250 tons, which were compensated with the acquisition of national carbon certificates from the project Cárvida Duratex, located in a southwest area of the department of Antioquia in rural areas of the municipalities of Jericó and Andes. Additional reductions of up to 9 million tons could be achieved in 2030 with the inclusion of the new projects.

- Adaptation component: seeks to incorporate climate risk management into the decision-making levels of the mining and energy sector in order to ensure supply.

- *Resilient infrastructure*: since 2019, the Ministry has developed technical evaluations related to the assurance of energy transportation, focusing efforts on two main transport systems: (i) by land; and (ii) by pipelines. In light of the diversity of actors that participate in the aforementioned activities, a portfolio of adaptation measures has been defined for the routes with the highest use frequency by the mining and energy sector, which can serve as a starting point for strengthening resilience conditions of the country's road infrastructure. Additionally, elements were identified that could potentially be improved from an environmental licensing standpoint for the construction and operation of pipelines under changing climate perspective.
- *Short and long-term planning*: since the implementation of the PIGCCme, the aim has been to include in the sectoral planning documents findings and perspectives regarding resilience in light of the changing climate. Consequently, there was an active contribution to the structuring and formulation of the National Energy Plan (PEN for its Spanish acronym), providing a more solid base to ensure the sustainability of the scenarios included thereto, regardless of the occurrence or not of climate events.
- *Management of the surrounding*: companies in the sector have been informed about the benefits that ecosystem-based adaptation can bring to social relations and competitiveness. Based on territorial evaluations carried out in 2018 and 2019, a portfolio was defined for the municipality of Paz de Ariporo (Casanare) prioritizing the following measures: defining conservation areas under the figure of Civil Society Natural Reserve, productive management for a sustainable landscape and integral management of water resources. Additionally, there is a responsive model for the territory, where the areas with the greatest biotic, water and climate potential were identified for the sustainability of each of the prioritized measures.
- *Information for adaptation*: since 2016, a climate risk analysis methodology was developed, which has been strengthened with more information and a better understanding of the conditions of the areas where the activity is present. Thanks to this work, these exercises have been incorporated as a key variable for business planning and operational decision making. This is seen in the analysis of climate risks in the hydrocarbon sector, the electric power sector (SIN), large-scale coal

mining and ZNI. The results were transformed into specific adaptation measures. Similarly, there is an ongoing early warning system pilot of the subsector of electricity generation with water sources, which has the potential to estimate with a high degree of certainty water excess or deficit scenarios in a basin within a period of time of up to six months. Likewise, the climate change risk management orientation of the sector has been aligned to the international agreements of which Colombia is a committed participant. This includes expanding the ambitions of the captured sector included in the Nationally Determined Contribution with three adaptation targets for 2025 and 2030.

- *Governance component:* aims to strengthen the coordination and management of the mining and energy sector through mechanisms and strategies for institutional or financial coordination, among others, so that the PIGCCme may be fully implemented.
 - *PIGCCme website* seeks to provide technical and timely information to the public on the management of climate change. Enables strengthening communication between the Ministry of Mines and Energy and the energy mining sector actors. It has already been developed and is operational; the site can be accessed at: <https://pigccme.minenergia.gov.co/public/web/>



*Scan this QR code with your mobile phone camera to access the website of the Integral Climate Change Management Plan of the Ministry of Mines and Energy



Image: Ministry of Mines and Energy of Colombia/César Nigrinis Name

- *Climate change roundtable*: seven meetings have been conducted as a forum to exchange experiences between the Ministry and businesses regarding mitigation strategies and adaptation to climate change. In addition, it provides a gauge to measure the ownership of the sector with regard to the PIGCCme.
- *Citizen participation in the implementation of the PIGCCme*: the Colombia 2020 Energy Culture Challenge was designed and implemented, the first open innovation process on climate change with citizen participation. The objective was to find an idea that would incentivize an energy culture in Colombians in order to generate consciousness and efficient energy consumption habits in households and small industries and commerce. The results of the process can be found at: <https://www.retoculturaenergetica.com>

The previously described advances have made it possible to deliver inputs to support various processes. Among these are the foundations that allowed the construction of the long-term contracting auctions, as well as the contribution to the country's green growth policy.

Finally, the Integral Climate Change Management Plan will be complemented with a long-term vision for 2050 so that the sector can achieve net-zero carbon while supporting the energy transition.

An active interest in sustainability

International organizations, such as the German Cooperation Agency, have recognized the progress of the sector. Such advances encourage climate change management in the agenda of new subsectors, such as mining for construction materials.

