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Pathways to Paris: Latin America

Executive Summary

Technology and Policy Options to Reduce GHG Emissions

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Main Takeaways

- For the Paris Agreement process, the Latin American countries pledge to reduce their emissions through 2025 or 2030 and introduce numerous policies to fulfill their pledges. This report offers a discussion of policy instruments and technologies in the energy sector that can assist ten selected Latin American countries ("LAM") in achieving their emission mitigation targets.
- In aggregate the LAM region is making strong progress towards its Paris goals with government-led efforts to increase the use of renewables and natural gas. Under the unconditional pledges, the LAM region faces an emissions gap (i.e., the needed reduction to meet the Paris pledges) of around 60 $MtCO_2e$, which indicates that the LAM region will need additional actions to reduce emissions by 2% by 2030 relative to its current trajectory. Under the conditional (i.e., subject to more ambitious global efforts and technology and financial transfers) pledges, the emissions gap is about 350 $MtCO_2e$, which indicates a needed reduction of 10% by 2030.
- Individually, while some countries are projected to be close to or to even over-achieve their unconditional and conditional goals for 2030, others require additional efforts. While some LAM countries face the challenge of developing stable regulatory and legal frameworks to further encourage private investments in clean energy projects, there are many policy and technology options available to them to reduce the emissions gap.
- Carbon pricing through taxes or cap-and-trade systems tends to be the most cost-effective option but can be politically challenging to implement. Other policy instruments are therefore needed to promote clean technology (e.g., enhancing renewable energy auctions and support to natural gas infrastructure development).
- While wind and solar generation provide attractive options for lowering emissions, enhancement of natural gas infrastructure enables higher penetration of intermittent renewables by serving as backup capacity.
- Our country-specific analysis for Argentina and Colombia shows that existing plans for the expansion of non-fossil electricity generation are sufficient to meet unconditional emission reduction targets in Argentina and Colombia. Conditional emissions reduction pledges can be achieved with moderate additional policies. For example, when non-fossil electricity targets are met, the addition of an all-sectors emission trading scheme (ETS) that caps emissions at the level consistent with each nation's conditional pledge results in carbon prices in Argentina and Colombia of, respectively, of \$2.7 and \$2.9 per tCO_2e.
- Our assessment is unique in that the gap analysis covers both larger and smaller Latin American economies and clearly documents the data and assumptions associated with our calculations. We hope the open source format of our input data and tools for analysis will enhance the capacity to analyze the Latin America countries' pathways in meeting their emission mitigation goals.

Executive Summary

Context

The world is facing a serious threat from global climate change. In the Paris Agreement, 195 nations have agreed to national greenhouse gas (GHG) emission reductions as a first step toward limiting the global temperature rise to less than 2 degrees Celsius (C) relative to the pre-industrial temperature. Reaching this goal will require a transformation of the global energy system over several decades. While the Latin American countries have shown impressive growth in renewables generation, they face the challenge of enhancing regulatory and policy frameworks to encourage private investment in clean energy projects, with the goal of further reducing their GHG emissions. To help them address this challenge, we focus on ten Latin American countries (Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Panama, Peru, Uruguay, and Venezuela—a group of countries referred to as "LAM" in this report) and use a variety of analytical tools—including country-specific, economy-wide models for two (Argentina and Colombia) countries—to understand the LAM region's aggregate emissions trajectory in both business-as-usual and climate policy scenarios. We also offer a discussion of policy instruments and technologies in the energy sector that can assist LAM countries in achieving their emissions mitigation targets. This assessment is enhanced by direct communication with ministerial representatives and energy experts from individual countries,[1] as well as the coordinative efforts of the Department of Sustainable Development of the Organization of American States (OAS). By maintaining an open dialogue on the data and policies incorporated in our projections, and even more, by providing all input data and tools used in our analysis in an open source format, we hope to enhance the capacity to analyze the LAM countries' pathways in meeting their energy, sustainability, and emissions goals.

Limiting global temperature rise to 2 degrees Celsius will require a transformation of the global energy system.

The LAM region is an important contributor to global development. In 2010, its population accounted for about 7.2% of the global population and about 8% of global gross domestic product (GDP) measured at purchasing power parity. In terms of GHG emissions from energy, industry, transportation, agriculture and final consumption (i.e., all sources excluding land use), the LAM region's global share in 2010 was about 6%.[2] While eventually emission reductions will need to come from all sectors of the economy, the energy sector offers a significant opportunity to obtain reductions using available technology and policy solutions at a relatively low cost.

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The LAM region is projected to have a steady growth in energy demand—approximately a 25% increase in total primary energy consumption from 2015 to 2030—due to its growing population and economy. Continued progress to lower-carbon or no-carbon energy (e.g., natural gas, wind, and solar) today will ease the task of reducing GHG emissions in the future.

1 We are thankful to Juan-Cruz Monticelli (OAS), Rocío Rodríguez, Ministry of Energy and Mines (Argentina), Juan Pedro Searle Solar, Ministry of Energy (Chile), Olga Victoria Gonzalez, Mining and Energy Planning Unit (Colombia), Marco Valencia, Ministry of Foreign Affairs and Human Mobility (Ecuador), Luis Lepe, Ministry of Energy and Mines (Guatemala), Betsy Bandy, Ministry of Science, Energy and Technology (Jamaica), Erika Streu Steenbock, Energy Secretariat (Mexico), Fernando Diaz, National Secretariat of Energy (Panama), Beatriz Olivet, Ministry of Industry, Energy and Mining (Uruguay), Angelo Gurgel, Fundação Getulio Vargas (Brazil), Lourdes Melgar (Mexico), Claudia Octaviano (Mexico).

2 Of Latin America in its entirety, the ten countries considered in this report represent about 84% of the population, 93% of GDP PPP, and 90% of GHG emissions in 2010.

