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KONRAD ADENAUER STIFTUNG

Perspectives of Carbon Pricing in Latin America by 2030

Report on the Project "Carbon pricing and electricity sector in Latin America"

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I. Abbreviations

DWL	Dead weight loss
EU	European Union
GEF	Global Environment Facility
ETS	Emission Trading System
GHG	Greenhouse Effect Gases
GPC	Global Protocol for Community-Scale GHG Emissions inventories
ICAP	International Carbon Action Partnership
IPC	Climate Policies Institute (by its Spanish acronym)
IEA	International Energy Agency
KAS	Fundación Konrad Adenauer Stiftung
MDVCCR	Carbon Voluntary Domestic Market of Costa Rica (by its Spanish acronym)
MRV	Measurement, Reporting and Verification
NAI	Non-Annex I Countries (Kyoto Protocol)
NC	National Communication
NDC	Nationally Determined Contribution
LATAM	Latin America
LCOE	Levelized Cost of Energy
OLADE	Latin American Energy Organization (by its Spanish acronym)
PMR	Partnership for Market Readiness
RBCF	Results-Based Climate Financing
VAT	Value Added Tax
SDGs	Sustainable Development Goals
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme (now, UN Environment)
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

II. Summary

On April 14 and 15; July 20 and 21 and September 28, the series of events entitled "Carbon Pricing and the Electricity Sector in Latin America" was held virtually under the organization of the International Energy Agency (IEA), the International Carbon Action Partnership (ICAP), the Regional Program for Energy Security and Climate Change in Latin America of the Konrad Adenauer Foundation (EKLA-KAS) and with the collaboration of the Institute for Climate Policies (IPC). The sessions convened at least 40 specialists from the region to discuss with regulators in Argentina, Brazil, Chile, Colombia, Mexico, Peru, USA and the EU about the challenges involved in managing a carbon pricing for electric systems and achieving the delicate balance between mitigation of CO2 emissions and economic prosperity.

The analyses carried out in these sessions concluded that at the beginning of 2021 there were 64 operational carbon pricing instruments in the world (including ETS: Emissions Trading System) and that they cover 21.5% of global emissions of GHGs (Greenhouse Gases). This year is particularly interesting because of the effect of the launch of the Chinese ETS and that it has become the largest carbon market in the world. Regarding price levels, we observe that countries with high levels of decarbonization of their economies and strong climate policies, such as Switzerland, Sweden, Finland and Norway have the highest ranges, from 52 USD/tCO2e onwards, with the aim of maintaining the pressure of technical changes in the economic sectors that are still in transition to neutrality. For Latin America, the price range is [1, 5] USD/tCO2e, with operating instruments in Argentina, Chile, Costa Rica, Colombia and Mexico with an average age of less than a five-year period. Although there is no uniform or common reality of the jurisdictions that have implemented a carbon pricing, and although the sensitivity of each market changes according to its level of development, depending on the way in which the carbon pricing may imply an increase in energy prices for consumers, it is possible to see carbon prices rise as decarbonization rates advance in an economy.

On the other hand, climate policies have not gone hand in hand with the developments of these abundant resources. For example, carbon pricing mechanisms have begun to be adopted in the region since the past decade, but the prices are not high enough to drive significant changes in consumption or investment patterns. The causes are practically fifty years of policies that took advantage of the oil boom, subsidies, motor-vehicle taxes, to collect revenue for the state and other distortions that have made it difficult to incorporate an environmental sense into the "polluter pays" principle among consumers.

Brazil, the largest economy in the region, has an electricity generation portfolio that is already at least 85% decarbonized, so it is difficult to think of an effective tax for the remnant who consume fossil fuels. There are studies underway for an ETS or a direct tax,

but it is not yet clear due to the contingencies it generates in its lower social segments and those sensitive to a price increase. The topic of thermal energy is being considered in the discussion.

Costa Rica has taxed fossil fuels for years and its collection is transferred to environmental care with a so-called "ecological tax", which finances forest conservation. As the MDVCCR is a voluntary market, it will issue only Costa Rican Compensation Units and not greenhouse gas emission rights, mostly linked to markets with emissions and transactions limits.

In Mexico, the carbon content of fuels is being taxed in order to discourage their use and to mitigate GHG emissions. All revenues derived from the collection of the carbon tax in Mexico go directly to the general budget of the country and are not labeled for a specific use. As of February 2020, the total income collected through this instrument was 41336 million pesos (2025 MUSD). Natural gas has been an exception to this policy. In addition, a market for CO_2 emission rights has been developed, Mexico being a pioneer in the region in this regard. The facilities that carry out activities in the energy and industrial sectors participate in the Emissions Trading System. During the Pilot Program (which ends in late 2022), only facilities whose annual emissions are equal to or greater than 100,000 tons of direct carbon dioxide emissions will participate.

In Argentina, a carbon tax for liquid fuels based on a local rate began in January 2019. The tax is grounded on law 23.966. The rate slides within a band of [1, 10] USD/tCO2e, and it was provided that a proportion of the money obtained from the collection of the measure would be shared among the provinces and would finance various programs and funds of the national government. Finally, a proportion would be destined to financing measures to promote renewable energies. It was expected that the tax rates that would be applied to each fuel would be updated quarterly based on the Consumer Price Index provided by the National Institute of Statistics and Censuses. In addition, biofuels in their pure state were exempted, and biodiesel, bioethanol and biogas were taxed only on their fossil fuel component.

In Colombia, a tax has been proposed from which only companies with certified carbon neutral operations will be exempted. The guidelines for ensuring the environmental integrity of the instrument are being developed. The Carbon Tax has a specific rate considering the carbon dioxide emission factor for each specific fuel. The rate is fifteen thousand pesos/ tCO2e. It is created by Law 1819 of 2016 (Structural Tax Reform). Colombia is the third Latin American country, after Chile and Mexico, to implement a tax on greenhouse gas emissions. The expected collection is approximately 220 million dollars per year. These funds are designed for a specific use: 70% of the proceeds go to the Peace fund to support the process in conflict zones, 25% to help reduce deforestation, coastal erosion, climate change and efforts of biodiversity conservation, and 5% to support the national system of protected areas.

In Peru, a carbon tax has been evaluated in the transportation sector where there were already motor-vehicle taxes, so there was a rejection from consumers that aborted the bill. There are other measures already deployed, such as the carbon footprint program, already operational, and a national registry of reductions currently being developed.

The discussions held during the events presented the expectations of the various interest groups in the region regarding the implementation of a carbon pricing in electric systems. It was concluded that there are four general expectations: a more transparent communication for consumers, the use of the funds for a second environmental or social effect, effective institutional arrangements and clear and conflict-free instruments.

The challenges of LATAM by 2030

The main conclusion of the set of workshops was the need to have greater ambition regarding carbon prices in the remainder of this decade, a rather unusual situation because it is strongly linked by the energy transition, with the restrictions generated by the peak of mineral coal that occurred a decade ago and possible peaks in oil and natural gas on the way, and which may occur before 2040. The region is very rich in fossil resources and, in this part of its history, carbon prices are going to become a very important economic burden. The lessons that the European Union leaves with two decades of carbon pricing are simply one: to be ambitious and timely with carbon pricing adjustments and to promote the various low-carbon energy solutions that are entering the market and to be flexible to the placements of taxes, as well as for the eliminations since the changes are going to be permanent. The following topics are recommended for future carbon price events in the electricity sector in LATAM:

1. *Developing tax incentives for the decommissioning processes of plants that are fossil-fuel- or coal-intensive. Companies in the region face pressure to invest in clean energy, but they also have contracts and equipment in depreciation, so it is necessary to think that incentives are necessary for a "soft" exit without economic shocks. This issue is associated with a correct financial analysis, contractual conditions that have to be respected and long-term planning to sustain the energy security of domestic, commercial and industrial consumers, which is why it is possibly the most important of all.*

2. *Building regional capacities for developing and regulating in economic and financial terms the carbon pricing for the electricity sectors and those that use thermal energy. The format could be asynchronous sessions so that regulators can take a short and effective program of a maximum of 4 hours and then have options for advanced topics, or by technologies, with additional hours.*

3. *Developing regional capacities in general financial models for PG energy projects and low carbon solutions, from photovoltaic solutions to hydrogen, and taking into account models such as LCOE and capital financial expectations.*

4. *Building capacities to design policies in general that use the carbon pricing effectively during this energy transition by 2030. This point must be accompanied by discussions on scenarios based on national circumstances, as there are no two countries with identical casuistry and scenarios are mandatory as global warming is a very long-term problem.*

5. *Developing further technical analyses on "low-carbon solutions" and the effects of carbon pricing taking into account the upcoming changes. These analyses would take into account the current and future efficiencies and maturity levels of the technologies, as well as the processes for introducing new technologies.*

6. *Reporting on more "lessons learned" from countries that have achieved positive effects with these policies. Especially developing casuistry by economy and/or sector size.*

7. *Developing casuistry on the institutional arrangements and their effects on the design, deployment and regulation of the carbon pricing. Emphasizing two issues: the roles and responsibilities of the arrangements between ministries and the development of information programs for end-consumers on their "climate awareness" that should end up on their electricity bill at the end of the month.*

8. *Developing the "carbon-intensity-index" business models that are associated with carbon pricing and corporate-responsible responses.*

9. *Designing effective communication campaigns on climate and carbon pricing. There is a significant experience of regional energy efficiency campaigns that can be extended to the climate and carbon issue.*

10. *Generating a directory of regional researchers and/or experts. This can be generated through groups of experts on media such as LinkedIn and/or Facebook without the need for accreditations for competencies or exams. Professionals interested in being part of a community dedicated to exchanging technical information and experiences can sign up on these platforms in order to receive notifications of future developments in the region and logging in, with the prior consent of the participant, in order to provide contact emails. This activity can be organized through an outsourced service.*

    For the continuation of this process in LATAM, it is recommended to start designing decentralized regional events, taking into account the points mentioned above, in order

to achieve a process with greater participation and greater feedback from stakeholders and partners, as well as to convene more regulators and private energy companies into the discussions.

