DECARBOOST
Catalysing Investment to Decarbonise LAC

FUNDACION TORCUATO DI TELLA

Report

Deep Decarbonization Latin America Project -Argentina -

April 2022

Dossier of mitigation opportunities and their prioritization

Activity II AR 2

Prioritization of measures and preliminary feasibility analysis - Executive Summary

April 2022

Content

I. Introduction

This is the executive summary of the report *"Dosier de oportunidades de mitigación y su priorización".* In this report, a number of mitigation options (those included in Argentina's NDC and sectoral plans, as well as new ones identified and analyzed throughout this Project) that are categorized into "mitigation packages", were prioritized. The purpose of this prioritization was primarily to identify those packages in the Energy and AFOLU sectors that were to be further analyzed as part of the project activities by developing a specific technical-economic feasibility analysis.

The main findings of this assessment demonstrate that it is possible to achieve the decarbonization of the economy by 2050 with available greenhouse gas emissions mitigation and capture technologies, for both aforementioned sectors. In the Energy sector, the identified transformations are extremely challenging in terms of CAPEX requirements. Nevertheless, the order of magnitude of those requirements is in the same level as the disbursements being made for developing the infrastructure of current carbon-intensive activities, such as the upstream in the hydrocarbons sector, as well as the new power generation capacity incorporated in the last decade. On the other hand, in the AFOLU sector, the need of reallocating a significant portion of current investment flows was recognized. The identified transformations are challenging in terms of capital investment requirements and the development of financial and public policy instruments.

The purpose of this report is to contribute to identifying the measures on which future climate efforts should be focused in order to develop corresponding economic and financial feasibility analysis, as part of the set of concept notes, to be elaborated for the mitigation investment opportunities selected.

In next phases, new policy proposals, regulatory amendments and financial instruments will be developed based on the results of the feasibility analysis in order to create the enabling conditions to make selected mitigation actions feasible, as well, as more broadly, a larger number of mitigation actions that might be also facilitated or stimulated by the emerging conditions.

Finally, in this sequence the concept notes of selected mitigation opportunities will be part of the sectoral investment plan that consolidates the prioritized measures, which in the case of Argentina, will mainly focus on the energy and transportation sector.

II. Methodological approach

Mitigation options

Within the proposed program of work of this regional Project, mitigation options included in the National Action Plans for Energy, Transport, Industry, Infrastructure, Agriculture, Land Use Change and Forestry, and Climate Change, were thoroughly studied and, in addition, new mitigation options -not previously contemplated were identified and proposed as additional sensible options.

Then the full set of mitigation options considered, both for the Energy and Transport and the AFOLU sectors, were assessed and prioritized using a methodological approach specifically developed for the purposes of this assessment and report[1]. The prioritization methodology considered three dimensions. For each of these dimensions, a scale was created that reflects increasing degrees of mitigation potential, transformational capacity as well as feasibility qualifications.

Firstly, prioritization was carried out for each of the mitigation options considered. Then, the mitigation options were clustered into **"mitigation option packages"**, according to the mitigation objective of each of the options.

Finally, the mitigation options packages were then also prioritized, to identify those that were to be further analyzed in order to develop the technical-economic feasibility analysis for those cases.

- **Energy and Transport**

According to the latest greenhouse gas (GHG) inventory, energy accounts for 51.3% of Argentina's GHG emissions, with a cumulative annual growth rate of 1.3% in the last decade. Decarbonization of the energy sector requires actions that influence, broadly speaking, two variables: the energy intensity of the national economy and the GHG intensity of energy consumption. To impact on these variables, mitigation options were grouped in packages, as presented in Figure 1, below.