In the Paris Agreement process, each country determines its own contribution to reduce GHG emissions to mitigate climate change. There is no mechanism to force a country to take on a certain target. Countries are free to choose the stringency of their emission mitigation targets and they may or may not specify the mechanisms to achieve the targets. Countries' pledges (called Nationally Determined Contributions, or NDCs) have various types of targets, such as (1) a reduction in emissions relative to a business-as-usual (BAU) projection, (2) a reduction in emissions relative to some historic year, (3) a reduction in emissions intensity (i.e., the ratio of emissions to GDP), (4) a targeted level or percentage of renewable energy, (5) a reduction in deforestation or an increase in a forest cover of a country, and (6) sector-specific targets such as efficiency improvements. Many countries also provide two stringencies of emission mitigation targets in their NDCs: unconditional (i.e., what a country is planning to do regardless of actions by other countries) and conditional (i.e., unconditional targets plus additional mitigation actions by a country if specific conditions are satisfied, such as a global climate accord, financial assistance, or technology transfers).

Emissions Pathways

This report provides a projection of the LAM countries' future emissions up to 2030 based on our assessment of economic growth and announced plans for energy supply and power generation (we refer to this scenario as the Policy scenario in contrast to the business-as-usual (BAU) or Baseline scenario that is based on energy trajectory without enforcing new energy plans or the Paris Agreement pledges). In 2030, the estimated Policy scenario emissions are 3,640 million tonnes of CO_2-equivalent ($MtCO_2e$). Using an MIT-developed BAU trajectory, the unconditional emissions target for LAM is calculated as 3,572 $MtCO_2e$. Consequently, the emissions gap (i.e., the volume of reductions to be achieved under a specific target) from the Policy scenario is 68 $MtCO_2e$, which indicates that, in aggregate, the LAM region will have to reduce its emissions by an additional 2% relative to the Policy scenario to meet its countries' unconditional NDC pledges. Under the conditional emissions target (3,289 $MtCO_2e$), the emissions gap is 351 $MtCO_2e$, which indicates a needed reduction of 10% relative to the Policy scenario emissions.

Achievement of NDC goals will be affected by both the type of power generation and the type of fuel for transportation and industry added in each country. For example, investments in coal power plants (without carbon capture and storage, CCS) would lock-in substantial carbon emissions associated with coal use while investments in generation from natural gas—which has a lower carbon intensity than coal—or investments in wind and solar with zero carbon emissions in power generation, would pave the way for more aggressive emission reductions in the future. Nevertheless, while wind and solar generation provide the most attractive options for lowering emissions, further development of natural gas infrastructure in the LAM region would enable higher penetration of intermittent renewables by serving as backup capacity. Some LAM countries are already leading the way in this area. Brazil, for example, maintains three floating storage regasification units (FSRUs), with plans for a fourth unit, to support the country's substantial LNG imports, which provided crucial backup generation when droughts impacted hydropower output in 2012 to 2016.

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Policy Options

Policy frameworks are the key to determine a nation's ability to incentivize the deployment of new technologies, attract private capital, internalize externalities (such as the health effects of air pollution), modernize electricity transmission and distribution, and expand access to energy. These policies can range from broader policies like energy price reforms and energy subsidy reduction to technology-specific policies like renewable portfolio standards, feed-in tariffs and renewable energy auctions. Carbon pricing through taxes or quantity controls with tradeable units both leave the allocation of resources to the market and can thereby equalize abatement costs across all covered entities, avoiding technology-picking and offering superior cost-effectiveness over alternative instruments.

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Other types of instruments—such as price support measures and fiscal subsidies—can be successful in building coalitions of support, and have also been confirmed through opinion surveys to be more popular with the public. Weak administrative capacities, legal challenges, and unclear mandates can undermine or delay the practical implementation of these instruments which promise to be the most effective and efficient in theory, as shown in the operation of complex policy instruments such as an emissions trading scheme (ETS; see case study of the European Union ETS in Section 7.3.1). Likewise, constitutional or statutory property rights, or state contracts and transparent dispute settlement procedures guaranteeing the rights of investors, are a key factor determining the ability of countries to attract clean energy investment.

Currently, electricity market designs are again facing substantial pressure to transform. Emergence of disruptive technologies, such as distributed energy resources, energy storage, and digitalization, coupled with ever more stringent environmental policy requirements, are fundamentally changing the landscape in which energy markets operate. Design of electricity markets, for instance, needs to facilitate the integration of all distributed or centralized resources contributing to the efficient provision of electricity services and attainment of other public objectives.

To successfully integrate growing shares of variable renewable energy sources, electricity market design has to ensure proper incentives for adequate reserve and balancing capacity, for instance via capacity markets or other mechanisms. A comprehensive and efficient system of market-determined prices and regulated charges needs to reflect energy-related services (such as electric energy, operating reserves, firm capacity, and ramp-up capability) and network-related services (such as network connection, voltage control, power quality, network constraint management, and energy loss reduction). Market interconnections with other countries/regions provide the potential to make more efficient choices and to better integrate intermittent and distributed resources (Denmark provides an example of a country where good connections with neighboring countries allows for a substantial uptake in wind power).

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Another important feature of many electricity markets with substantial repercussions for climate change mitigation is price supports for conventional energy, such as fossil fuel subsidies. The reduction and eventual elimination of energy subsidies leads to the correction or

removal of distortions in costs and prices that inform the decisions of producers, investors, and consumers. In many cases, energy subsidies prolong the life of older technologies and energy-intensive methods of production while often undermining the credit worthiness of utilities. Subsidy removal reduces the strain on fiscal resources and potentially leads to their improved allocation. Some LAM countries are already well into the subsidy removal process. Chile, for example, has removed almost all of its energy sector subsides, with the exception of a measure supporting low income households in the event of an electricity price spike. The country otherwise avoids government intervention in electricity pricing and has 100% private participation in generation, transmission, and distribution.