1. Background

On April 14 and 15; July 20 and 21 and September 28, the series of events titled "Carbon pricing and electricity sector in Latin America" was conducted virtually, organized by the International Energy Agency (IEA), the International Carbon Action Partnership (ICAP), the Konrad Adenauer Stiftung Foundation (KAS) through the Regional Program on Energy Security and Climate Change in Latin America (EKLA) and with the collaboration of the Climate Policies Institute (by its Spanish acronym).

The conferences convened at least 40 specialists from the region to discuss, together with people in charge if regulations in Argentina, Brazil, Chile, Colombia, Mexico, Peru, the USA and the EU, the challenges implied by the management of carbon pricing for electric systems and achieve the delicate balance between a mitigation of CO_2 emissions and economic prosperity. The setting of the price on carbon has been an efficient instrument with many years in the market, especially in the European Union, and one that is able to drive decarbonization transparently by influencing the prices of goods and services.

The topics addressed were various: the situation of carbon pricing at the international level; the future perspectives on the development of carbon pricing mechanisms in the region; the use of the funds generated by the instruments; the possible compensations for the adverse effects for the more exposed social segments; communication in society and the institutional arrangements in order to generate effective coordinations of its deployment. This document seeks to summarize the main lessons learned in these discussions and setting the challenges for the region in the remainder of the decade in order to ensure that the setting of the price on carbon has an effect on the decarbonization of LATAM.

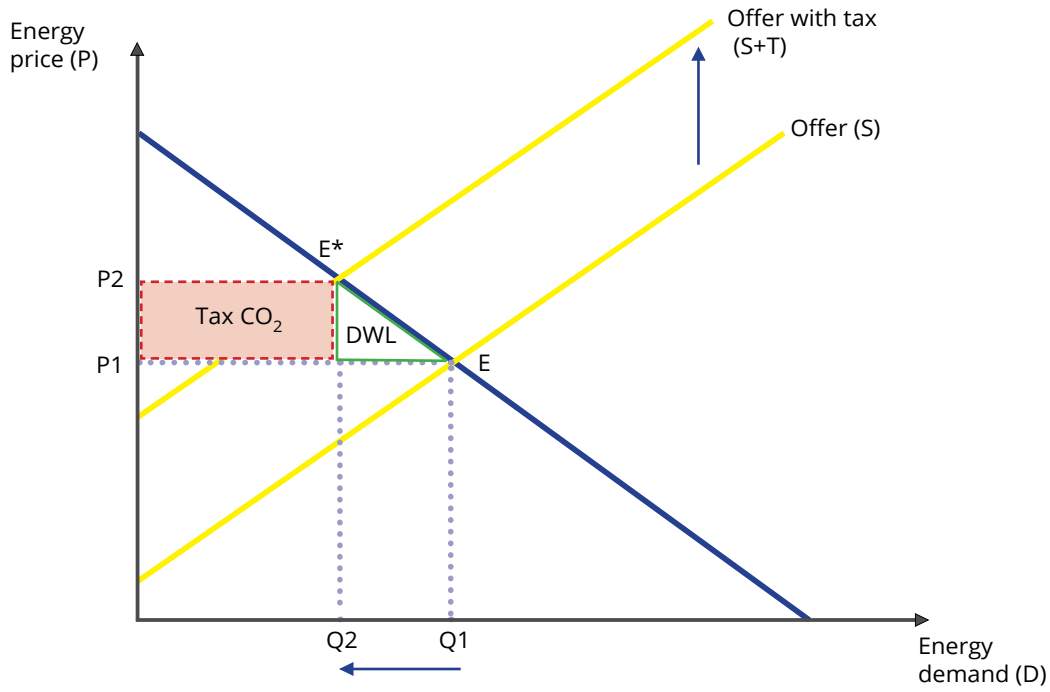
The context is notably special for the region. On July 14 of this year, the EU, one of the most important commercial partners of LATAM, adopted a proposal for a new carbon adjustment mechanism[1] at the border, which will set a price on carbon on the imports of a group of target products, in order to avoid the leaking of carbon in the Union. This will ensure that the reductions in that region truly contribute to the global objective of a firm mitigation of carbon dioxide emissions and will also align the commercial partners in the same direction.

1 See *https://ec.europa.eu/taxation_customs/green-taxation-0/carbon-border-adjustment-mechanism_en*

2. ¿What is carbon pricing? Current situation.

Carbon pricing is understood as those policies that explicitly set the price of the carbon content of goods: carbon taxes, emissions trading systems and accreditation mechanisms. Carbon pricing can cost-effectively reduce emissions and generate significant additional co-benefits aligned with sustainable development. Carbon pricing policies are widely recognized as necessary to correct the distortions or specific conditions of a market due to the externalities of climate contamination, given that the prices paid for the use of fossil fuels do not internalize the present and future social costs that climate change imposes on the world.

FIGURE 1. Effect of the carbon tax and the loss of social efficiency



Source: Produced in-house

From a strictly economic and free competition standpoint, the additional tax on CO_2 is a distortion of the market and this generates for society a loss of economic efficiency, or dead weight loss, on first assessment in the short term. The balance moves from

point E to E*, generating an increase in prices, a lower use of energy, and a triangle of loss of social efficiency is formed when the surplus of consumers is reduced. But, if we incorporate the externalities from the damages that will come from climate change, and which, in the case of Latin America, are presumed to be very severe, as confirmed by the recent AR6 report[2], the economic vision of short-term efficiency must yield to reality at the geological scale of climate change.

We can talk about two general pricing categories for the purposes of this document. The first one is set at the governmental level through local or international regulations and can be an explicit price. In the case of explicit pricing, it usually occurs with mitigation policies that are cost-effective and that also allow for the use of investments or the expenditure of public funds, in order to generate activities of environmental improvement, fulfill international commitments, or simply a greater development.

The most common one is **ETS (Emission Trading System)** as ceiling and floor prices. The two forms of ETS are cap-and-trade and baseline-and-credit. It is a system where the emitting agents can trade units of emission in order to cover their objectives in a regulated market that allows the prices to be efficient through offer and demand. In the case of cap-and-trade, a cap, or absolute limit on emissions, is applied within the ETS and emission rights are usually distributed through auctions. Whereas, the baseline-and-credit systems define the levels of emission by individual regulated entities and the credits are issued to entities that have succeeded in reducing their emissions below this level. These credits can be sold to other entities that have exceeded their levels of emission and their base lines.

A carbon tax puts a carbon pricing by defining a fiscal tax on the carbon content of a fossil fuel or on the emissions of regulated entities (for example: 15 USD/tCO_2e). Carbon taxes differ from an ETS in that the result of the reduction of emissions from a carbon tax is not predefined, but, rather, the price in itself.

A compensation mechanism designates the reductions in GHG emissions from activities based on projects or programs, which can be sold at the national level or in other countries. The compensation programs issue carbon credits according to an accounting protocol and have their own record. These credits can be used in order to fulfill an international agreement, national policies or corporate citizenry objectives related to GHG mitigation.

Results-Based Climate Financing (RBCF) is a financing approach where the payments

2 See the report at *https://www.ipcc.ch/assessment-report/ar6/*

are made after the delivery and verification of products or predefined results related to climate change management, as emissions reductions. The purpose of many RBCF programs is to acquire verified reductions in GHG emissions and, at the same time, to reduce poverty, improve access to clean energy and offer benefits for the health and the community.

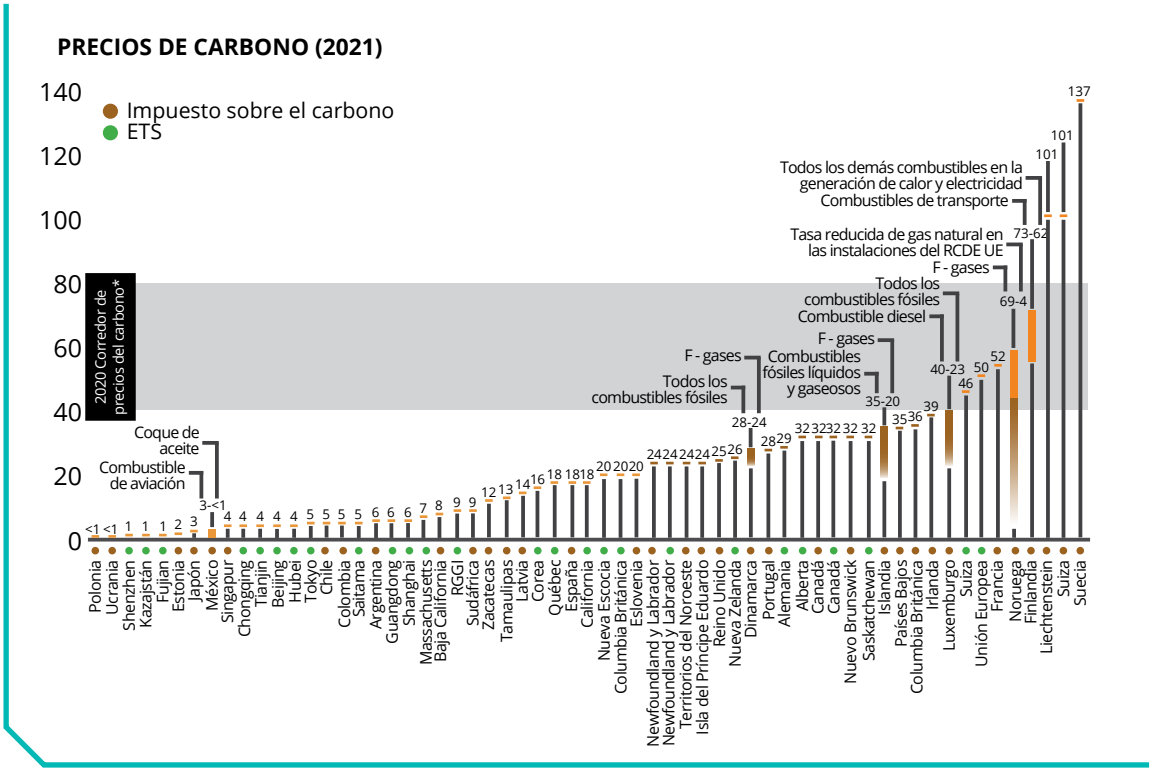
At the beginning of 2021 there are 64 operational carbon pricing instruments[3] in the world (including ETS), which cover 21.5% of global GHG emissions. This year is particularly interesting due to the effect of the launching of the Chinese ETS and which has become the largest carbon market in the world, with 2225 entities in the generation sector and an annual coverage over 4000 $MtCO_2$.