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[1] Details of the prioritization can be found in the complete document "*Dosier de oportunidades de mitigación y su priorización*" (only available in Spanish)

Figure 1: Mitigation option packages – Energy and Transport

Electricity generation from renewable sources

- Large-scale penetration of renewable power generation in the national grid
- Off-grid renewable power generation
- Distributed renewable power generation connected to the national grid
- Solar PV and wind power in industry
- Large scale hydro power generation
- Generation and/or cogeneration based on concentrated biomass in industries
- Biogas and biomass production
- Alternative fuels

Electromobility and fuel substitution

- Blend of biofuels in liquid fossil fuels
- Development of low emission mobility – Promotion of low emission light vehicles; and promotion of alternative energy buses
- Hierarchization of the railway – Development of Regional Express Railways (RER)
- Recovery of railways — Re-establishment of inter-urban passenger rail services

Energy efficiency

- Energy efficiency in power generation
- Energy efficiency in residential and public sectors
- Energy efficiency in the industry sector
- Energy efficiency in the transport sector

Other options in the Energy sector

- Nuclear power generation
- Carbon capture and storage (CCS) in in thermal power plants (*)
- Use of black liquor in the pulp and paper industry
- Fossil fuel-based cogeneration
- Resource efficiency in the food industry
- Increase of additives in the cement industry
- Reuse of scrap residues
- Alternative fuels in the cement industry
- Hydrogen (*)
- Bioenergy with carbon capture and storage (BECCS) (*)

Other options in the Energy sector

- Hierarchization of the railway - Construction of non-level crossings; and Rail Freight Investment Plan (PIF)
- Urban passenger transport - Renewal of bus fleets (Euro III to Euro V); and Implementation of Metrobuses
- Urban passenger transport — Modernization of commercial aviation
- Enhancement of road freight transport efficiency - Paseo del Bajo; and National Road Plan to 2025
- Non-motorized mobility - Development of bicycle paths

(*) new mitigation options proposed by the project. Packages framed in orange are the prioritized ones.