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For the LAM countries with more advanced administrative and technical capacities, we recommend carbon pricing through taxes or quantity controls with tradeable emission permits because they offer the greatest economic efficiency benefits. These instruments are particularly suitable for countries with substantial experience with market-based mechanisms and competitive electricity markets. Already, a handful of LAM countries (Argentina, Chile, Colombia, and Mexico) have implemented targeted carbon prices in some sectors, and interest in this highly cost-effective and scalable policy option is high with several LAM countries considering adoption of a carbon tax or an ETS as part of their national strategies. International experience with such markets is extensive (for an overview of experience, see Section 7.3 of the report).

For countries where a carbon tax or ETS is not currently feasible, we recommend an initial focus on technology-specific policies such as renewable energy auctions and renewable portfolio standards. Such support measures can be more successful in building coalitions of support for ambitious climate policies, and also in creating the domestic supply chains and know-how needed for robust markets in clean technology. In Uruguay, for example, a $5.68 billion renewables investment program and reverse auction increased wind and solar output nearly twenty-fold from 2011 to 2015 and pushed the country to around 95% of generation from renewables by 2015. At a later stage, however, such targeted support measures should be reviewed and, where political will and institutional capacities allow, gradually phased out as more cost-effective mitigation instruments, such as carbon pricing are introduced and scaled up.

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In the medium-term, enhancement of natural gas infrastructure could enable higher penetration of intermittent renewables by serving as backup capacity. To realize the potential of natural gas, policy options include a support to natural gas infrastructure development and loosening or removing price rigidities. An important component is allowing more private participation in supply, transportation, and marketing of natural gas, including third-party access to natural gas infrastructure. An early experience by other countries that promote natural gas use (e.g., China, Egypt, and in LAM, Mexico) illustrates the need for natural gas pricing reforms that reflect the market fundamentals and promote competition, thereby enhancing new supplies that ultimately lower the costs.

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critical to secure investment decisions and implement and execute projects. This targeted policy package performs differently than a combination of various core policy instruments with different objectives. In terms of assembling policy portfolios, this difference should be clearly recognized.

Because different policy objectives require their own policy instruments, we recommend that policies adopted to promote climate mitigation should avoid the simultaneous pursuit of other policy objectives, such as development, labor, or industrial policy goals. Combining policy instruments can lower overall efficiency due to adverse interactions and trade-offs.

We therefore recommend establishing a clear and transparent policy mix that allows for periodic policy review and adjustments. In many cases, pilot programs (1-2 years) can serve to fine-tune policy design and prepare economic actors for policy compliance; thereafter, however, policies with long time horizons (5 years or more) are recommended to provide planning and investment certainty to market participants. These long-term policies should contribute to overarching mitigation strategies and should be accompanied by robust planning processes to ensure consistency across instruments as well as to establish the supporting institutional and regulatory frameworks.

Further progress towards emission mitigation goals can be achieved by a reduction and eventual elimination of fossil fuel subsidies. Although fossil fuel prices in most LAM countries fluctuate based on prices in international markets, they remain regulated and are not fully liberalized. As electricity demand is growing in LAM countries, a reform in electricity subsidies will be a key issue despite the associated political difficulties. Subsidy removal reduces the strain on fiscal resources and potentially leads to their improved allocation. We therefore recommend continuation of recent efforts at subsidy removal (e.g., experiences with removing energy subsidies in Chile, reducing electricity subsidies in Argentina, and reforming discretionary electricity pricing mechanisms in Mexico), combined with creation of targeted support to low-income consumers.

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Technology Options

Numerous technology options are available for GHG emission mitigation. We categorize the most promising options into three clusters. In *Tier I* we include options related to building or retrofitting power plants to provide lower-carbon generation options than in the current fleet. The options vary by their capital-intensity, maturity and scale and include the development of wind, solar, natural gas, hydro, geothermal, and waste technologies. However, while wind and solar generation provide better options in terms of lowering carbon emissions, natural gas also has a substantial role both as a fuel with a lower carbon content than coal and as a technology that allows a higher penetration of intermittent renewables by serving as a backup capacity to provide reliability for the electricity system.

In *Tier II* we group the technology options that lead to improved efficiency (more-efficient turbines, digitalization, etc.), both on the production and on the consumption of electric power. The options in *Tier III* relate to technologies that enhance market and network organization (e.g., enabling distributed generation, time-of-the-day pricing, etc.), and include options for improved integration of renewables (e.g., new transmission lines, battery energy storage, virtual power plants, microgrids, tools for better citing and forecasting of wind and solar farms to maximize their utilization).

Despite substantial progress in bringing down costs of certain types of low-carbon power generation, the considerable uncertainty about the future costs of different technologies and the challenges for their integration to the system necessitates a flexible approach. We recommend that policy makers incentivize emission reductions from all sources of energy rather than favor any particular technology. Most LAM nations have already adopted new technologies for emissions reduction. As countries update their NDCs, however, there is an opportunity to create frameworks that encourage further private investment in these technologies to further improve the efficiency of the power sector and reduce emissions.

The LAM countries are still at relatively low levels of penetration of intermittent renewables, and therefore, their integration into the power system is currently relatively simple. LAM nations can learn from others how to avoid the challenges of higher levels of renewables penetration by directing policy makers, regulators, market and network operators, utilities, and other players to plan and prepare for the integration of higher shares of non-dispatchable technologies such as wind and solar. The experience of countries with large shares of intermittent renewables (e.g., Germany, Denmark, Belgium, and Portugal) provides valuable guidance for understanding challenges and opportunities of intermittent generation sources.

As LAM countries continue to develop their wind and solar generation fleets, natural gas can be a resource to manage the intermittency of these zero carbon options. Many LAM nations are introducing natural gas as a fuel choice in their economies by developing access to LNG, piped gas, or domestic supply. We have seen this trend grow in China, Japan, Korea, and Taiwan, as well as more recently in Malaysia and Pakistan. However, because future emission reduction targets (for the period beyond the current Paris pledges) are likely to be more aggressive, we also recommend exploring options for nuclear and CCS technologies—e.g., as in relatively heavily coal-powered Chile, where the government has placed a moratorium on new coal plants without CCS—keeping in mind that these capital-intensive projects require longer planning timelines and extensive government support.