Regarding price levels, the next figure shows the most representative values for the current years, between [1, 137] USD/tCO_{2e}, where one can see that the countries with high levels of decarbonization of their economies and strong climate policies, such as Switzerland, Sweden, Finland and Norway have the highest levels, from 52 USD/tCO_{2e} upwards, in order to maintain the pressure of technical changes in the economic sectors that are still transitioning to their neutrality. Then we observe a group of countries with processes already implemented more than one decade ago, with values around [10, 50] USD/tCO_{2e} and, finally, a group with values below 10 USD/tCO2e, which are starting their price signals in very constrained sectors. For Latin America, the price range is [1, 5] USD/tCO_{2e}, with operational instruments in Argentina, Chile, Costa Rica, Colombia and Mexico, for less than five years, on average.

Although there is no uniform or common reality of the jurisdictions that have implemented carbon pricing, and although the sensitivity of each market changes according to its level of development, depending on the manner in which carbon pricing may imply an increase in energy prices for consumers, it is possible to see that carbon prices increase as decarbonization rates advance in an economy.

3 See the World Bank report at *https://openknowledge.worldbank.org/handle/10986/35620*

FIGURE 2. Carbon pricing references in USD/tCO2e in several countries



Source: World Bank Carbon Pricing 2021

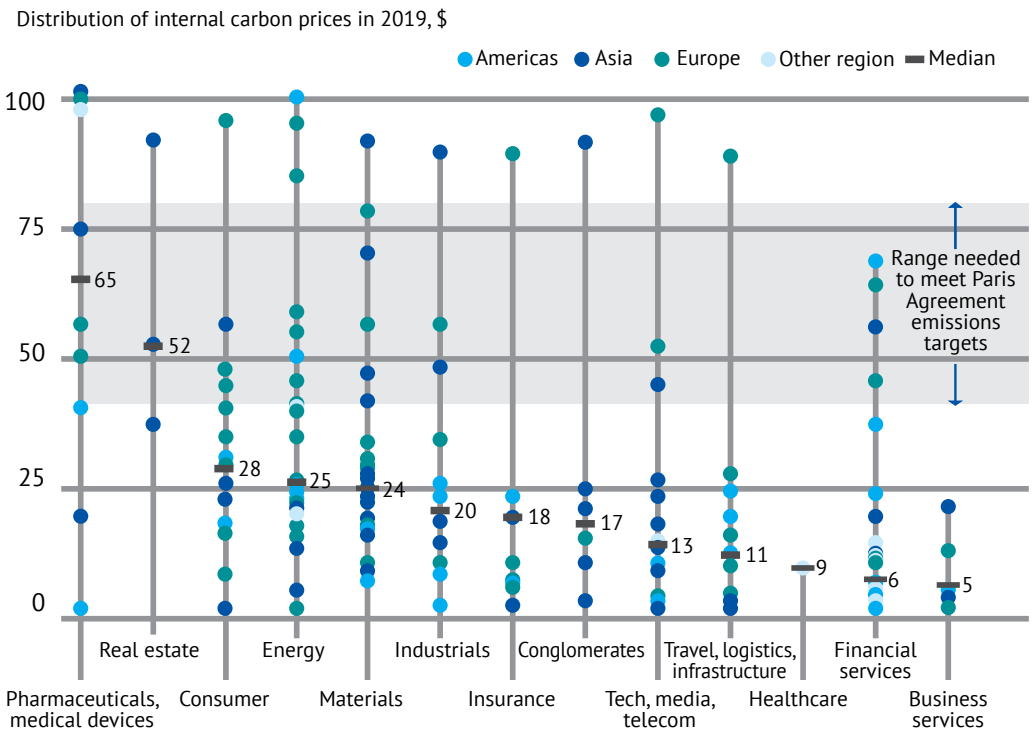
Corporate internal price

The internal price on carbon used by corporations is an internal-use tool for steering their decision-making processes in investments related to impacts on climate change, risk perception, commercial opportunities and response to their most important stakeholders. McKinsey estimates that the corporate internal price, in general, is below what they need in order to cover possible externalities of carbon emissions, *Oil & Gas* sector being the most sensitive one due to the valuation of gas and oil deposits with CO_2 content. Median prices turn around [20, 25] USD/metric tons of carbon (one ton of carbon is equivalent to 3.6 tCO_{2e}) for the industrial and energy sectors, as shown in the chart below, but should jump to a range between 50-100 USD/tCO_2 until the late 2030s in order to be in line with the Paris agreement and the reality of the prices set by public entities. Carbon pricing is normally associated with other tools for monitoring the risk of businesses, such as the risk from carbon intensity or the carbon footprint of the company's main products/services. For example, the Spanish energy company Repsol[4]

4 See indicator model at *https://www.repsol.com/imagenes/global/en/carbon_intensity_indicator_tcm14-198668.pdf*

has an intensity indicator, expressed in grams, of CO_{2e}/MJ, which is reported quarterly together with its financial statements, and which is part of its investment decision-making model.

FIGURE 3. Reference of corporate carbon prices per metric ton



Source: Summary of 2,600 reports from the Carbon Disclosure Project 2019

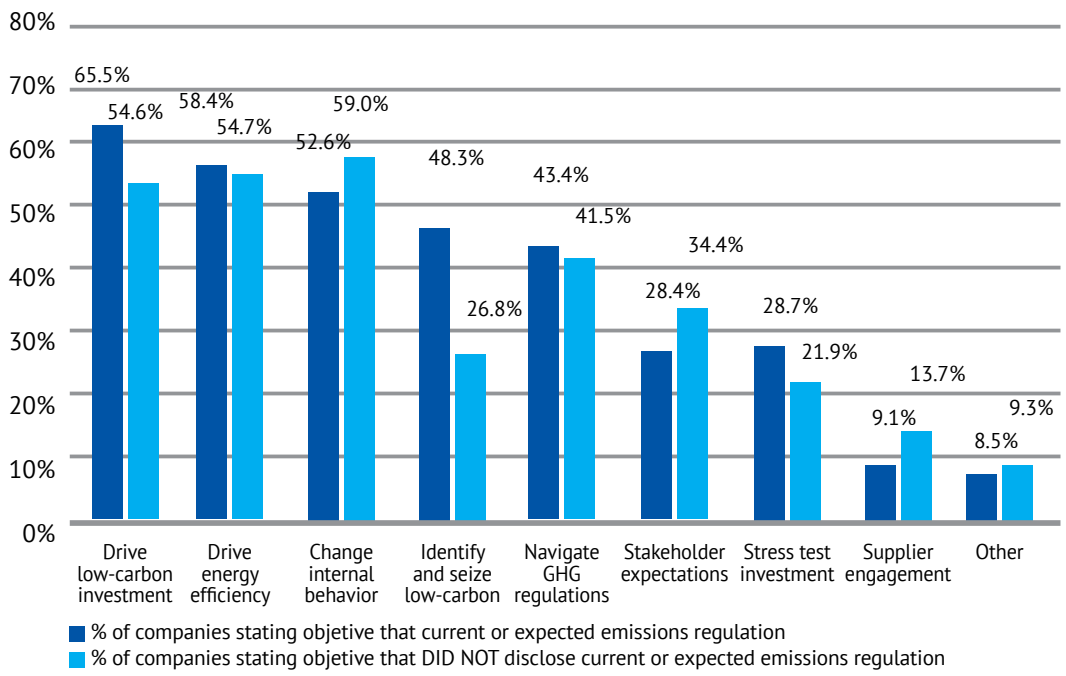
Corporate prices are normally those that vary the fastest for being of internal use and responding to the pressures of the financial and insurance sectors. CPD[5] conducted a revealing study in 2020 that shows important trends in the motivation of the use of these reference prices: almost 60% of the users mentioned that they steer low-carbon investments as the main objective of these prices in 2020, which represents a 15% increase compared to 2019.

The most cited second objective was energy efficiency, with 58% of responses to that effect. This trend is due to the assurance of a certain considerable level of

5 See the 2021 rport at *https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/005/651/original/CDP_Global_Carbon_Price_report_2021.pdf?1618938446*

repayment. The automaker Renault, for example, has used the reference prices in order to steer investments toward energy efficiency measures and product offers that promote a better use of energy in all its manufacturing operations. For its part, the Korean electronics company Samsung has made decisions regarding the use of photovoltaic energy plants with shorter repayment periods when incorporating the carbon price. This has generated a positive effect on the company's decision-making. Additionally, having an internal price is a sign for the firm's employees that they see in their organization a message on decarbonization in their operational activities, which stands as another way of doing business in the long term.