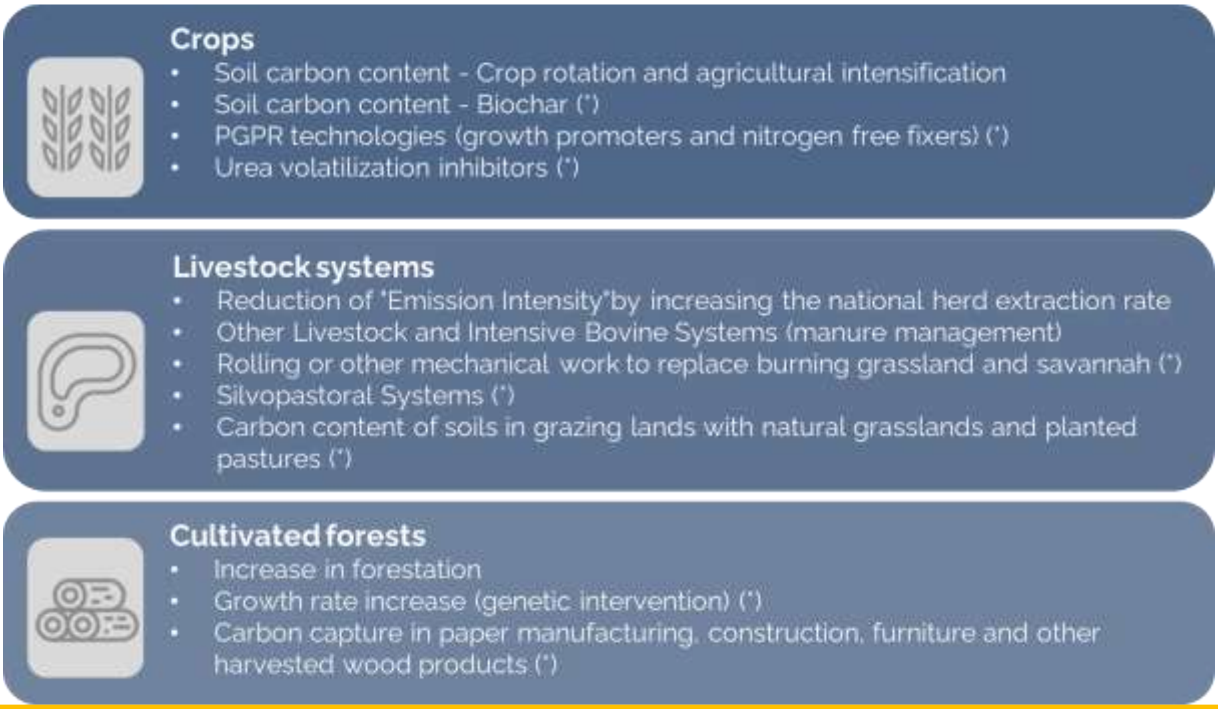
AFOLU

According to the 3rd GHG national inventory (2016), the AFOLU sector accounted for 37% of total emissions in Argentina. The mitigation actions proposed for the sector are concentrated in extensive agriculture, livestock production and planted forest sectors.

Some of the proposed actions are related to the adoption of input technologies (e.g. urea volatilization inhibitors) and other ones to process technologies (management practices or integrated production systems).

Figure 2 below presents the mitigation option packages for the AFOLU sector. Considering that the three sets of mitigation measures analyzed obtained relatively similar high scales, all of them were prioritized and further analyzed.

***Figure 2: Mitigation option packages –* AFOLU**



(*) new mitigation options proposed by the project

For those packages with a higher priority level, the team of Decarboost Argentina built scenarios considering carbon neutrality as a key goal to be achieved by 2050 and then conducted a preliminary feasibility analysis, presented in the following chapter.

III. Main results of the preliminary feasibility assessment

1. Energy and Transport

Scenarios

The preliminary feasibility assessment for the prioritized packages in the Energy and Transport sector has been structured under two scenarios.

- **Baseline scenario (business as usual or BAU)**, in which energy sector consumptions follow historical trends.
- **Electrification scenario**, in which all fossil fuel consumption in the residential, commercial, industry and transportation sectors is replaced by electricity produced from non-GHG emitting sources to the greatest extent possible, with technologies that are economically feasible today and other technologies envisioned over the assessment horizon.

The method consists of projecting the baseline year (2018) to the horizon year (2050), in the BAU scenario, using as explanatory factors the historical evolution of consumption for each energy product, the evolution of the Gross Domestic Product (GDP), the evolution of the average income, and the growth of the private vehicle fleet.

The **Electrification scenario** was modeled on the basis of assumptions consistent with three levels of evolution of the GDP. Possible trajectories are analyzed by defining the target of zero net emissions in 2050, and then moving backwards (backcasting method) to the present.

Modeling results for the prioritized mitigation option packages in the Electrification Scenario

- **Electricity generation from renewable energies**
  - The evolution required for decarbonization in end-use electrification implies that electricity demand must grow four to five times by 2050. In turn, this implies bringing the penetration of electric power over final consumption from the current 21% to around 70%, including the new electric demand generated by approximately 24 million electric light vehicles (EV).

- To meet the expected increased electricity demand, power would have to be added at a rate 12 times higher than in the last 10 years. This would imply adding an annual average of 14,750 MW of power during the period 2041-2050, which contrasts with the 1,130 MW added on average annually during the period 2009-2018.
- The installed capacity of the generation equipment would increase in this scenario from 38.5 GW in 2018 to 243.8 GW in 2050, which represents a growth equivalent to more than a six-fold increase in installed capacity, at a cumulative annual growth rate of 5.9%, including batteries and other types of backups.
- From 2027 onwards, investments in thermoelectric generation (excluding nuclear) will represent less than half of the total additions and will be made exclusively for the purpose of providing backup and flexibility to the system. In the decade from 2031 to 2040 these additions will be equivalent to less than 20%. From 2040 onwards additions will entirely cease, rather with withdrawals of thermoelectric power being expected.
- In terms of generation, while in the decade prior to 2018, 36% of Argentina's electricity generation came from emission-free sources, with the remaining 64% coming from the use of fossil fuels, between 2041 and 2050, 92% of generation would be combustion-free while the rest could come from biofuels or hydrogen.
- As a result of this change, the GHG intensity for electricity generation would decrease from 309.4 tCO2e/GWh to 49.8 tCO2e/GWh, representing a reduction in intensity of 84%, computed pessimistically (considering that the remaining combustion is based on natural gas).