We also recommend a wider use of technologies that enable energy efficiency improvements, both in the construction of more efficient power plants and through the use of digital technology to improve existing supply- and demand-side processes. Decision-makers should monitor the latest advances in technologies that enhance market and network organization (e.g., enabling distributed generation, time-of-the-day pricing, etc.) and consider options for the improved integration of renewables.

We emphasize that other technologies may become more attractive in the future. Possible options include advanced long-term energy storage as well as the production of hydrogen with renewable power and its consequent use for energy needs. Therefore, we recommend monitoring technological progress and adjusting the options under consideration as new

technologies become more economically feasible. At the same time, decision makers should be able to perform an objective evaluation of the prospects of the advanced technologies rather than rely on potentially over-optimistic promises of sellers of new technological options. Nevertheless, mitigation strategies most likely need to employ a set of different options in different sectors of the economy rather than achieve all emission reductions exclusively in the power generation sector.

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Deep Dive: Argentina and Colombia

Targets for renewable electricity (including planned increases in electricity from nuclear and hydro) combined with business as usual efficiency improvements are sufficient to meet unconditional pledges in Argentina and Colombia. In both countries, more-stringent conditional emission targets can be achieved with moderate additional policies. For example, an economy-wide ETS that caps emissions at the conditional level resulted in carbon prices in Argentina and Colombia of, respectively, $6.8 and $2.9 per tCO_2e.

The key insight here is that the sectoral coverage of climate policy should be a broad as possible.

However, when the ETS only covered electricity and energy-intensive sectors, the carbon prices were much higher ($419.6 and $602.5 in, respectively, Argentina and Colombia) and the GDP costs were greater. The key insight here is that the sectoral coverage of climate policy should be a broad as possible. This can be achieved by either including as many sectors as possible in the ETS, or linking non-ETS sectors to included sectors by allowing domestic offset credits to be surrendered in lieu of ETS permits.

The simulations also showed that adding an RPS to an all-sectors ETS increased the cost of meeting emission targets (even though it decreased the carbon price). This is because the RPS reduced emissions in only the electricity sector and it did so in a specified way (increasing the share of electricity from non-fossil sources). Notably an RPS does not penalize coal electricity for its higher CO_2 intensity relative to gas power, so it does not incent a shift from coal to gas generation. In contrast, an economy-wide ETS reduces emissions wherever and however emission reductions are cheapest. These findings illustrate the well-established concept that regulations (e.g., a RPS) are more costly than market-based measures (e.g., a carbon price evolving under an ETS).

Simulations evaluating the impact of digitalization indicated that greater adoption of digital technologies can reduce the cost of meeting emission targets while at the same time increasing electricity generation.

Policy Recommendations for Argentina

Argentina has made considerable progress with its energy and climate policies in recent years, deregulating gas and electricity prices, strengthening its policies to accelerate growth of renewable energy, and introducing a carbon tax on fossil fuels. Robust implementation of the RenovAr auctioning platform (including the penalties for delays and default on contracted terms), continued

expansion of electricity transmission infrastructure and grid interconnections, responsible development of its abundant shale gas reserves, and further expansion of the carbon price are all recommended for continued decarbonization in line with Argentina's NDC pledge.

In recent years, Argentina has deregulated gas and electricity prices, strengthened its policies to accelerate growth of renewable energy, and introduced a carbon tax on fossil fuels.

Argentina was the first country to revise and strengthen its NDC following the election of President Mauricio Macri. Unveiled at COP22 in 2016, the revised NDC is significantly more ambitious than the original pledge, partially due to a changed methodology for quantifying historical emissions data. This step signalled a reversal of how prior governments had approached climate change, affording it limited weight relative to the priority of economic recovery and social development after the crisis of 2001. For much of the decade, scarcity of capital, price-distorting subsidies, and political risk combined to make Argentina a relatively unappealing destination for clean energy investment. Under the new government, legal and administrative reforms to strengthen institutional capacity, rebuild investor trust, and liberalize energy markets offer a unique opportunity to advance Argentina's climate policy performance.

Institutionally, the new government has upgraded the executive agency responsible for environmental protection to the level of ministry, designating it the Ministry of Environment and Sustainable Development (Ministerio de Ambiente y Desarrollo Sustentable, or MAyDS). Within the ministry, climate change falls into the purview of the Office of the Undersecretary of Climate Change and Sustainable Development (Subsecretaría de Cambio Climático y Desarrollo Sustentable) and the newly established National Directorate of Climate Change (Dirección Nacional de Cambio Climático, or DNCC). Also newly created is an National Cabinet on Climate Change (Gabinete Nacional de Cambio Climático, or GNCC), a working group composed of members from 17 different ministries that is coordinated by MAyDS and has the task of elaborating the strategies and instruments to implement national climate objectives.

As projected by our modeling framework, future emissions growth in Argentina will largely center in the energy sector.

As projected by our modeling framework, future emissions growth in Argentina will largely center in the energy sector. Rapid growth in electricity demand and related power sector emissions, coupled with a relatively ambitious NDC, offer a significant opportunity for renewable energy deployment. Recent developments in energy legislation suggest that Argentina is looking to harness this opportunity. Under Law N° 27.191, passed on 15 October 2015, it has increased earlier targets for the share of renewable energy (other than large hydro) in electricity consumption to 8% by the end of 2018, 12% by 2019, 16% by 2021, 18% by 2023 and 20% by 2025.

An early system of modest feed-in tariffs adopted in 2006 under Law N° 26.190 proved relatively ineffective in driving renewable energy investment, and was narrowed to facilities with generating capacity below 30 MW under Law N° 27.191. Instead, Argentina has joined many of its neighboring countries by relying on reverse auctions for long-term Power Purchase Agreements (PPAs) to promote the development of renewable energy. As early as 2010, it launched the Renewable Energy Generation Program (Programa de Generación de Energía Eléctrica a partir de Fuentes Renovables, or GENREN) tender program, requiring the state utility (Energía Argentina Sociedad Anónima, or ENARSA) to contract at least 1 GW of renewable energy capacity and sell it to the grid at fixed rates for a period of 15 years. Although

this early scheme yielded 1.4 GW in offers and 895 MW in signed contracts, only 128 MW ended up actually being commissioned. Lack of financing due to high perceived sovereign and offtaker risk were cited as the primary reason for this weak outcome.