With regard to the general public, the Colombia 2020 Energy Culture Challenge was held as the first open innovation climate change process with citizen participation. The objective was to find an idea that would encourage energy culture in Colombians hoping to generate conscious and efficient energy consumption and habits in households, small businesses and commerce. A total of 160 people from 11 cities participated with 44 initiatives. The winner was the SIMI proposal, a program that pursues a transition from conventional meters to advanced meters through a virtual platform that will allow users to know their daily energy consumption and carbon footprint and provides recommendations to generate savings plans and gamification strategies⁶ and generates an alarm, among others (more information is available at <https://www.retoculturaenergetica.com>).

Additionally, through a strategy called voluntary agreements, the Ministry works together with XM and companies in the energy mining sector to define voluntary mitigation and adaptation goals. In 2021, several companies including AES Colombia, ISA, EPM, URRÁ and ENEL created the Carbon Neutral Alliance, which aims to voluntarily endorse the carbon neutrality of SIN activities in the medium (2030) and long-term (2050).

6 | Gamification is a learning technique to transfer the mechanics of games to the educational-professional field in order to achieve better results, either in terms of knowledge absorption, skill improvement, or to reward specific actions, among other objectives.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

CHAPTER 9

Perspectives and new technologies

Throughout this document, it is clear that Colombia is moving rapidly along the path of energy transition. The leap into the field of non-conventional renewable energy, as well as advances in the sustainable mobility strategy and the strengthening of public policy aimed at enabling new technologies, have positioned the country as a benchmark in the region.

Additionally, the comparative advantages resulting from its geographic location and its water resource, have allowed the country to have one of the cleanest energy matrixes in the world, and therefore a lower proportionality of carbon emissions compared to other nations. However, it is highly dependent on climate variances.

Consequently, future challenges are framed within two pivotal axes: first, to make the system flexible so that energy is available when its consumption is required. Innovation in new storage models and the inclusion of new technologies play a fundamental role in achieving the objective.

Second, energy efficiency and fuel substitution will facilitate the incorporation of other sectors into the energy transition strategy in order to achieve the gradual decarbonization of the economy. For example, green hydrogen from renewable sources through electrolysis, and low carbon blue hydrogen generated from fossil fuels with carbon capture, are called in to play a significant role in this process.

Hydrogen: a very attractive option

Hydrogen is an energy carrier that makes it possible to integrate unused renewable energy, supporting the inclusion of non-conventional renewable energy into the electrical system. In addition, it facilitates the substitution of raw materials and fuels used in industry, opening a new technological pathway for sectors that have historically proven difficult to decarbonize.

Twenty nations that represent 70% of the world's GDP already have a strategy in place to integrate the aforementioned alternative into their energy matrix. Thus, an accelerated deployment of low-carbon hydrogen-based technology is anticipated, which would make it possible for blue and green hydrogen to become competitive alternatives in less than a decade.

Currently, hydrogen plays an important role in oil refining, especially in the conversion of heavy crude to byproducts, which makes it a key input for the auxiliary systems throughout the process. It is also used to improve plasma welding and cutting operations, as well as in the chemical industry, especially in ammonia and fertilizer production. However, the hydrogen used in Colombia comes from fossil fuels without carbon capture, so there is a clear opportunity to involve green and blue hydrogen in manufacturing. The hope is that cheaper renewable energy will eventually make green hydrogen the most sustainable energy option on the market.

Globally, the commitments of various nations to climate change and the development of new technologies have driven the increasing global demand for hydrogen. Germany and Japan have announced their interest in becoming importers, while Europe, in general, has included it in its economic recovery plans, since it is considered one of the most promising technologies for achieving carbon neutrality targets. Consequently, the European Union predicts that the share of hydrogen in energy demand will grow from 2% to 14% in 2050.

The Old Continent has limited availability of renewable resources compared to Latin America. Thanks to the multiplicity of non-conventional renewable resources Colombia has, especially in the north, our country has a positive outlook for the development of green hydrogen.

On the other hand, the national territory is known to have large coal deposits. Faced with this reality, the Government has opted for complementarity. The strategy includes the production of blue hydrogen from coal, which serves two purposes: first, it is a transition mechanism towards renewable hydrogen, accelerating the learning curve along the entire value chain, which includes technological regulatory and infrastructure matters. Second, it aims to use the abundant coal resource more cleanly, providing a transition alternative to the country's departments whose economy depends on this resource.

Blue hydrogen can also be obtained from natural gas. Through incomplete combustion, the carbon released from this process is captured and stored, substantially reducing emissions. In addition to being a more sustainable alternative to fossil fuel hydrogen, this technology is expected to reach competitive pricing earlier than other options.

In order to focus efforts towards promoting the production and use of low carbon hydrogen, the Ministry of Mines and Energy launched the roadmap for the implementation of Green and Blue hydrogen in the country, developed with the support of the Inter-American Development Bank - IDB, the consulting firm I-deals and the participation of academia and industry representatives.