⊃ **Electromobility and fuel substitution**

- Most light-duty vehicles will need to be converted to electric power. This additional demand must be accompanied by the necessary infrastructure for vehicle charging, with its implications upstream of chargers in the transport and distribution networks, and also cost reduction of batteries
- In the electrification scenario, it is projected that by 2030:
  - 30% of light-duty car sales are to be electric.
  - 50% of short-distance bus sales are to be electric.
  - 30% of gasoline vehicles are to have flex technology.
  - Effective bioethanol cut-off: 16% (12% mandatory).
  - 12% of sales of cars and light vehicles are to be electric.
  - 8 thousand short distance buses to be B100.
  - Effective biodiesel cut-off: 11.5% (10% mandatory).
  - 50% of short distance bus sales are to be CNG.
  - CNG vehicle share to rise to 22% (from 12% in 2018).

  - 25% of heavy-duty vehicle sales (except buses) to be LNG-powered.
- Urban light-duty vehicle fleet in the medium scenario GDP almost doubles, reaching 25 million cars, with a percentage of EV sales in 2050 (out of the total) of 96%, and a 75% penetration of EVs in the fleet. Thus, 62% of the energy consumed by the light vehicle segment will be electricity, and 38% will be fossil fuels with a net zero emissions balance (biofuels, hydrogen).
- The demand on the electricity generation sector will require the incorporation of 13,000 MW to supply the transportation system, in addition to the demand that the system will require for other uses.

⊃ **Energy efficiency**

- Energy efficiency is an underestimated assumption in Argentina.
- Given the multiplicity of actors (consumers, producers, service companies), decisions are more of a decentralized and private decision-making nature than the result of a top down policy approach from the State.
- It is possible to propose a general trajectory of the energy system with a component of Rational Use and Energy Efficiency that assumes a level of reduction of energy intensity of 1.5% per year, which accumulates, over 30 years, a decrease of 45% with respect to the base year 2021, in line with international experience.
- **Policies that emphasize demand-side policies can produce energy savings equivalent to those generated by policies that focus on changes in energy sources, but at a much lower cost and with much smaller scale social, environmental and health impacts.**
- In terms of energy efficiency: Use of more efficient appliances, promoting lower consumption technologies; substitution of fuel consumption for electricity, increasing the efficiency of final conversion; integrated environmental planning; issues related to resources, health and well-being in cities; transport networks and modes; design of buildings and single-family homes; industrial processes; lighting systems; training of technicians and professionals with a high level of training in sustainability issues.
- In terms of responsible energy use: improvements in behaviour, habits, customs and practices, generating environmental awareness, promoting education and technical and professional training, and discouraging luxury consumption or high consumption of carbon-intensive goods and services.
- Energy efficiency covers 67.5% of the mitigation measures identified in Argentina's Sectoral Climate Change Plans for Energy, Transport, Industry and Infrastructure and Housing.

- In the energy sector, energy efficiency actions are the second most important after infrastructure construction, with an estimated mitigation potential of 47.8 $MtCO_2$ according to the National Energy and Climate Change Plan. This magnitude represents 43.5% of the conditional and unconditional reductions for the Energy sector.
- If all energy efficiency measures for the Energy sector are considered, but also those included in the national plans for Industry, Transport and Infrastructure and Housing, the impact on the latest NDC submitted by Argentina would be in the order of 35%.
- In general, the contribution of emission reductions from energy demand appears to be underestimated in the National Plans, and this may be due to limitations in the basic information needed to calculate the impact of each measure, and to the fact that the measures were developed and proposed taking into consideration the management possibilities of each portfolio.
- The creation of an energy efficiency market through the development of energy service companies (ESCO), which are practically non-existent at present, could leverage the investment for energy efficiency in different sectors (industry, public, commercial and housing)
- The presence of ESCO in this aspect would make it possible to have an integrated, cross-cutting perspective, providing the necessary information for the elaboration of future plans in this area.