FIGURE 4. Objectives for an internal (corporate) carbon price based on the expectations of current regulations

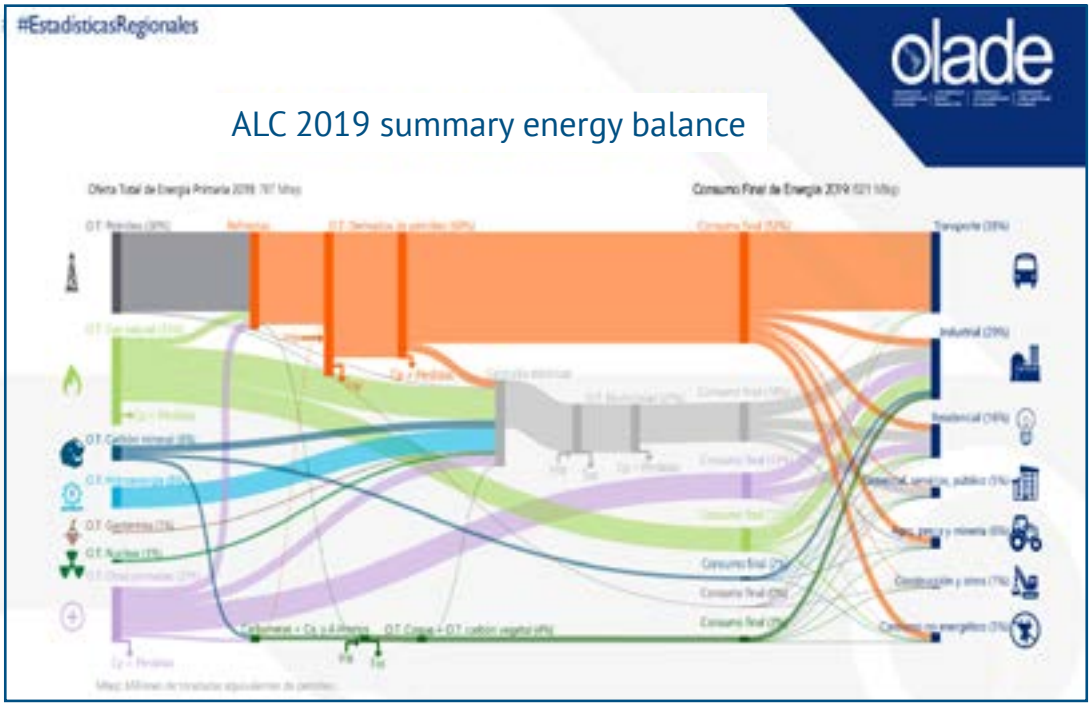


Source: CDP, Setting a price on carbon 2021

3. Situation of carbon prices in LATAM

Latin America is a region with great energy resources ranging from hydric resources to natural gas, mineral carbon, oil, biomass and radioactive minerals. The balance shown below shows that, all told, almost two thirds of the energy consumed in the region comes from oil and natural gas, and at least 75% of the energy is consumed in transport, industry and the residential sector, which are the great emitters of GHG.

FIGURE 5. Energy Balance of Latin America 2019



Source: OLADE

On the other hand, climate policies have not been accompanied by the development of these abundant resources. For example, the carbon pricing mechanisms have started to be adopted in the region since the last decade, but the prices are not high enough to drive significant changes in consumption or investment patterns. The causes are practically fifty years of policies that took advantage of the oil boon, subsidies and the motor-vehicle tax, in order to collect income for the State, and other distortions that have made it difficult to incorporate an environmental sense: the "contaminators: payers" principle among consumers.

Brazil, the largest economy in the region, has a power generation portfolio that is already decarbonized at least by 85 %, so it is difficult to think of an effective tax for the remnant who consume fossil fuels. There are studies underway for an ETS or a direct tax, but this is not yet clear due to the contingencies that it generates in its lower social segments, which are sensitive to a price increase. The issue of thermal energy is being considered in the discussion.

Costa Rica[6] has been taxing fossil fuels for years and the tax revenue generated is directed to environmental care with a so-called "ecological tax", which finances the conservation of forests. The MDVCCR, since it is a voluntary market, shall only issue Costa Rican Compensation Units and no greenhouse-effect gasses emission rights, linked mostly to markets with systems of emission and transaction limits.

In Mexico[7], they are taxing the carbon content of fuels in order to disincentivize its use and mitigate GHG emissions. All the income derived from the collection of the carbon tax in Mexico goes directly to the general budget of the country and is not earmarked for a specific use. By February of 2020, the total income collected through this instrument was 41,336 million pesos (2,025 MUSD). Natural gas has been an exception to this policy. Moreover, they have developed market CO_2 emissions rights, pioneering it in the region in this sense. The installations that conduct activities in the energy and industry sectors participate in the Emissions Trade System. During the Trial Program (which ends by late 2022), the installations whose annual emissions are equal to, or greater than, 100 thousand tons of direct emissions of carbon dioxide will be the only participants.

In Argentina, they started in January of 2019 a carbon tax for liquid fuels based on a local rate. The tax is supported by Law 23.966. The rate turns within a range of [1,10] USD/tCO_{2e} and it was planned that a proportion of the moneys obtained by the collection[8] from the measure would be shared among the provinces and would finance various programs and funds of the national Government. Finally, a proportion would be destined to financing renewable energy promotion measures. It was provided that the tax rates[9] that were to be applied to each fuel would be updated quarterly as a function of the Consumer Price Index furnished by the National Statistics and Census Institute. Furthermore, biofuels in a pure state were exempted and biodiesel, bioethanol and biogas were taxed only in their fossil fuel component.

6 See the policy at *https://www.cr.undp.org/content/costarica/es/home/library/mercado-domestico-voluntario-carbono.html*

7 See the system at *https://www.gob.mx/semarnat/acciones-y-programas/programa-de-prueba-del-sistema-de-comercio-de-emisiones-179414*

8 See references at *http://servicios.infoleg.gob.ar/infolegInternet/anexos/0-4999/365/texact.htm*

9 See references at *http://biblioteca.afip.gob.ar/cuadroslegislativos/cuadroLegislativo.aspx?i=5*

In Colombia[10], they have established a tax from which shall be exempted only the companies with operations certified for carbon neutrality. The guides[11] for ensuring the environmental integrity of the instrument are being developed. The Carbon Tax has a specific rate that considers the carbon dioxide emission factor for each defined fuel. The rate is of fifteen thousand pesos/tCO_{2e} and is created through Law 1819 from the year 2016 (Structural tax Reform). Colombia is the third Latin American country, after Chile and Mexico, in implementing a tax on greenhouse-effect gas emissions. The revenue collection expected is of approximately 220 million dollars per year. These funds[12] have a specific use by design: 70% of the revenue collected is destined to the Peace Fund, in order to provide support to that process in the conflict zones: 25% to help reduce deforestation, coastal erosion, climate change and for the biodiversity conservation efforts, and 5% to provide support to the national protected areas system.

In Peru, they have assessed a carbon tax in the transport sector, where they already had a motor-vehicle tax. So, there was a rejection from the consumers, which aborted the legislation project. There are other measures already deployed, such as the carbon footprint program, already operational, and a national record of reductions underway.

10 See a summary at *https://ledslac.org/wp-content/uploads/2019/09/EdC-Impuesto-al-Carbono-Colombia-ago19-comentarios-RA-_VF-rev.pdf*

11 See references at *https://asocarbono.org/wp-content/uploads/2020/10/EL-CAMBIO-CLIMATICO-Y-EL-MERCADO-COLOMBIANO-DEL-CARBONO-Cap.-3.pdf*

12 See the reference at: *https://icapcarbonaction.com/en/?option=com_attach&task=download&id=723*

BOX 1. Carbon pricing in Chile

The Chilean case is the most successful of Latin America, especially in the electric sector. Chile now has three new taxes on emissions from mobile sources and fixed sources, which were included within the Tax Reform approved in Law 20.780 from the year 2014.

The first one applies to the first sale of light vehicles, according to their urban performance and their nitrogen oxide emissions. The second one applies to fixed sources and taxes emissions into the atmosphere of local contaminants, particulate matter and sulfur dioxide, which affect directly the communities adjacent to the places where these are emitted. The third one is a direct tax on the emission of carbon dioxide, the main global contaminant that is responsible for climate change, and is applied to the same aforementioned fixed sources.

For fixed sources, the law considers those establishments that use boilers or turbines that total a power equal or greater than 50 MW, considering the upper limit of the fuel's energy value. The Ministry of the Environment shall publish annually a list of establishments whose installations comply with these conditions and shall keep a record of boilers and turbines that must be declared through the One-Stop-Window System of the Record of Contaminant Emissions and Transfers. The authority has produced an annual publication list with the subject establishments, which produce close to 40% of the total emissions of CO2 equivalent.