This roadmap establishes clear national goals in terms of clean hydrogen production and uses by 2030. In terms of production the country has a target of having 3 GW of installed electrolyzer capacity at a competitive price of 1,7 USD/kg of hydrogen.

This goals will be achieved through the following work axes.

1. Legal and regulatory enablers: regulation of low-emission hydrogen, system of guarantees of origin and certifications, technical regulations (production, use and transport).
2. Market development instruments: Analysis of new incentives, financing mechanisms, promoting consumption of H2 and derivatives in industrial and transport sectors.
3. Support for the deployment of infrastructure: study the possibility of natural resources for H2 production, evaluate Carbon capture and storage potential, H2 geological storage and water availability.

4. Promotion of technological and industrial development: implementation of a regulatory Sandbox for the development of pilot projects, promotion of industrial capacities, and development of R + D + i programs.

The application of low-carbon hydrogen for industrial uses will encourage competitiveness, helping to maintain a low environmental footprint in production. This is one of the main objectives of the country in the midst of a new reality of reducing emissions and adjustments in CO₂ costs.

In addition to the above, the use of this clean fuel can support the sustainable mobility strategy promoted by the Government. In testing, it has proven its efficiency in long hauls with shorter recharge times, adding thereto an energy density three times higher than that of gasoline.

One more application that was evaluated for Colombia is storage, since it is a way to provide balance and flexibility to the network. This is because stored hydrogen can be used to generate low-carbon or renewable electricity. Unlike batteries, the impact of shelf-life on overall cost is limited, which is ideal for storage periods of days and weeks.

Additionally, UPME is evaluating internal demand, including industrial and mobility applications. That is the justification for the open call issued jointly by the Ministry of Science and UPME “*Sustainable energy and its contribution to mining-energy planning - 2020*”.

The intent thereof is to develop a planning system for the Colombian energy matrix that can evaluate scenarios integrating green and blue hydrogen, assessing the impacts of including this new fuel on the economic and environmental variables. A report should be available by the end of 2021.

Geothermal: another interesting alternative

Energy from the heart of the earth. The privileged geographical location and favorable geology that Colombia enjoys indicates that in its subsoil lies a latent potential for the development of heat energy transmitted from its inner layers to the outermost part of the Earth’s crust. This source has advantages over others of an intermittent nature, such as hydro, solar or wind, and therefore deserves a more comprehensive appraisal.

Given that part of the territory is located on the Pacific Ring of Fire, an area where the natural temperature of the subsoil is high, manifested by volcanic activity, the geothermal potential of the country is evident in areas adjacent to volcanoes and sedimentary basins. In this sense, the Colombian Geological Service, an entity attached to the Ministry, has studied and identified hot water geothermal systems in Colombia's mountain ranges. The entity defined a methodology to explore hydrothermal riches, carrying out investigations in areas including Paipa, Azufral, San Diego, Nevado del Ruiz, Santa Rosa and Cerro Machín.

Since 2015, the Ministry has led inter-institutional working groups to define a specific regulatory framework for geothermal energy, but it was in 2019, with the "Initiative for the Development of Geothermal Energy", that its basic working principles were defined, including: (i) evaluate international experiences in terms of licensing and environmental monitoring of geothermal projects; (ii) develop a legal, institutional, environmental, and regulatory framework that allows the proper use of the geothermal resource; (iii) provide preliminary economic viability assessment of geothermal generation and of its competitiveness versus other sources of power generation; (iv) provide assistance for structuring appropriate financing mechanisms for geothermal project developers; (v) provide assistance to studies to establish the geothermal potential of geothermal areas within the national territory; (v) develop technical competencies in the institutions involved in the development of geothermal energy.

The general goal of the effort is to identify the technical, financial, economic, environmental and social challenges of this activity. It was constructed through joint collaboration among various entities including the Colombian Geological Service, the Ministry of Environment and Sustainable Development, ANLA, CREG, UPME, the National Planning Department, the Regional Autonomous Corporations and the National Natural Parks Service of Colombia.

The support of the Inter-American Development Bank has been fundamental for developing these assessments, based on the premise that the country can diversify its energy basket and develop alternative sources of cleaner energy generation, thus contributing to reducing GHG emissions, as well as further its ability to adapt to climate changes. The multilateral institution supported the process of contracting consultancies to evaluate a legal, environmental, regulatory and institutional framework, as well as the financial and economic viability of the technology.