Preliminary considerations on investment requirements

- The installation of new power would require an annual average of up to 11.5 billion USD in the last decade of the estimated period, which starkly contrasts with the approximate average of about 2 billion USD invested annually during the ten years prior to the base year (period in which the latter is included). This variation represents an increase of almost 6 times in the investments of the period, which could be even lower if investment costs per unit of installed power continue on a downward trajectory as observed to date.
- In the period 2012-2020, investments in hydrocarbon upstream reached 7.1 billion USD, which added to the 2.02 billion USD of new electric power, totalizing 9.12 billion USD per year. When contrasting this value vis a vis the USD 11.5 billion required on average for the last decade of these scenarios, it is observed that the order of magnitude of the investments required annually (on average) is of the same order, being 26% above the former, but growing rapidly towards the last years, as more consumption is electrified.
- It should be noted that subsidies (which we refer to here as transfers for current expenses) were on average in the last decade, in the order of 9.87 billion USD per year, of which approximately 35% corresponds to fossil fuels, from which at least two relevant conclusions can be made:

- **first, that the transfers for current expenses disbursed by the National State to subsidize energy are in the order of investments in new generation in the decade of 2041-2050 (and exceed it for the previous decades)**
- secondly, it is highly relevant to know the impact of these new policies on the average cost of the system, since the capacity of the demand to pay for the economic cost of energy provision will also depend on it, as well as its affordability and eventual fiscal costs.

These cost scenarios will naturally have to be contrasted with their thermoelectric counterparts, but always computing a carbon price under different scenarios in the analysis horizon.

It is possible to achieve decarbonization by 2050 with the available mitigation and capture technologies and the direct reallocation of investment flows.

The identified transformations are extremely challenging in terms of CAPEX requirements, but the order of magnitude of the requirements in the planning horizon today is in the same order as the disbursements made for the infrastructure of carbon-intensive activities, such as the hydrocarbon upstream, as well as the new generation capacity incorporated in the last decade.

2. AFOLU

Scenarios

The present preliminary feasibility assessment has been developed under two scenarios, which will be evaluated against the baseline scenario.

- **Baseline scenario (business as usual or BAU)**, sector production and associated emissions follow historical trends.
- **High scenario**: implementation of mitigation measures in agriculture and livestock production and an increase in forested area of 60,000 ha/year.
- **Carbon neutrality scenario**: considering the effect of increasing the forested area, as this is the most significant mitigation measure for the sector, while the rest of the mitigation measures keep the same assumptions.

The objective of this analysis is to quantify the necessary area of planted forests[2] in Argentina to offset emissions from agricultural soils (residues and fertilizers), livestock (enteric fermentation and excreta) and land use change (deforestation and change in soil carbon stock).

On the other hand, measures that reduce carbon intensity per unit of product are analyzed and scenarios are considered according to the degree of adoption of plant growth-promoting rhizobacteria (PGPR) technologies (growth promoters and nitrogen free fixers) and extraction practices of beef cattle herds:

- **High scenario**: gradual adoptions that would reach 100% by 2050 of PGPR (increase productivity without increasing fertilizer use) and efficiency indicators reach 80% in calf - cow ratio (15% more than the base year) and average slaughter weight up to 245 kg eqRcH (15% more than the base year).
- **Medium scenario**: gradual adoptions that would reach 70% by 2050 of PGPR and production efficiency by improving the calf - cow ratio up to 73% (10% more than the base year 2016). Likewise, meat production is increased by augmenting the average slaughter weight to 235 kg eqRcH (10% more than the base year).

[2] This estimate was made on the basis of pine, eucalyptus and salicaceae plantations, as these species have higher growth rates, genetics and a closer industrialization potential. The underlying assumption is that afforestation is done without affecting existing ecosystems. However, the decision to be made on the species to be adopted for afforestation purposes should consider in each case the biome in which it is to be implemented and ecosystemic requirements.