In execution of Law N° 27.191 and its implementing Decree N° 531/2016, the Ministry of Energy and Mining (Ministerio de Energía y Minería) has elaborated a new renewable energy auctioning program (Plan de Energías Renovables Argentina 2016-2025, or RenovAr) featuring a reverse auction bidding process to contract renewable electricity. It addresses the shortcomings of the GENREN program by lowering risk and ensuring better financial conditions for bidders. This time, the liquidity of the offtaker of contracted electricity, the Wholesale Electricity Administrator Company (Compañía Administradora del Mercado Mayorista Eléctrico, or CAMMESA), is backed by a newly created Fund for the Development of Renewable Energies (Fondo para el Desarrollo de las Energías Renovables, or FODER). Through this fund, the government serves as trustor and residual beneficiary, the Bank of Investment and Foreign Trade (Banco de Inversion y Comercio Exterior, or BICE) as trustee, and owners of investment projects are the beneficiaries. Itself backed by a World Bank guarantee, FODER protects bidders from offtaker, PPA termination, currency conversion, and certain political risks.

A value-added tax (VAT) rebate, accelerated depreciation rules, and additional income tax and import duty benefits (including a local content rule) further improve the financial viability of renewable energy projects, as do improved transparency requirements about nodal capacities and potential transmission constraints. PPAs awarded under RenovAr have a duration of 20 years and are denominated in US$, but paid in Argentinian Pesos using a conversion mechanism and adjusted by an incentive factor to promote fast project completion. Under Decree N° 531/2016, large consumers, defined as those with average consumption exceeding 300 kW, can opt out of the tendered PPAs and obtain their supply directly from a distributor or from the wholesale market at a price ceiling of $113 per MWh or through self-generation of cogeneration.

RenovAr has so far resulted in three electric power auctions: Round 1, Round 1.5 and Round 2. Under the first round, it solicited bids for 1,000 MW of renewable energy to the grid, broken down by technology: 600 MW of wind, 300 MW of solar, 65 MW of biomass, 20 MW from small dams, and 15 MW from biogas. It yielded submissions from over 75 companies for 123 projects amounting to 6,346.3 MW in proposals, making the tender six times oversubscribed. Overall, the three RenovAr bidding rounds have resulted in awards to 147 projects for a combined capacity of 4,466.5 MW, evidencing the successful uptake of this instrument as a mechanism to promote renewable energy investment: in 2017, Argentina attracted more investment in one calendar year than in the prior six years combined. With average prices in each auction falling from $59.70 per MWh in Round 1 (July 2016) to $40.40 per MWh in Round 2 (November 2017), however, there have been concerns that developers may be undervaluing assets and bidding below actual project cost, which may compromise their ability to secure financing and make a final investment decision. Initial delays with the execution of projects awarded so far suggest that these concerns are not unfounded, meriting close scrutiny going forward.

Aside from RenovAr, Argentina has introduced several additional programs to promote renewable energy in power generation and transportation. Renewable electrification of remote rural areas is promoted under the Project on Renewable Energy in Rural Markets (Proyecto de

Energías Renovables en Mercados Rurales, or PERMER), which has recently entered a second phase. Meanwhile, Law N° 26.093 of 12 May 2006 and its implementing regulations introduced mandatory fuel blending quota for bioethanol and biodiesel in transportation fuels, and currently mandate a 10% share of biodiesel in diesel fuels and 12% of bioetanol in gasoline.

More generally, Argentina has made important progress in reforming its market for electricity and gas. Already one of the most deregulated electricity markets in Latin America, with around 75% of generation capacity in private ownership, Argentina has also recently liberalized electricity and gas pricing. Following the economic recession and fiscal crisis of 2001, the government had responded to political pressure about the cost of energy by fixing electricity and gas prices, which, over time, prompted a considerable decline in infrastructure investment and threatened the security of supply. Despite abundant domestic resources—both conventional and renewable—Argentina therefore faces a current power deficit. Over considerable resistance, the new government has repealed price subsidies for electricity and gas, bringing these closer to real cost.

With around 75% of generation capacity in private ownership, Argentina already has one of the most deregulated electricity markets in Latin America, and has also recently liberalized electricity and gas pricing.

On the latter front, Argentina is set to join the small number of Latin American countries which have introduced a carbon price when it implements a carbon tax (impuesto al dioxido de carbono) from 1 January 2019. Adopted on 28 December 2017 as part of a comprehensive tax reform, the carbon tax will be imposed as a percentage of the full tax rate of US$ 10/tCO_2e. For most liquid fuels, the tax will be levied at the full rate, whereas for mineral coal, petroleum, and fuel oil, the tax rate will at a tenth of the full tax rate, increasing annually by 10 percent to reach 100 percent in 2028. Producers, distributors and importers of these fuels are liable for payment of the tax, although certain sectors and uses are partially exempt, such as international aviation and shipping, fuel exports, the share of biofuels in mineral oil, and raw materials used in (petro)chemical processes. Altogether, the tax is expected to impose a carbon price on approximately 20% of Argentina's emissions.

Going forward, Argentina faces numerous policy challenges as it pursues implementation of its climate pledges. Given initial delays under the landmark RenovAr tendering program, the country has to demonstrate the capabilities of this new incentive framework to ensure reliable deployment of renewable energy sources in electricity generation, with robust enforcement of the penalties for delays or default on the part of project developers. For its part, the government should continue pursuing its tendering process for new transmission infrastructure. In a country where a large share of renewable resources are located in the windswept Patagonia region that is covered by a separate grid (Sistema de Interconexión Patagónico, or SIP), adequate interconnection with the country's main grid (Sistema Argentino de Interconexión, or SADI) will be key to mitigate any curtailment risk for both renewable and thermal generators.