Thanks to this work, the Ministry currently has a predictive model of the economic and financial feasibility of electricity generation projects using geothermal resources for Colombia, a ArcGIS tool providing graphic results regarding environmental and social sensitivity in geothermal areas of interest, and a report reviewing the socio-environmental and regulatory legislative framework for geothermal energy that served as the basis for the preparation of the legal draft published for comments for the first time on December 2020, and after additional analysis and changes due to the sanctioning of the Energy Transition Law, published for a second time on august 2021.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

The draft decree designated “Whereby provisions are established to develop activities aimed at generating electricity through geothermal energy” addresses the barriers identified by the Government in relation to granting legal security to investors in this field, taking into account the high level of investment required for this sort of project. Through this policy instrument, records are created for the exploration and exploitation of the resource destined for the generation of electrical energy, which is required to delineate areas and prevent overlap in their use. The final document with the guidelines for the development of electricity through geothermal energy will be ready on December 2021.

For its part, the Colombian Geological Service also presented, within the agenda of the aforementioned roundtables, the estimated geothermal resources using the stored heat volumetric method, which estimated a stored heat of 138.60 EJ and electrical power of 1170.20 megawatts. However, it is possible that these levels might be higher because this estimate did not include blind systems, hot dry rock systems, nor systems housed in sedimentary basins.

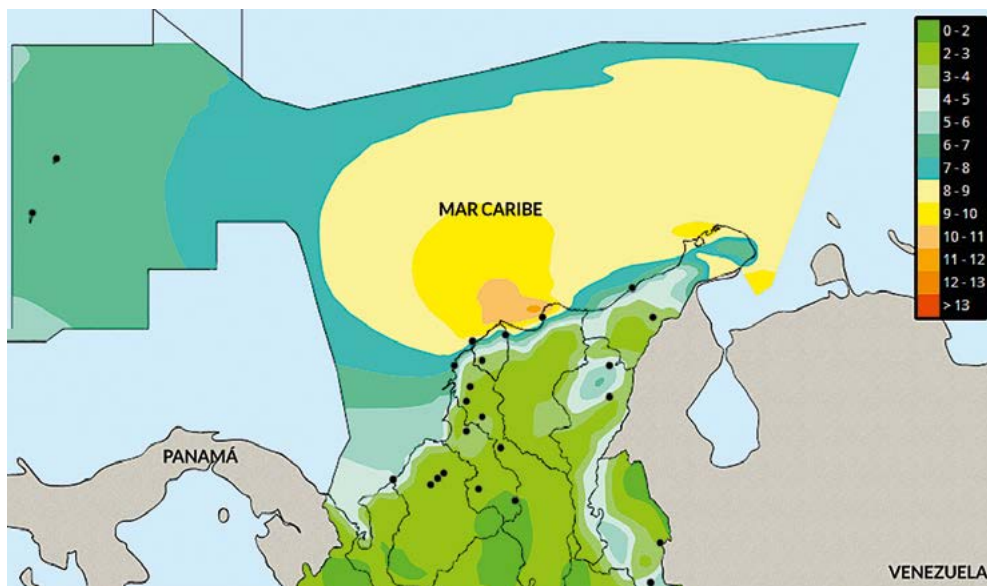
The next step for the adoption of the decree will be to prepare regulation for technical conditions that establish the guidelines to be followed in terms of drilling, intervention, characterization and abandonment of geothermal wells, considering information requirements, standards, characterization and sampling of fluids obtained therein as well as the disposal of said fluids, among other guidelines required to execute activities, monitoring and control.

Lastly, an opportunity for companies in the hydrocarbon sector has been identified that, due to their current activity, have already conducted geological, geophysical and geochemical exploration processes required to identify geothermal potential. In this sense, the Ministry will continue with its initiative by holding roundtables with the ANH and companies in the sector to define provisions that allow oil and gas producing fields to diversify production with the addition of geothermal resources destined for electricity generation.

Offshore wind power: a further possibility

Offshore wind turbines can play an important role in energy transition by providing clean energy that enhances the government’s recent efforts to develop renewable generation in the country. The Caribbean Coast has great potential for providing offshore wind energy, as it has a wind speed of up to 10 m/s at a height of 10 m. Preliminary estimations show a potential between 24 and 37 GW in the Caribbean.

Figure 28. Map of offshore wind power potential



Source: Wind Atlas, IDEAM

In addition to the electricity that would be provided by these projects and the possibility to further reduce its marginal price, one of the advantages of this option is that its perceived impact by the communities may be less than inland alternatives since they would not be installed in populated areas. Additionally, the offshore alternative displays a greater potential efficiency than projects installed onshore in continental areas, since offshore winds reach higher speeds and encounter fewer obstacles to obstruct their path.