The measure is aimed at the emissions coming from the burning of fossil fuels in the processes of these establishments and which generate emissions of both of global and local contaminants. The majority of these taxes fall on the electric power generation sector, which still maintains a high consumption of fossil fuels, although it shall also tax emissions from establishments belonging to other production sectors, such as agriculture, fishery and foodstuffs. In the case of mobile sources, the tax applies to those vehicles that are less efficient and those that generate greater emissions of toxic gases and are precursors of the formation of particulate matter, a local contaminant that affects the health of people. Green taxes shall not apply to

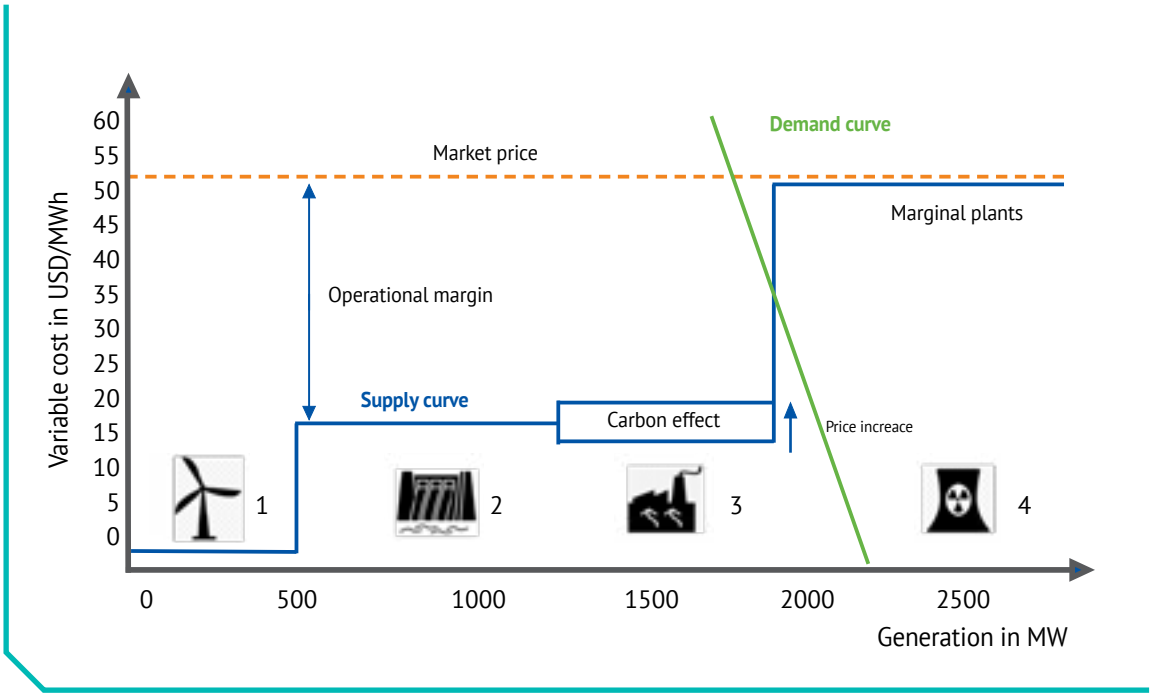
emissions based on means of generating nonconventional renewable energy whose primary energy source is biomass. The green taxes went into effect on January 1, 2017, while their Rules of Application were published on December 30, 2016. The Superintendency of the Environment is in charge of establishing the methodologies and systems for monitoring, reporting and verifying emissions subject to tax. The value for the carbon tax was established at 5.00 USD/tCO2 emitted, whereas for the local contaminants a formula was defined for its calculation that includes factors such as the social cost and the population affected by a fixed source subject to the tax.

Source: *http://www.precioalcarbonochile.cl/ipc-en-chile#claves-de-los-instrumentos-de-precio-al-carbono*

4. Primary and secondary prices

The primary benefit of a carbon pricing instrument is the generation of changes in the consumption patterns when differentiating the prices of a high-emission service or product against low-emission products and services. This gives a clear signal to the consumer of the social cost that the carbon-intensive goods and services entail. The figure below shows a typical example of the electric sector, where there are four technologies with different levels of emission. These technologies interact with a market offer and demand that sets a price if they are all coordinated with an operator. The comparison is made against a variable cost, which is easier to present more clearly in the analysis, given that the fixed costs depend on elapsed lifetimes and accounting effects. The positions of the plants between 1 and 4 as a function of the demand for power are normally price-adjusted and there may be situations where there is a difference that prevents the entry of a technology that is cleaner than others, as would be the case of positions 2 and 3, where there is an effect from carbon pricing which has raised the operational cost of the gas turbine, which places it behind a hydraulic plant.

FIGURE 6. Relationship between the variable cost and energy generation with the intervention of technologies



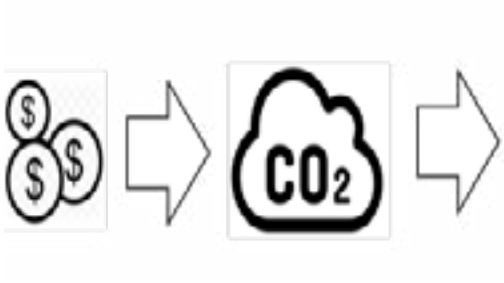
Source: Produced in-house

It is not possible to set universal rules, as each market has its particularities and its specific 24-hour load factor: for example, the nuclear units, which are price-takers, go to the extreme of the theory because they need to place all their load. However, in the cases where there are two technologies with different levels of atmospheric emissions, the carbon-pricing instrument ought to allow to generate a gap in favor of renewable or cleaner energies.

Regarding the validity terms that a carbon pricing should last, the European experience indicates to us that not all options are long-term. One must take into account the current energy transition and national commitments in order to set programs under five years in length and to see the evolution of the market structure. The changes in the electric grids, for example, do not consist solely in the technological change in the power generation source from solar, wind or geothermic energy, but, rather, there are additional elements that generate energy efficiency and, consequently, emissions reductions, with the use of batteries and smart distribution systems.

Moreover, there is a group of effects, normally positive, that are caused by the effect from the investments in new technologies with lower or zero emissions into the atmosphere and which generate an important sequence of benefits that are summarized in the following figure.

FIGURE 7. Co-benefits from the changes in the energy systems



- Less Air Pollution
- Less chemical deposits on the ground
- Fewer stools in bodies of water
- Less Corrosion of infrastructure
- Less damage to the health of sensitive groups
- Energetic increase in security
- Technology transfer
- Low carbon type innovation
- Extra income to the treasury
- More jobs and maintenance / construction services

Source: Produced in-house

For example, the process of changing a plant based on natural gas with a plant based on a wind-turbine system will have positive effects on society, starting with the economic effects derived from the construction and later operation of the equipment, as well as the transfer of technologies with advanced systems that allow them greater reliability and duration. Additionally, the wind-turbine system eliminates all the emissions from the gas turbine, a contrast that intensifies when the comparison is made against a plant with power generation based on mineral carbon. Aerial emissions end up being depositions on water and land bodies close to the operation, in addition to which there are the nearby corrosion effects on the infrastructure or the quality of the air that is breathed by the collectives of sensitive elderly or children.

The table shown below is an exercise for boilers with the same power and which are compared on the bottom line with a wind-power plant. Under the green block, we observe how thermal efficiencies, and ultimately the economic efficiency of the system, change considerably between fossil fuels and the use of the biomass. The lower block, in blue, presents estimations made with the EPA[13] standard for fixed sources of CO_2, NO_x and SO_2, which show the advantages in emissions between wind-power production and that which uses the biomass and fossil sources. The complexity of the analysis increases if we have to add energy safety considerations, gas import contracts or biomass by pipeline or ships and similar logistics.

13 See *https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors*

TABLE 1. Comparison of environmental externalities per type of fuel

Energy use	Power	Thermal efficiency	LCOE USD/MWh	Useful life
Carbon	100 Mw.	90 %	45	40 years
Natural Gas	100 Mw.	86 %	25	25 years
Biomass	100 Mw.	75 %	55	25 years
Asphaltenes	100 Mw.	88 %	60	30 years
Wind	100 Mw.	Load factor <25 %	60	20 years on ground.

Emisiones al aire	Kg SO_2/h	Kg NO_x/h	tCO_2/h	Particulate matter
Carbon	405.5	105.64	38.4	Yes
Natural Gas	0.1	25.25	26.9	No
Biomass	1.7	26.2	0	Yes
Asphaltenes	241.1	84.5	30.6	Yes
Wind	0	0	0	0

Source: Produced in-house

5. ¿What do the stakeholders in the region expect?

The discussions conducted during the events presented the expectations from the various stakeholders in the region around the implementation of carbon pricing in the electric systems. It was concluded that there are four general expectations for a proposal of this nature, which are detailed below:

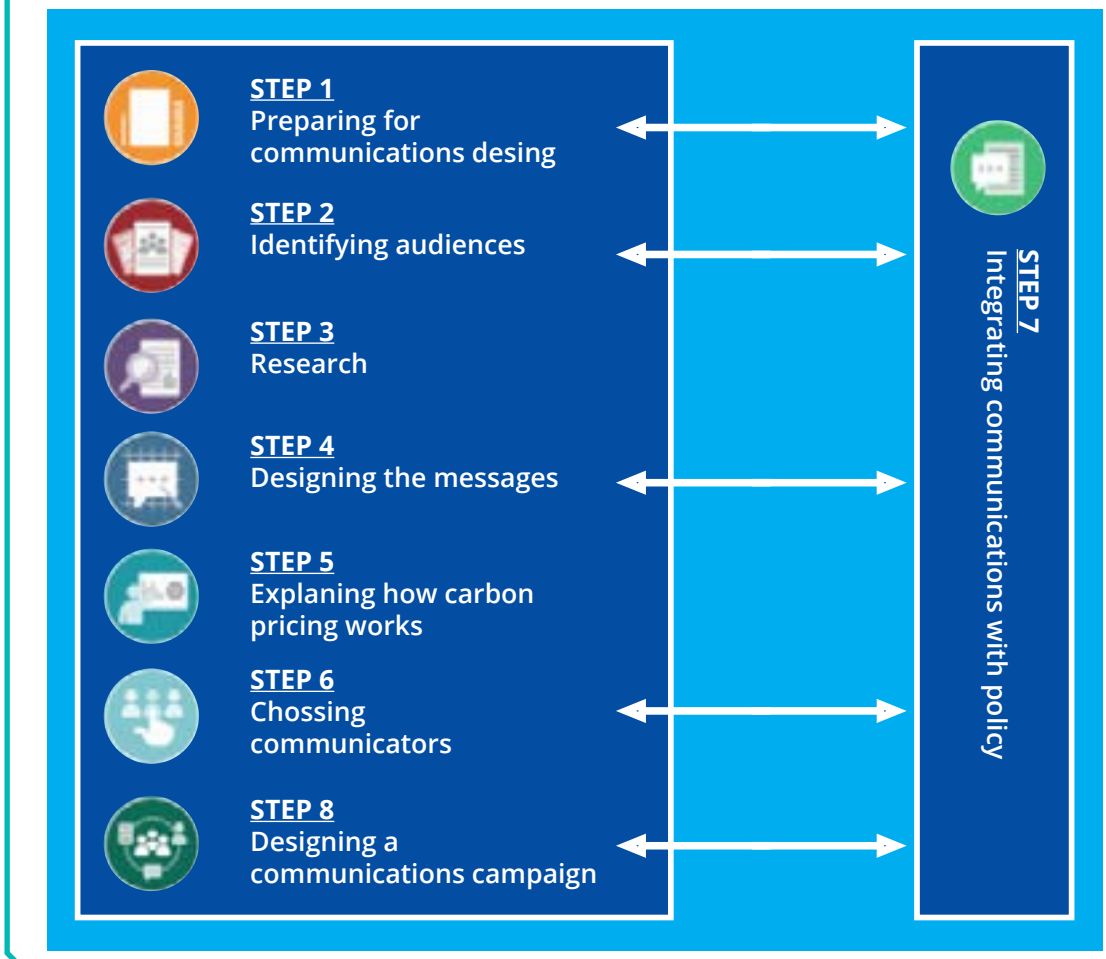
Communication

It is a fundamental element in any initiative that affects the pocketbook of consumers and which, in the case of LATAM, is usually the digital or physical receipt given to a consumer, with little or no information on the climate externalities. The effective communication processes on the introduction of carbon pricing have been a topic of a guide published by PMR and which represents an eight-step method for generating a campaign, as shown in the figure below, and which covers critical topics such as campaign design, the selection of communication channels, the integration into the policy and other initiatives from the State, the use of opinion leaders and maintaining a transparent and timely communication regarding the results, especially in a context of growing interest for energy transition and of concern for the effects of global warming.

As previously indicated, it is very difficult to generate the connection between electric or thermal consumption with climate change for the common consumer, and even for the industrial sectors. If this connection is not generated, there will be a lack of support or a position opposing any level of introduction or ambition pertaining to carbon pricing through the election cycles. A lesson learned is that the messages must not concentrate on the technicalities of the instrument, but, rather, on the short- and long-term benefits.

In some jurisdictions of the region, such as Mexico and Colombia, it has been found that there are conflicting opinions regarding the proliferation of renewable sources for electric power generation. Environmental and climate change problems are placed below other relevant issues, such as the precariousness of the economy, the pandemic and corruption. There are also criticisms against large projects, especially for hydroelectric installations, that may impact negatively the communities from the effects of erosion and changes in the ecosystem balance, which generates a lower quality of the soil for the agricultural sector. In the case of Peru, the attempts at readjusting the fuels due to the climate effect ended up with closed stances against a part of the transport sectors at the labor union level.

FIGURE 8. Eight-step guide for a carbon pricing campaign



Source: World Bank, PMR 2018

The final message on this point is the need to generate trust, to deliver messages regarding well-measured activities and which are going to be fulfilled, and that these are perceived as such in monitoring surveys in order to generate social acceptance, as well as getting society involved in the solutions against global warming, but in a fair transition.

Use of the funds for a second environmental or social effect

Normally, energy taxes go to the government's budget, whether it is the VAT or additional taxes for externalities, and the case of carbon pricing is no different. But the generation of an increase in electricity costs is, indeed, of concern for developing

economies and where, additionally, there is no sensitivity and/or connectivity with the climate crisis in the long term. Hence, we may speak of two points to be reviewed in the design of this tax.

The first one is to see the necessary legislative modifications in order that the design of the instrument contemplate a percentage of the flows to be redirected to mitigate the cost overruns from electric power to segments identified for their low income level in specific geographic zones, or the identification of a cadaster for social support or analyzed through the consumption values of their receipts. The mitigation of the adverse effect must be total inasmuch as possible, and it must be clear in the communication plan that it is a temporary effect in order to achieve the changes in the system.

The second one is to generate an additional effect to the price signal. From the ideas reviewed with experts from the region, which include reforestation, introducing green hydrogen, electric transport subsidies, generating national capabilities in new clean energies, the preferred one was that of energy efficiency, because it is a measure that normally has an important return-on-investment level, which makes it attractive both in the industry (for example, by means of a grid thermal insulation plan) and for residential/commercial consumers (for example, migrating to LED lighting), and which can be instrumentalized through campaigns, technical guides and direct subsidies for showcase pilots. Reforestation measures also have a high preference because they are cost-efficient measures which require a low investment per recuperated hectare, they are processes that last at least 10 years and have a quick impact on job creation for the reparation of forests and monitoring processes, which, in the case of LATAM, are relevant because they are in the zone of equatorial forests, with high levels of biomass generation, which can contain up to 280 tC/Ha.

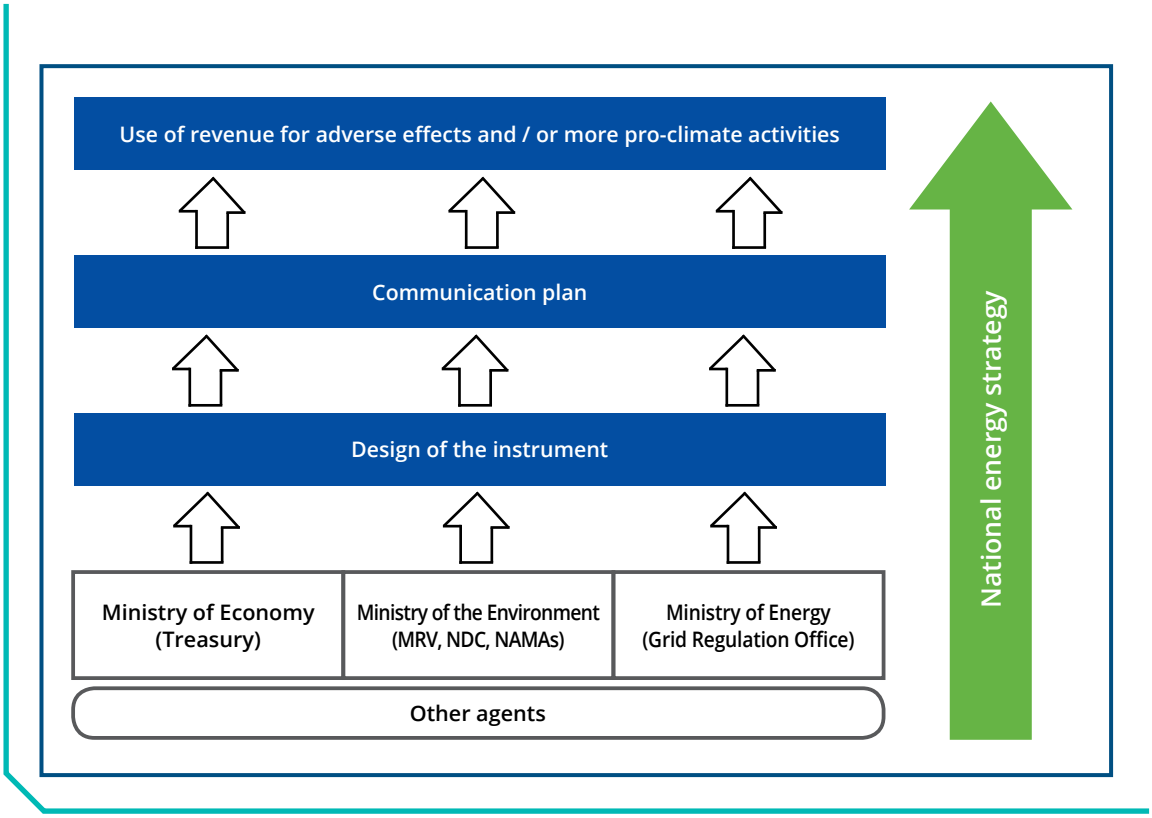
Effective Institutional Arrangements

The low connectivity and individualism of Latin American institutions are also to be taken into consideration in order to achieve a successful, and above all transparent, instrument. Consistently, the people who participated in the workshops identified the ministries of economy, energy and environment as the players whose coordination is necessary for the design of an instrument. Furthermore, and depending on the uses of the funds coming from the instrument, the ministries of agriculture and industry were mentioned as players that ought to be involved.

The above statement implies that the design of the instrument be accompanied by a communication plan for the development of capabilities and the connection with the

stakeholders, as well as a monitoring plan and a clear governance structure for the synergies that may arise. This must be aligned with the national energy plans, in order to maintain the consistency of actions and messages, as presented in the following graph.

FIGURE 9. Governance of a carbon price proposal



Source: Produced in-house

Finally, the governance of the carbon-pricing implementation process must also maintain the synergies of the ministries and leading functionaries in each of its critical components, in order that the objectives not be in dissonance with the national plans and that there be minimum standards of transparency and fairness toward the stakeholders that will be affected by the tax.

Economic instruments that are clear and without conflict

Carbon pricing is usually not the only energy instrument used by the countries of the region, but it is possibly among the newest that they have implemented. The participants identified the fact that most of the countries already have energy strategies

and some level of national planning, but there are conflicting sectorial interests that it is important to map. The most common cases that were detected during the sessions were:

- Conflicts with energy security and the abundance of the energy resources of a country. Two cases of special attention that were mentioned by the participants are those of Colombia and Peru. Colombia is one of the most important exporters of high-quality bituminous coal in the world.
  This product has already reached its consumption peak, which exposes this industry, which has a long history in the country, to the possibility of having to close in a few years or having to bet on initiatives that are costly and not yet mature, such as the use of storing coal underground in order to extract hydrogen from the coal. In the case of Peru, the country has abundant gas resources and is the only exporter of cryogenic LNG on the South Pacific coast. This industry is faced with a similar dilemma, in spite of the lower level of emissions of methane. Peru has a chain of enormous value in the form of market hubs, pipelines, processing plants for liquids, cryogenic plants and ports, which are exposed to the energy transition.