Abundant shale gas reserves in the Vaca Muerta Formation offer an opportunity to simultaneously address energy security concerns and provide a dispatchable, lower-carbon bridge fuel to balance the growing share of variable renewable sources in electricity generation until battery storage is economically more viable. Attracting foreign investment through robust legal guarantees, fiscal incentives, and adequate infrastructure is vital to accelerate the pace of natural gas exploration and extraction. Care has to be taken, however, to develop these resources responsibly, addressing environmental impacts such as methane leakage, and considering the longer term evolution of the national and global energy system when locking in investment and associated emissions over significant periods of time.

An important step in this regard is the recent introduction of a carbon tax, which can help correct the central market failure underlying climate change. By signaling a more accurate cost of emissions from the production and consumption of fossil fuels, the carbon price can help investors align their investment strategies with decarbonization pathways. Over time, therefore, Argentina should consider expanding the scope of the carbon price beyond the current sectors and activities to cover the economy at large, and increasing the tax rate to a level more consistent with the estimated social cost of carbon. Together with removal of distorting energy subsidies and continued liberalization of the electricity market, these measures can ensure that Argentina meets its growing energy needs in a secure, affordable, and, above all, environmentally sustainable manner.

Policy Recommendations for Colombia

Colombia has made significant progress in the development of a robust climate and renewable energy policy framework. Recent advances include the adoption of a national framework law on climate change, the introduction of a carbon tax, and targeted pursuit of greater diversification in the electricity mix through auctioning. Still, abundant domestic reserves of oil and coal pose a challenge to the meaningful reduction of greenhouse gas emissions in the energy sector, including in transportation. Intensified land-use in post-conflict areas has also contributed to a concerning rise in emissions from tropical deforestation. To tackle these challenges, Colombia should expand the use of economic instruments such as carbon pricing and ensure a level playing field for all energy sources, continue investing in energy efficiency and clean alternatives for electricity generation and transportation, and carefully manage its ongoing land reform process.

Colombia is among the most vulnerable countries to climate change in Latin America, affording it a powerful incentive to contribute to global efforts on climate change mitigation. It has played a constructive role in international climate negotiations, and is one of the regional pioneers in comprehensive and progressive climate policies, such as a national framework law on climate change and a carbon tax. At the same time, sustaining a fragile peace in the formerly war-torn country and ensuring continued economic growth remain central priorities of the national government. Colombia therefore faces pressure to expand the development of its ample oil and coal reserves, solidifying the role of fossil fuels in the domestic energy mix. Together with a regional expansion of agriculture into previously inaccessible areas, resource extraction has contributed to a recent spike in tropical deforestation rates, posing a serious challenge to meaningful reduction of domestic emissions. This broader context explains some of the particularities of Colombia's current approach to climate and energy policy.

Recently, Colombia has adopted a national framework law on climate change, introduced a carbon tax, and targeted pursuit of greater diversification in the electricity mix through auctioning.

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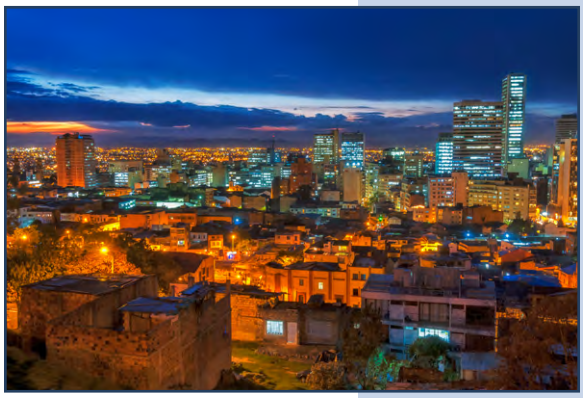
Institutionally, the National Economic and Social Policy Council

(Consejo de Política Económica y Social, CONPES), Colombia's highest authority for national planning, is the body charged with translating climate change components into policy documents. On 14 July 2011, it adopted CONPES 3700 on the Institutional Strategy for the Articulation of Policies and Actions in Climate Change, recommending the establishment of a National System of Climate Change (Sistema Nacional de Cambio Climático, SISCLIMA) as the institutional framework for the coordination and promotion of climate policy. Presidential Decree 298 of 24 February 2016 formally established SISCLIMA, which consists of several government entities—including the Ministries of Environment and Sustainable Development, Interior, Finance, Agriculture and Rural Development, Mines and Energy, Transport, Foreign Relations, and National Planning—as well as state, private and civil society entities. Its mandate includes "coordinating, articulating, formulating, monitoring, and evaluating policies, rules, strategies, plans, programs, projects, actions and measures on matters related to climate change adaptation and the mitigation of greenhouse gases." SISCLIMA is managed by the Intersectoral Comission on Climate Change (Comisión Intersectorial de Cambio Climático, CICC), which is, in turn, operated by the National Planning Department (Departamento Nacional de Planeación, DNP) and the Ministry of Environment and Sustainable Development (Ministerio de Ambiente y Desarrollo Sostenible, MADS), as well as nine Regional Climate Change Nodes (Nodos Regionales de Cambio Climático, NRCC).



In its work, SISCLIMA is guided by several national strategies and planning documents, including the National Climate Change Adaptation Plan (Plan Nacional de Adaptación al Cambio Climático, PNACC), the National REDD+ Strategy (Estrategia Nacional para la Reducción de las Emisiones debidas a la Deforestación y la Degradación Forestal de Colombia, ENREDD+), the Strategy for Fiscal Protection Against Natural Disaster (Estrategia de Protección Financiera ante Desastres), and the Colombian Low Carbon Development Strategy (Estrategia Colombiana de Desarrollo Bajo en Carbono, ECDBC), and the National Climate Finance Strategy (Estrategia Nacional de Financiamiento Climático). Within a year after its formal establishment, SISCLIMA published a National Policy on Climate Change (Política Nacional de Cambio Climático, PNCC), which builds upon all the foregoing strategy and planning documents, and provides guidelines for climate planning and management at the sectoral, local, departmental, regional, and national levels.