In order to make this possibility a reality, the country must overcome environmental, regulatory and technical challenges. It must begin by determining how environmental permits will be assigned on these waters, either through a concession granted by the Environmental Authority which would establish the limits and areas where the projects can be developed, or through an environmental license such as the one used in inland projects on the territory, wherein the project sponsors carry out the relevant environmental studies required to be granted the approval.

The technical challenges are considerable. There is an inherent difficulty to constructing on the ocean floor and in establishing an interconnection with the continent, in addition to the existing restrictions of the transmission network, already present in continental projects. Due to this, the Government is deepening its analysis to identify policy and regulatory needs, quantify the cost-benefit relationship considering environmental and social impacts, the cost of interconnection and the potential effect on the energy rate of users. The inputs to this evaluation should not ignore the ample possibilities that exist, which deserve a detailed assessment, along with expected future technological advances and relevant experiences in other latitudes. An offshore wind roadmap is being developed to help the country establish the regulatory framework for these projects.

Storage and resilience

In recent years, efforts have been made to reduce network restrictions and the resulting costs borne by users through efforts aimed at expanding the STN and STR. Network restrictions translate into the need to establish more expensive plants in different areas of the country, and these security generation charges are transferred to the users in their service rate. Therefore, the expansion of networks is essential to reduce these negative effects, as it has been identified that storage systems can lessen network restrictions and reduce associated costs, especially when there are delays in the expansion works of the STN and STR.

In 2019, regulations were established to include Electric Energy Storage Systems with Batteries in the STN and STR in order to mitigate the effects of network scarcities. CREG resolution 098 of 2019 established that the UPME would identify the need to implement said systems to alleviate congestion and network restrictions and will carry out a competitive process to execute the project.

Thus, in 2020 was awarded the first battery system with the capacity to deliver 45 megawatt-hours of energy to operate under contingency conditions of the STR of the department of Atlántico.

International interconnections: a promising option

International interconnections are a very attractive option to increase the size of the market, enable the creation of an energy hub to export renewable energy, increase competition and contribute towards overall reliability. In addition, they provide greater operational flexibility, which is necessary for the integration of non-conventional renewable sources and distributed generation on a large and small scale.

The Colombian electrical system is complemented with exchanges through an electrical interconnection with Ecuador, and to a lesser extent with Venezuela. With the former, there is a 138 kilovolts interconnection and another of 230 kilovolts, with a maximum design capacity to export 535 megawatts and to import 295 megawatts. However, due to operational restrictions, they only allow a maximum export of 300 megawatts and an import of 200 megawatts. With the latter, there are three interconnections with a maximum capacity to export 336 megawatts and import 205 megawatts.

Additionally, on several occasions Colombia and Panama have evaluated the possibility of developing an interconnection system. The review is now underway and includes issues such as regulatory harmonization, financing arrangement for a possible line, and environmental impacts in a border area with great biodiversity. The most recent project, which could be completed in the middle of this decade, includes the construction of over 500 kilometers of power lines, divided into three sections (two terrestrial and a submarine cable), with a transport capacity of 400 megawatts.

In order for international interconnections to meet the stated objectives, it is necessary to: (i) establish within the energy policy the creation of an Energy Hub to trade energy; (ii) have regulatory harmonization arrangements; (iii) create the figure of International Agent of Colombia that can freely negotiate in the different markets; (iv) develop a liquid contract market that and that guarantees the creation of low-risk portfolios for the parties; (v) allow free access to interconnections; (vi) include within network expansion plans, those interconnections whose social benefit is greater than one and are agreed with neighboring national or regional markets in such a way that its cost is handled by the demand; and (vii) allow the development of at-risk interconnections.



Image: Ministry of Mines and Energy of Colombia/César Nigrinis Name

Colombia is also part of the Andean Electric Interconnection System (SINEA for its Spanish acronym) to which Ecuador, Peru, Chile and Bolivia also belong. SINEA seeks to achieve regional energy integration and promote energy exchanges between its members by optimizing the use of sources and energy assets in the Andean region and ultimately increase the welfare of their populations through the reduction of both energy costs as well as GHG emissions.

From an electrical standpoint, the hemisphere is divided into four major systems: (i) North America, including Mexico; (ii) Central America represented by the Central American Electrical Interconnection System (SIEPAC for its Spanish acronym); (iii) the Andean region, represented by SINEA; and (iv) the southern cone, presented by Southern Energy Integration System (SIESUR for its Spanish acronym). Given the above, SINEA is considered central for

the development of a large electrical interconnection for the Americas, which would allow for further connections with SIEPAC and SIESUR.

The first roadmap of the integration system was defined in 2014, which has recently been updated for the next decade, 2020-2030.