- The balance between introducing carbon pricing for the electric and thermal consumption sectors. In this regard, Brazil was identified as the most interesting case, as it is an economy with a decarbonization of its electric grid above 85% and which is facing difficulties to incorporate a carbon pricing among the producers based on fossil fuels, on the one hand, or introducing a tax on thermal energy in a market that has developed biofuels considerably for decades and has pricing schemes that were designed to that effect, on the other hand.

- The beginnings of consumer conglomerates with self-generated renewable energy on their roofs with solar panels and batteries, which will keep increasing in the remainder of this decade and which could place their clean energy surpluses on the grid. This situation is a challenge for their formal incorporation into the system with adequate prices and a free competition.

- The integration of carbon pricing (actual or shadow prices) into the long-term energy plans, in the operation of grids and in the preferential auctions of the State, is a process that will probably become legally complicated, given that the current designs emerged without considering the impact of these instruments. Their incorporation will require a very extensive analysis in order to clarify their consequences. In addition to this, there are the certifications that can be adopted in order to give more seriousness and transparency to the processes or adaptations to operate with a national record of carbon projects, or to connect to article 6 of the Paris agreement.

Finally, it is key to merge, stabilize and be clear about the cycles during which these concepts will last, since the changes must take place at one point and one cannot limit the economic competitiveness and efficiency of a permanent market. The review of the strategies must compare, combine and redesign, inasmuch as possible, the energy systems with high consistency and in line with the final decarbonization objectives. One must add to all this a flexibility regarding all that will come in the energy transition in the form of hydrogen, Power-to-X, e-fuels, nuclear-fusion energy, smart systems and more sophisticated developments of batteries.

6. The challenges for LATAM by 2030

The main conclusion of all the workshops was the need to be more ambitious regarding carbon pricing in the remainder of this decade, a very unusual situation because it is strongly connected to the energy transition, with the restrictions generated by the mineral carbon peak that occurred one decade ago and possible peaks in oil and natural gas coming ahead, and which may occur before the year 2040. The region is very rich in fossil resources and, in this part of its history, carbon prices are going to become a very important economic load.

The lesson from the European Union, with two decades of carbon pricing, is simply to be ambitious and timely with the adjustments of carbon prices and the promotion of the various low-carbon energy solutions that are entering into the market, as well as being flexible for the placement of taxes, as well as for the eliminations, since the changes are going to be permanent.

BOX 2. Perspectives of the European Union by 2030

Reuters informed in mid-2021 that carbon prices in the emissions trading system of the European Union are expected to increase significantly in the next decade, due to stricter climate objectives. This perspective is based on a broad survey of the industry published on June 14. The emissions trading system of the European Union (EU ETS) is the largest carbon market in the world, covering around 45% of the production of greenhouse-effect gases in the block and has emitters paying for each ton of carbon dioxide that they emit.

The survey from the International Emissions Trading Association (IETA) found that the members expect carbon prices in the EU ETS to average 47,25 euros (USD 57) per ton between 2021 and 2025, and 58,62 euros per ton between 2026 and 2030. This is due mainly to a stricter objective from the EU to reduce emissions by at least 55% by 2030, compared to the levels of 1990. The survey from last year predicted a median price of 31,71 euros per ton for the fourth phase of the ETS, which extends from 2021 through 2030. The reference prices in the ETS are currently quoted around 53 euros per ton.

The internal emissions trading scheme of Great Britain started to be traded in May of this year. The majority of those surveyed expect it to be connected to the EU scheme by 2023. The participants anticipate that the global median price of carbon necessary by 2030, in order to steer the world toward compliance with the objectives for stopping the increase in global temperature, is of 63,20 euros per ton, compared to the expectation from last year, of 55,97 euros per ton. The members of IETA include banks, stock exchanges and energy and industrial companies. The association received replies from 158 representatives of members for the survey.

Source: *https://www.reuters.com/business/sustainable-business/europe-carbon-prices-expected-rise-2030-industry-survey-2021-06-14/*

The above statements can be exemplified in an exercise with recent data from two technologies that are going to be found competing extensively in the region: natural gas in gas turbines or with extra-combined-cycle equipment, and wind farms, in a region that has good wind and solar conditions for renewable solutions.

If this exercise is conducted on the basis of 100Mw of output for a plant that can be composed of a single turbine in order to gain greater output efficiency, we obtain an LCOE, or nominal Levelized Cost of Energy of 61.86 USD/MWh, dispatched to the reception substation and with a level of emissions of 0.47 tCO2/MWh. The main advantage of a turbine is the speed of intake into the system, the quality of energy for synchronization and the stability of power that can be delivered by design, by depending on the combustion of an abundant supply, such as natural gas, and which arrives through pipelines. The lifetime of the asset normally exceeds that of a wind-power plant and it is an equipment with a construction and installation cycle that can be below 12 months, and does not require studies on variable conditions, such as wind, but, rather, the assignment of long-term contracts for the gas. The gas turbines keep improving in their design and the materials used and, therefore, their efficiencies, should keep increasing by 2030 and the prices of natural gas, disconnected from oil, should remain stable, or decrease, inasmuch as new competitors (such as hydrogen) continue to advance. Moreover, there are huge reserves yet to be exploited in LATAM.

TABLE 2. Technical data of a natural gas turbine and its emissions

LCOE analysis of a wind farm

Capacity data of the farm

Farm wirh several turbines		
Size of the plant	100	MW
Load Factor	43%	
Generation Unit	232.6	MW
Energy produced	849,720	MWh/año
Energy consumed	1,976,093	MWh

Capital expenses

CAPEX	100	USD/KW installed
CAPEX	43%	USD

Operational expenses

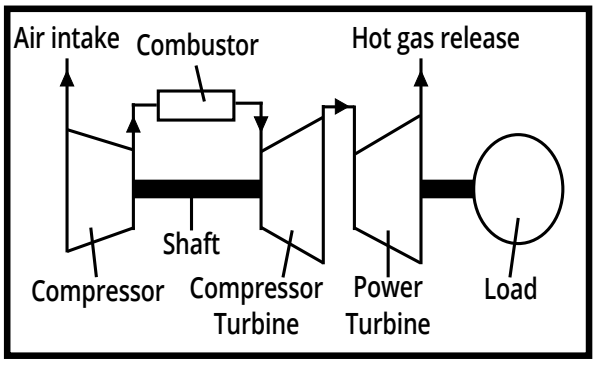
Fixed expenses	4,534,884	USD/year
Variable expenses	1.75	USD/MWh
Administration	3,458,163	USD
	12.8	USD/MWh
Natural Gas	25,293,991	USD/year
OPEX total	33,287,037	USD/year

Financial rate

WACC of the Company	12%	

LCOE	61.86	USD/MWh

CO_2 emissions	56.1	tCO_2/Tj
	399,092	tCO_2/year
	0.470	tCO_2/MWh-output



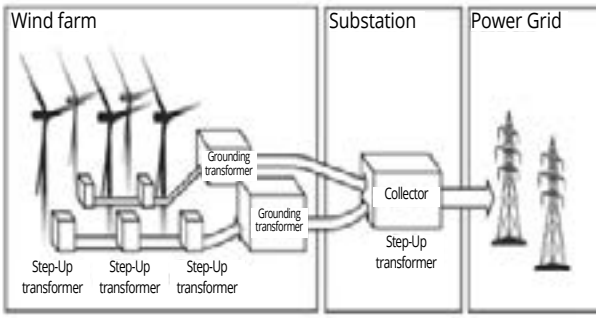
Source: Produced in-house

The analysis of a wind farm presents many complexities: the first one is the load factor, where the engineering of the rotor and blades is currently achieving wind energy capture values of 35% that were unthinkable one decade ago, when it was supposed that their future was to be placed off-shore, with greater costs. Moreover, the use of satellite information has reduced the previous analyses for determining the wind levels all year long and allowing more solid business cases. In this comparative exercise that assumes an output power equal to the case of the gas turbine, the LCOE is of 65 USD/MWh without emissions, as it is a totally renewable solution. On the side of uncertainties, the larger quantity of mechanical elements in motion and any extraordinary variation over the availability of wind are factors that can change the economic conditions of the project on its useful life. Regarding the construction materials of this type of plants, the blades have succeeded in generating confidence in achieving lifecycles of up to 20 years without difficulties. The annexes show the cash flows of both cases, with a rate of 12%, common in power downstream businesses.

TABLE 3. Technical data of a 100Mw wind farm.

LCOE analysis of the wind farm

Capacity data of the farm		
Farm wirh several turbines		
Size of the plant	100	MW
Load Factor	34%	
Generation Unit	294.1	MW
Energy produced	849,720	MWh/year
Energy consumed	1,603,245	MWh (max. wind, Betz's law)
Capital expenses		
CAPEX	1100	USD/KW installed
CAPEX	323,529,412	USD
Operational expenses		
Fixed expenses	9,705,882	USD/KW-year
Variable expenses	1.38	USD/MWh
Administration	2,212,478	USD
OPEX total	11,918,361	USD/year
Financial rate		
WACC of the Company	12%	
LCOE	65.00	USD/MWh



Source: Produced in-house

In both cases, we can appreciate a difference, which, depending on the contractual conditions (base, peak, other) and climate conditions, could generate variations causing greater complications to the wind farm than the gas turbine. It is possible to observe that there is clearly an opportunity for the price signal if a tax is imposed on the externality generated by the burning of natural gas. Values within a range of [1,5] USD/tCO_2 are unable to deliver a strong signal capable of covering all the variations that typically come in the cases of energy businesses. In this illustrative example, the price ranges must be higher in the remainder of this decade in order to provide a solid price signal that may disincentivize investment in the plant with gas turbine.