In 2015, the Colombian government launched a project to elaborate a national climate change law, resulting in a draft law being submitted to the national legislature (Congreso de la República de Colombia) on 9 August 2017. The law passed through relevant committees in the Senate (Senado) and the House of Representatives (Cámara de Representantes) in June 2018, and was adopted in a plenary vote followed by signature of the President in late July 2018, allowing its entry into force just before the national elections in early August. Adopted as Law 1931 of 27 July 2018, the new law defines concepts and principles governing national climate change policy, formally enshrines SISCLIMA in federal law and establishes a National Climate Change Council (Consejo Nacional de Cambio Climático) as a permanent organ of the CICC, delineates the national system on climate change information and establishes a national greenhouse gas registry (Registro Nacional de Reducción de las Emisiones de Gases de Efecto Invernadero, RENARE), and sets out economic instruments to address climate change, including a National Program of Tradable Greenhouse Gas Emission Quotas (Programa Nacional de Cupos Transables de Emisión de Gases de Efecto Invernadero, PNCTE).

Colombia already has been gaining experience with economic instruments to address climate change. Law 1819 of 2016 introduced a carbon tax on the sales and imports of fossil fuels, including all liquid petroleum derivatives and natural gas for industrial uses, but exempting coal and natural gas used for electricity generation as well as exported fuels. From 1 January 2017, these fuels have been taxed based on their carbon content at a tax rate of approximately US$5/tCO$_2$, increasing annually by the rate of inflation plus one percentage point until the price reaches approximately US$10/tCO$_2$e. Decree 926 of 2017 added an option for regulated entities to reduce their tax liability by becoming certified as "carbon neutral" through use of eligible offset credits. In the first semester of 2017, approximately 2 MtCO$_2$ of offsets were surrendered to lower the tax liability of covered entities. Revenue collection and administration is conferred on the National Directorate of Taxes of Colombia (Dirección de Impuestos y Aduanas Nacionales, DIAN) is in charge of the administration and revenue collection, whereas the Ministry of the Environment and Sustainable Development oversees the emissions reporting as well as the accredited verification entities. Revenue from the tax—estimated at approximately US$ 220 million per year—flows into a fund for environmental sustainability and sustainable rural development in former conflict zones (Fondo para una Colombia Sostenible).

In the area of energy, Colombia—which already draws around two thirds of its electricity generation from hydroelectric sources—is favored by considerable renewable energy potential, including biomass, geothermal and solar energy, as well as some of the most favorable conditions for wind energy on the continent. An abundance of affordable domestic fossil fuel resources, including the largest known deposits of coal in South America, has however dampened uptake of alternative energy so far. Promoting the development of renewable energy is therefore an acknowledged priority for the achievement of Colombia's mitigation objectives. Another factor has added urgency to diversification of the country's energy supply: in recent years, increased climate variability, manifesting itself in alternating periods of heavy rain and extended droughts, has undermined the reliability of hydroelectric power, contributing to an energy crisis in 2016. To date, this has prompted growing reliance on fossil-fueled thermal energy.

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Institutionally, energy falls under the jurisdiction of the Ministry of Mines and Energy (Ministerio de Minas y Energía, MME), which is responsible for policymaking and supervision of energy markets. An Energy and Mining Planning Unit (Unidad de Planeación Minero Energética, UPME) assists the ministry with advice and support in planning and implementation, and the Energy and Gas Regulation Commission (Comisión de Regulación de Energía y Gas, CREG) regulates trading, transmission, distribution, generation, and interconnection. Colombia's electricity market is governed by Laws 142 and 143 of 1994, which divide the power market into four activities: generation, transmission, distribution, and retail. Colombia has been a pioneer in electricity market deregulation, implementing a wholesale power market in 1995 and—uniquely for Latin America—extending competition to the retail level. Power can either be traded through the spot market or through bilateral contracts.

On renewable energy, Colombia adopted a Program for the Rational and Efficient Use of Ener-

gy and Other Forms of Non-Conventional Energy (Programa de Uso Racional y Eficiente de la Energía y demás Formas de Energía No Convencionales, PROURE) in 2010, committing to indicative targets and timetables for renewable energy deployment. Specifically, it aims to achieve a share of renewable (other than large hydroelectric) generation of 6.5% in on-grid and 30% in off-grid generation by 2020. In addition, Colombia enforces blending mandates of 10% biodiesel in conventional diesel and 10% ethanol in conventional gasoline. On a more programmatic level, Law 1665 in 2013 endorsed the statute of the International Renewable Energy Agency (IRENA) and its broader objectives.

One year later, in 2014, Colombia adopted Law 1715 to promote the integration of renewable energy, including forestry and agricultural biomass, solid waste, reforestation activities, solar, wave, wind, small hydropower, and geothermal energy, into the electric grid, and to promote self-consumption of electricity generated in off-grid areas. It mandates the harmonization of environmental requirements, the development of environmental impact assessment procedures for renewable energy projects, and the establishment of a rapid assessment cycle for renewable energy projects. Under this law and subsequent decrees, small-scale generators under 1 MW of generating capacity can benefit from simplified procedures and net metering.

Additionally, investors in renewable energy equipment can claim several tax benefits, including: an income tax deduction of 50% of investment value for up to 50% of taxable income for up to 5 years; an exemption from the Value-Added Tax (VAT), which currently stands at 19%, for renewable energy equipment and services; an import duty exemption for renewable energy equipment not produced locally; and accelerated depreciation of up to 20% per year for renewable energy investments. Law 1715 also contains provisions to further develop, execute, and finance PROURE, and to establish best practices for public sector energy efficiency, targets for energy-efficient government buildings, and incentives for the development and implementation of demand-response infrastructure.