The expected progress can be classified into two categories:

- *Regulation.* Progress has been based on the results of the Andean Area Electrical Interconnection Studies, supported by the Inter-American Development Bank, focused mainly on regulatory harmonization among member countries. A first proposal for the design of a regional electricity market has been developed, seeking to minimize changes and adjustments of national regulations. Within the new regional regulatory framework, the creation of a Short-Term Regional Andean Electricity Market is established in order to carry out International Electricity Transactions through a coordinated dispatch of energy surpluses at minimum cost,



Image: Ministry of Mines and Energy of Colombia/César Nigrinis Name

conducted by a Regional Coordinator. The creation of a regulatory framework for electricity transactions in the SINEA countries was drafted by the Technical Group of the Andean Committee of Regulatory Bodies of Electric power services of the Andean Community (CAN for its Spanish acronym).

- *Infrastructure:* Colombia has been carrying out talks with Ecuador to determine the infrastructure required to reinforce the current interconnection. Studies have been carried out to evaluate the benefits, both in terms of power and financial, of reinforcing the existing interconnection, as well as evaluating the potential reinforcement of local networks in order to maximize transfer levels. Updated information on the current energy and electrical infrastructure, as well as the planned projects, was recently consolidated. Work is being done on updating the compatibility of the planning arrangement of the systems.

The main objectives for the 2020-2030 decade include the entry into force of the Andean Electricity Regulations, the completion of interconnection infrastructure projects and the completion of studies to corroborate the Regional Andean Electricity Market.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

Epilogue

PUBLIC POLICY ACTIONS TO SECURE THE ENERGY TRANSITION

Miguel Lotero Robledo

Vice Minister of Energy of Colombia

Public policy actions to continue securing Colombia's energy transition

In the previous pages, what can only be described as a fundamental transformation of the economic and social reality of Colombia has been detailed. The creation of an energy generation matrix supported by non-conventional sources is a reality that in turn has multiple implications, including environmental and accessible electricity in remote areas, among many others.

The set of policies adopted by this administration has been accompanied by tangible changes that are conveyed through dozens of projects both running and under construction, as well as in improvements in the quality of service for millions of households and businesses. Both those underway, as well as those already in place, will help support a sustainable recovery evermore essential after the ravages left by the COVID-19 derived pandemic.

However, although we have made great strides, the process is just beginning. Additional efforts are required over the coming years, not only for the country to comply with the international commitments it has signed, but also so that the following generations of Colombians can live in a society that takes care of its resources and can progress without negatively impacting the rich inheritance we received from nature. For this reason, it is important for those who will accept the baton in the future to reflect upon the following:

A universe of non-conventional renewable energies in continuous expansion

It is essential to maintain the roadway unobstructed in order to hearten the growth of non-conventional renewable energies so we can meet the objective of having a cleaner energy matrix. For this purpose, it is critical to continue with a program of centralized auctions and combine them with private initiative market mechanisms for the assignment of contracts that allow the financing of new generation plants. These mechanisms are not only a source of funding for entrepreneurs developing new projects, but also ensure that contracts are awarded at efficient prices for the end consumers.

There are important challenges to making feasible the installation of the wind projects resulting from the auction carried out in 2019. The logistical conditions of the department of La Guajira, where the greatest potential lies, must be improved through a coordinated effort of the entire State: its roads, ports, water infrastructure and training of the local population are crucial factors in a continuous improvement process.

The regulatory pathways for private parties to develop these mechanisms are shared with the regulation developed by Standardized Anonymous Markets, which in the coming years should be the natural replacement for centralized auctions in the assignment of contracts that make the expansion of renewable non-conventional energies feasible.

Likewise, tax incentives and connection procedures need to be constantly revised in such a way as to not only guaranteed that large-scale non-conventional renewable energy projects can enter into operation, are profitable for their sponsors and can inject energy into the network, but also so self-generation projects can become even more massive. It is also essential to allow users at all levels to manage their energy resources and strengthen their role in the system, not only as consumers but also as producers.

Storage systems: the “swiss army knife” for energy transition

Battery storage systems will play a key role in consolidating energy transition thanks to the multiple functions they can fulfill in an electrical system: they facilitate the work of the system operator in crucial matters such as regulating network frequency; they allow for the coordination of complementary services

and reduction of restrictions that are reflected in a lower rate for users. They also allow the entry and delivery of variable generation resources, such as plants based on wind and solar non-conventional renewable energy, on the mini-grids and the non-interconnected zones to reduce dependence on liquid fuels generation.

Despite the significant reduction in the cost of the various energy storage technologies, these remain quite high. The national government must continue to stimulate demand in order to foster its massive implementation with a suitable regulatory framework, tax incentives and the execution of more pilot projects.