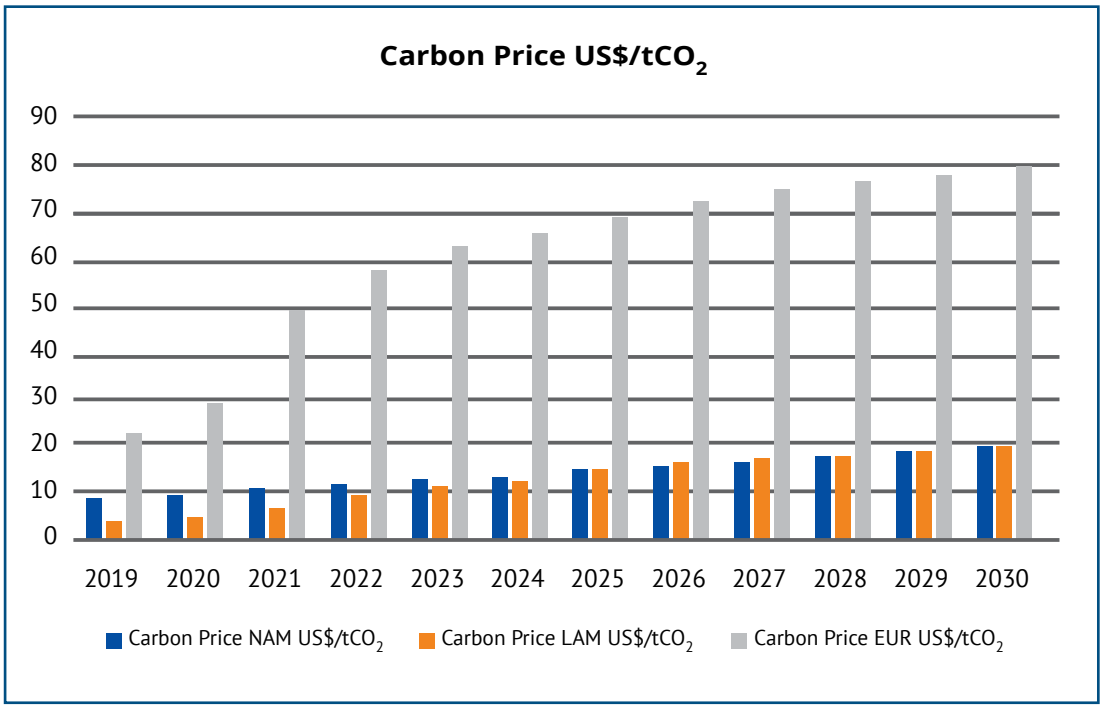
TABLE 4. The effect of carbon pricing on the compared cases

LCOE Gas turbine	61.86	USD/MWh		
LCOE Wind farm	65.00	USD/MWh		
Cost difference	3.14	USD/MWh		
Carbon	0.470	tCO_2/MWh		
Tax values	5	USD/tCO_2	2.3	USD/MWh
	10	USD/tCO_2	4.7	USD/MWh
	15	USD/tCO_2	7.0	USD/MWh
	20	USD/tCO_2	9.4	USD/MWh

Source: Produced in-house

In line with the above statements, the carbon-pricing scenarios throughout the world will be a permanent questioning during the energy transition. A recent analysis conducted by DNV shows the values up to 2030 and, for the case of Latin America, the values are projected around 20 dollars, which makes much sense in light of all the above statements and the need to contribute to the dynamic of the renewable energy market in this transcendental decade for mitigating climate change.

FIGURA 9. Governance of a carbon price proposal



Source: *https://eto.dnv.com/2021*

7. Recommendations on the contents of future events

The following topics are recommended for future carbon-pricing events in the electric sector in LATAM:

1. Development of fiscal incentives for the decommissioning processes in plants that are fossil-fuel- or carbon-intensive. The companies of the region are facing pressures for investing in clean energies, but also have depreciating contracts and equipments, so it is necessary to think about what incentives are necessary for a "soft" exit without economic shocks. This topic is associated to a correct financial analysis, contractual conditions that must be respected and the long-term planning in order to sustain the energy security of the domestic, commercial and industrial consumers. So, it is possibly the most important of all.

2. Constructing regional capabilities in order to develop and regulate carbon pricing economically and financially for the electric sectors and those that use thermal energy. The format could be asynchronous sessions in order for regulators to be able to take a short and effective program of a maximum of 4 hours, and then have options for advanced topics or for technologies with additional hours.

3. Developing the regional capabilities in general financial models for the projects on RE energies and low-carbon solutions, ranging from photovoltaic solutions to hydrogen, and taking into account models such as LCOE and the financial capital expectations.

4. Constructing capabilities in order to design policies in general that use carbon pricing effectively during this energy transition, by 2030. This point must be accompanied by discussions about scenarios depending on the national circumstances, as there are no two countries with an identical case analysis and the scenarios are obligatory because global warming is a very long-term problem.

5. Further developing technical analyses regarding the "low-carbon solutions" and the effects of carbon pricing, taking into account the looming changes. These analyses would take into account the current and future efficiencies and maturation levels of the technologies and the introduction processes for the new technologies.

6. Transferring more "lessons learned" from countries that have achieved positive effects with these policies. Especially, developing a case analysis by economy and/or sector sizes.

7. Developing a case analysis regarding the institutional arrangements and their effects for the design, deployment and regulation of carbon pricing. Emphasizing two topics: the roles and responsibilities of the arrangements among ministries and the development of information programs for the end-consumers, regarding their "climate awareness", which should end up on their electricity bill at the end of the month.

8. Developing the "carbon-intensity-index" business models that are associated with carbon pricing and the responsible corporate responses.

9. Designing effective communication campaigns on the climate and carbon pricing. There is an important experience in regional energy efficiency campaigns that can be extended to the climate and carbon issues.

10. Generating a directory of regional researchers and/or experts.

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9. Annexes

ANNEX I: Comparative analysis with LCOE of two systems

LCOE analysis of a turbine with natural gas

Period	Discount factor	Energía	E(t)	Investments	I(t)	OPEX	OPEX(t)
Years	(1+WACC)^t	MWh	MWh	USD	USD	USD	USD
0	1.000	0		151,162,791	151,162,791		
1	1.120	849,720	758,679			33,287,037	29,720,569
2	1.254	849,720	677,392			33,287,037	26,536,222
3	1.405	849,720	604,814			33,287,037	23,693,056
4	1.574	849,720	540,012			33,287,037	21,154,514
5	1.762	849,720	482,154			33,287,037	18,887,959
6	1.974	849,720	430,495			33,287,037	16,864,249
7	2.211	849,720	384,370			33,287,037	15,057,365
8	2.476	849,720	343,188			33,287,037	13,444,076
9	2.773	849,720	306,418			33,287,037	12,003,639
10	3.106	849,720	273,587			33,287,037	10,717,535
11	3.479	849,720	244,274			33,287,037	9,569,228
12	3.896	849,720	218,102			33,287,037	8,543,953
13	4.363	849,720	194,734			33,287,037	7,628,530
14	4.887	849,720	173,870			33,287,037	6,811,187
15	5.474	849,720	155,241			33,287,037	6,081,417
16	6.130	849,720	138,608			33,287,037	5,429,837
17	6.866	849,720	123,757			33,287,037	4,848,069
18	7.690	849,720	110,497			33,287,037	4,328,633
19	8.613	849,720	98,658			33,287,037	3,864,851
20	9.646	849,720	88,088			33,287,037	3,450,759
21	10.804	849,720	78,650			33,287,037	3,081,035
22	12.100	849,720	70,223			33,287,037	2,750,924
23	13.552	849,720	62,699			33,287,037	2,456,182
24	15.179	849,720	55,981			33,287,037	2,193,020
25	17.000	849,720	49,983			33,287,037	1,958,054
	Totals		6,664,472	151,162,791	151,162,791	832,175,930	261,074,863
LCOE 61.86 USD/MWh							

LCOE analysis of wind farm

Period	Discount factor	Energy	E(t)	Investments	I(t)	OPEX	OPEX(t)
Years	(1+WACC)^t	MWh	MWh	USD	USD	USD	USD
0	1.000	0		323,529,412	323,529,412		
1	1.120	849,720	758,679			11,918,361	10,641,394
2	1.254	849,720	677,392			11,918,361	9,501,244
3	1.405	849,720	604,814			11,918,361	8,483,254
4	1.574	849,720	540,012			11,918,361	7,574,334
5	1.762	849,720	482,154			11,918,361	6,762,798
6	1.974	849,720	430,495			11,918,361	6,038,213
7	2.211	849,720	384,370			11,918,361	5,391,261
8	2.476	849,720	343,188			11,918,361	4,813,626
9	2.773	849,720	306,418			11,918,361	4,297,880
10	3.106	849,720	273,587			11,918,361	3,837,393
11	3.479	849,720	244,274			11,918,361	3,426,244
12	3.896	849,720	218,102			11,918,361	3,059,146
13	4.363	849,720	194,734			11,918,361	2,731,381
14	4.887	849,720	173,870			11,918,361	2,438,733
15	5.474	849,720	155,241			11,918,361	2,177,440
16	6.130	849,720	138,608			11,918,361	1,944,143
17	6.866	849,720	123,757			11,918,361	1,735,842
18	7.690	849,720	110,497			11,918,361	1,549,859
19	8.613	849,720	98,658			11,918,361	1,383,802
20	9.646	849,720	88,088			11,918,361	1,235,538
	Totals		6,346,936	323,529,412	323,529,412	238,367,217	89,023,524
LCOE 65.00 USD/MWh							

Programa Regional
Seguridad Energética y Cambio Climático
en América Latina (EKLA)

KONRAD ADENAUER STIFTUNG

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Summary of the "Carbon Pricing and electricity sector in Latin America" workshops

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