Several public funds provide financial support for renewable energy projects, including a Fund for Non-Conventional Energies and Efficient Energy Management (Fondo de Energías No Convencionales y Gestión Eficiente de la Energía, FENOGE) created by Law 1715, a Rural Electrification Fund (Fondo de Apoyo Financiero para la Energización de las Zonas Rurales Interconectadas, FAER) approved in 2003 and a Fund for the Electrification of Non-interconnected Zones (Financiero para la Energización de las Zonas no Interconectadas, FAZNI) established in 2000. Each of these funds is financed by allocation of a small surcharge on wholesale energy prices.

Legal mandates and financial incentives are also in place to promote energy efficiency. Law 697 on the Rational and Efficient Use of Energy and the Use of Non-Conventional Energy Sources of, in particular, along with several subsequent decrees, set out general principles on energy efficiency, sectoral energy savings targets, and technology mandates for specific issues such as efficient lighting. In 2016, UPME published a roadmap for directing smart grid investment through 2030, focusing on four areas: smart metering roll-out, distribution automation, distributed energy integration and electric vehicle adoption. It anticipates that, by 2030, the planned investment will reduce outages from an average of 29.5 hours per year per Colombian household to 5.4 hours.

Overall, Colombia has elaborated a comprehensive framework of laws and regulations for

climate change mitigation and the promotion of renewable energy. Institutionally, SISCLIMA ensures a degree of coordination across government agencies, and progress is also being made in streamlining administrative actions at the national and regional level. With competition at the wholesale and retail level, the Colombian electricity market is among the most deregulated in Latin America. Together, this provides a solid basis for further advances in domestic climate policy and expanded use of Colombia's abundant low-carbon energy resources.

There is room for further improvement, however. While Colombia's pioneering role in introducing a price on carbon marks and important step to internalize the environmental cost of fossil fuel combustion in consumer behavior, it exempts coal and gas used in electricity generation. The latter stand to become a rapidly growing source of greenhouse gas emissions as the country grapples with climate-induced volatility in hydroelectric generation, and is forced to rely on dispatchable thermal generation to balance unanticipated shortfalls. Tax benefits for renewable energy sources are an important step in achieving a more diverse electricity mix, but have not yet had a significant impact on renewable energy penetration rates given abundant and low-cost fossil fuel supplies. As renewable energy technologies decline further in price, Colombia should consider reducing and eventually phasing out fiscal subsidies for all energy sources while extending carbon pricing—potentially through an emissions trading system, as allowed under the recently adopted Law 1931—to coal and natural gas, and ensuring price levels that better reflect the social cost of carbon emissions. This can achieve a level playing field across energy sources and better complement the aim of a competitive, deregulated electricity market.

As renewable energy technologies decline further in price, Colombia should phase out fiscal subsidies for all energy sources while extending carbon pricing—potentially through an emissions trading system—to coal and natural gas, ensuring price levels that better reflect the social cost of carbon emissions.

In the near term, targeted auctions for renewable energy can play a useful role in progressing the diversification of the Colombian electricity mix, and preventing further lock-in of long-lived carbon-emitting generation assets. A government decree issued in March 2018 to "strengthen the resilience of the electricity generation matrix to events of variability and climate change through risk diversification" and a resolution issued in August 2018 by MME establish guidelines for long-term contracting of electricity generation through auctions, including eligibility conditions and a system of guarantees. A first auction for 3,443,000 MWh of generation—or roughly 4.35% of projected electricity demand in 2022—has been scheduled for January 2019. Although all electricity sources are eligible, low- and zero-carbon technologies are heavily favored in the calculation of the award criteria. Aside from renewable energy sources, this can also improve the prospects for development of the country's significant, but largely untapped, natural gas reserves located in the Northern Coast and Barranca regions, and in the La Guajira department in northern Colombia.

The relatively modest carbon tax on fuel will likely prove insufficient to meaningfully curb emissions in the transportation sector, calling for consideration of additional measures—including targeted investment in public transportation and electric vehicle infrastructure—or an accelerated increase of carbon tax rates. Beyond the energy sector, improved land use planning and the shape of future land reform will be critical to manage a concerning trend of increased deforestation. Similarly, mining and extraction activities have the potential to significantly increase Colombian greenhouse gas emissions, requiring careful balancing of economic and environmental interests. Finally, to better understand the country's emissions pro-

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file, the elaboration of a national greenhouse gas emissions registry as envisioned in Law 1931 is an important step that merits allocation of required administrative and financial resources.

International Experiences

In aggregate the LAM region is making strong progress in GHG emissions mitigation and many successful policies can serve as valuable examples for other parts of the world. At the same time, countries in the LAM region can learn from positive and negatives experiences with emission reduction policy mechanisms in other regions of the world. We offer a detailed exploration of the lessons learned worldwide from employing policies to promote renewable energy, such as feed-in tariffs and renewable energy auctions. We also summarize the experience with standards, regulations, and carbon pricing systems in other regions.

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While feed-in tariffs were initially a popular instrument to develop wind and solar projects, renewable energy auctions have become a more established tool in the portfolio of clean energy support instruments. By fostering strong competition, they have contributed to low project cost bids. Time will tell whether these bids come at the expense of low realization rates. Concerns about the financial feasibility of some projects, difficulties in securing financing, and issues with access to transmission infrastructure help explain certain countries' relatively low realization rates for certain projects in Brazil, Mexico and Argentina. At this point, it is too early to tell if the experience of these initial projects is indicative or the realization rates will be improved with more maturity in this policy instrument. The example of auctions illustrates the value of studying international policy experiences. Overall, we recommend that LAM policy makers carefully survey the lessons learned in other regions with emission reduction policies, and apply best practices by tailoring these policies to local conditions.

Already, LAM countries have leveraged many of the benefits of a diverse instrument portfolio. At the same time, experience shows that coexistence of multiple policy instruments can result in negative policy interactions, increasing the economic cost of achieving climate targets. By favoring specific technologies, targeted policies may also miss valuable abatement opportunities. Over time, as LAM countries explore more ambitious goals for future NDC cycles, we therefore recommend they focus on economy-wide carbon pricing as a central pillar of their mitigation strategies and better harmonization of existing policies until they achieve that goal.

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