Image: Ministry of Mines and Energy of Colombia / César Nigrinis Name

Energy for all: the democratization of the energy transition

Few things have the power to transform the life of an individual like access to electricity. Bringing this service to those who do not have it breaks barriers that obstruct development and positively impacts mind, health, education, nutrition, connectivity and gender equity indicators, among others.

For this reason, since the onset of President Iván Duque's administration, the most ambitious goal that any government has had in terms of electricity coverage was set: to reach 100,000 Colombian households during the 2018-2022 period with public resources. The work of the Ministry of Mines and Energy already has concrete results: 60,185 households received for the first time the transforming power of electricity during the past three years. And, of this number, about 20,816 users now enjoy electric power services generated from renewable energy that comes from the sun. In this same sense, the pathway for connecting new users to natural gas networks and cleaner fuels such as LPG should continue, since its substitution in Colombian households of other more polluting and health-damaging fuels such as firewood, coal, or gasoline contributes to an improvement in the health of the populace and reduces deforestation.

To keep on course, those responsible for public policies have the challenge to encourage private companies to develop these projects, reducing CAPEX subsidies and guaranteeing the sustainability of operation over time, through auctions that assign operations in areas where management is difficult and through the adoption of new technologies that allow measuring consumption and monitoring the provision of services.

Sustainable transport: charging infrastructure and air quality

To date, 74,6% progress has been achieved in the National Development Plan's target to have a fleet of 6,600 electric vehicles in Colombia. Despite the pandemic, in 2020 the sale of more than 1,000 such vehicles was recorded, surpassing the figures of the previous year by 30%, and reaching a current number of more than 4,928 electric vehicles nationwide.

This achievement was made possible in large part by the Electric Mobility Law issued in 2019 and the National Electric Mobility Strategy, which generated actions to accelerate this transition and incorporated incentives such as

VAT reduction, zero tariffs and discounts in mandatory insurance rates, and technical-mechanical review.

However, the public policy challenge is how to deploy electricity charging infrastructure at a similar rate to that of electric vehicle sales. In Colombia, there are currently approximately 117 public fast and semi-fast charging stations installed, of which 38% are located in the Metropolitan Area of the Aburrá Valley and 28% in the city of Bogotá.

The increase in capacity requires joint collaboration at the national and local level, as well as effective regulation that encourages their installation. The Ministry of Mines and Energy issued in July 2021, the regulation to standardize the charging stations for electric vehicles and define clearer market conditions.

Migrating towards sustainable mobility also implies the use of more environmentally friendly fuels. Accordingly, in order to contribute to the reduction of greenhouse gas emissions and particulate matter, and to improvements in air quality, in 2020 hydrogen and electric energy for mobility were determined as zero-emissions fuels, while natural gas, LPG, ethanol and biodiesel and their mixtures were classified as low-emitting energy sources.

Voluntary superior biofuel blends were also authorized. The government of President Iván Duque has within its commitments to issue the regulation that will establish higher ethanol and biodiesel blends throughout the national territory.

Public policy actions to secure the energy transition

In December 2020, all regulations that freed LPG to be used in land and river transport means came into effect. Therefore, we should begin to see during the first half of 2021, the first Auto LPG service stations in the country.

The foundations for introducing new technologies

It is also important to establish a solid foundation for the development of new technologies that will play an important role in the transition. For this, it is advisable to prioritize regulation to further the development of electricity generation projects with geothermal energy. According to the preliminary analyzes of the Colombian Geological Service, the country has significant potential in this area. The experience acquired from the exploitation of

hydrocarbons regarding knowledge of the subsoil will be an important input for subsequent development, savings efforts in the exploratory phase.

Likewise, in september we launched the roadmap for hydrogen production in our country. This fuel will be very significant for the different transport modes in the transition, for power generation and for the petrochemical industry. The processes for obtaining it from the use of renewable energies will play an important role in the carbon-neutral goals, and the potential for Colombia to become an exporter to more industrialized economies that demand it must be fully explored.

Furthermore, the potential that exists on the Atlantic Coast for the development of NCRE should not only focus on the continental area. It is known that wind conditions are also exceptional in the Colombian maritime area, which is why it is necessary to define the rules to develop viable offshore wind projects.

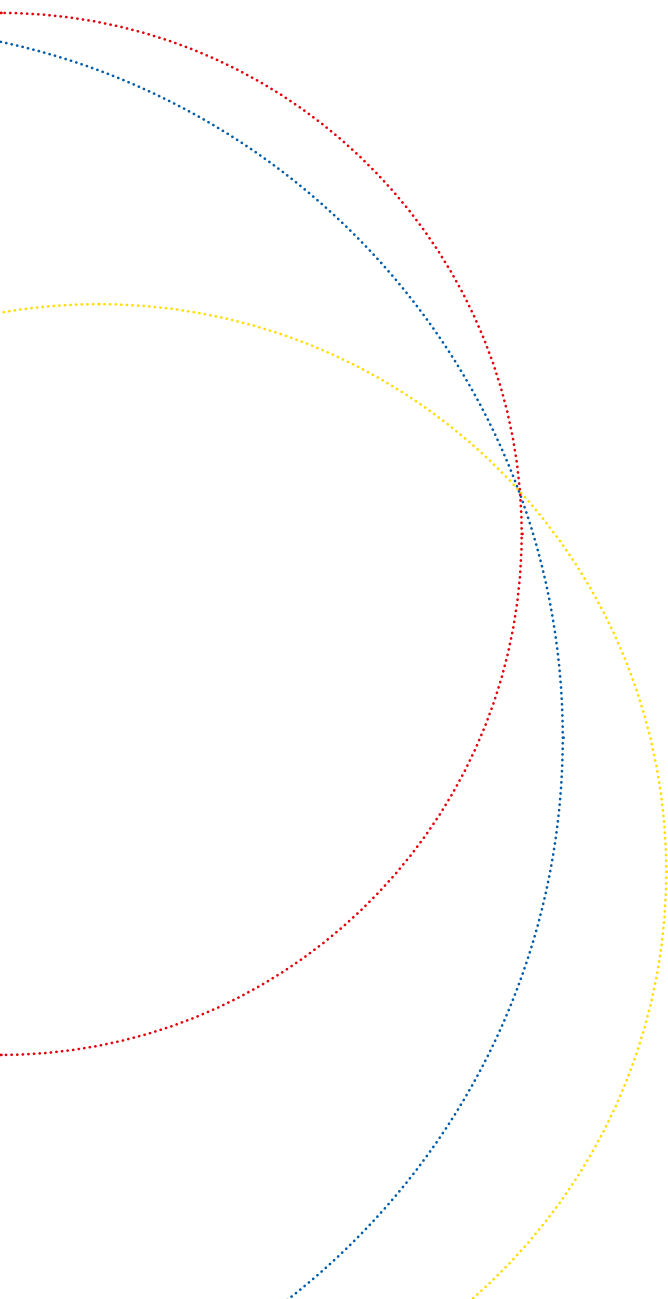
In conclusion, there is a wide horizon, and Colombia's possibilities in this field are many. If all is done correctly, the country will consolidate to become a global benchmark and will be able to attract investments that include, for example, the option of becoming a major exporter of electricity, hydrogen and synthetic fuels, CO₂ neutral from an emissions standpoint.

That this future is a real possibility has been made clear throughout this document. The combination of clear policies with market signals, of concern for the macro but also for the well-being of people, is something that has been achieved in recent years. Consequently, what has already been attained allows us to look ahead to what is coming with a dose of optimism, knowing that we must increase the efforts underway.

Varied assessments agree that the world's demand for energy will continue to grow rapidly, hand in hand with the population increase, the greater consumption capacity, the digitization and electrification of the economy, and the evolution of mobility. The key is not hampering this journey, but rather to adapt and take advantage of our unique comparative advantages, as Colombia has been doing. The roadway is laid out. All that is needed is to continue on the journey.

"Energy transition" has become the shorthand for discussions about the future of energy, especially since 195 countries pledged in the 2015 Paris climate

agreement to keep global temperatures from rising 2 degrees Celsius above preindustrial temperatures and to make best efforts to cap the rise at closer to 1.5 degrees. The target for getting there has evolved into the concept of “net zero carbon” by 2050 or shortly thereafter—a goal already adopted by over 100 countries, including the United States, China, the European Union, Britain and Japan, among others. As much as two thirds of global emissions – and roughly two thirds of global gross domestic product – now originate in countries with commitments to net zero of varying degrees. As it progresses, energy transition will transform the way the world produces and uses energy, and the very nature of important parts of the global economy.




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“That is the context as Colombia launches the transformation of its energy systems. The directions in policy are clear: increasing the share of non-conventional renewable energy from under 1% to more than 12%; raising its target to reduce greenhouse gas emissions from 20% to 51% by 2030; and making “sustainable revitalization” the driving force of its economic recovery strategy coming out of COVID.”

Daniel Yergin

IHS Markit Vice President, international energy Author and Expert.
Pulitzer Prize Winner

“Colombia has emerged as a global leader in energy transition. From the IDB, we have been able to support the country in this effort with public policy instruments to manage long-term contract auctions, strengthen regulatory frameworks, and adopt technical tools to adequately incorporate non-conventional sources of renewable energy.”

Mauricio Claver-Carone

President of the Inter-American Development Bank