- **Low scenario (BAU)**: gradual adoptions that would reach 30% by 2050 of PGPR and a typical scenario in Argentina, which only slightly increases the stock of cattle (8%) as a financial safeguard variable. There would be no changes in efficiencies.

Modeling results for the prioritized mitigation option packages

- **Crops**

  - The mitigation actions proposed are interrelated and seek to minimize soil carbon emissions through increased annual carbon production from plant biomass.
  - Carbon capture in soils: related to soil type, climate and annual biomass production and tillage system. Annual biomass production depends on crop yield and crop type. The participation of cereals in the rotation is of utmost importance in the carbon balance of an agricultural soil. Preliminary analysis for the carbon neutrality scenario indicates a potential reduction of 16.7 MtCOe/year (501 MtCOe towards 2050).
  - Biochar: would be mainly used in soils degraded by a high number of tillage operations, such as intensive horticultural crops, and non-degraded soils of intensive fruit tree production. Its use could also be extended to large areas of degraded agricultural or livestock soils. Preliminary analysis for the carbon neutrality scenario indicates a potential reduction of 1.36 MtCOe/year (40.8 MtCOe towards 2050).
  - PGPR technologies: would make it possible to increase plant biomass without generating additional emissions, which would have a positive effect on the carbon balance in soil and a decrease in the intensity of emissions per unit of product. Potential reduction of the high scenario, is estimated in 115.26 MtCo2e/tn
  - Urea volatilization inhibitors: its use could reduce emissions generated by nitrogen fertilizers. Preliminary analysis for the carbon neutrality scenario indicates a potential reduction of 0.31 MtCOe/year (9.2 MtCOe towards 2050).

- **Livestock**

  - The improvement in the extraction rate of the herd aims to increase meat production without increasing the stock of cattle, generating a slight increase in methane emissions, but achieving a more than proportional reduction in emissions per unit of product.
  - Implementation of biodigesters (or other techniques) in manure management in intensive livestock systems, utilizing methane for energy production
  - In Argentina, with a pending debt in the sustainability of soils and in the contribution of nutrients (recycling), due to historically extractive productions, use of excreta and slurry to improve the sustainability of soils and in the contribution of nutrients (recycling), seems to be more feasible to implement, due to the safety and investment requirements. These are practices that do not require large investments and are

culturally easier for the producer to manage, and the management is always indoors, and does not depend on any market price.

⊃ **Cultivated forests**

- This category includes three elements that are related to carbon sequestration by annual increase in forest biomass:
    - annual increase in forested area: achieving carbon neutrality by 2050 would imply increasing the planted forest area to more than 8 million hectares, which would be added to the current 1.3 million hectares. This implies planting 270,000 hectares of land/year. Although it is feasible to expand the forestry sector, the average annual rate of increase to 2050 significantly exceeds the current values, so a long-term policy would be required to generate a consistent momentum to achieve both the expansion of the forested area and the expansion of wood consumption and demand. In addition, the availability of forestry land at the national level should be analyzed, as well as instruments and incentives for the rapid deployment of industry to accompany the growth of forestry production.
    - increase in annual growth rates due to genetic improvement of implanted species (in smaller proportion).
    - carbon sequestration in harvested wood products (HWP). The latter is relevant in relation to incentives to the type of demand by industry (pulp, furniture, construction and other wood products). The HWP category has not been included in GHG inventories or projections for the forestry sector, overestimating emissions from harvesting and cutting in the forestry sector. Sequestration in harvested wood products can increase forestry efficiency by 20% or more.

Preliminary considerations on investment requirements

- Cultivated forests: the cost of planting one hectare is approximately US$ 1,400. The annual implantation of 270,000 hectares would imply a total annual investment of around 380 million dollars, equivalent to 11 billion dollars towards 2050. Currently there is a forestry promotion law (25,080 and subsequent modifications) that subsidizes 80% of the investment. Therefore, this increase should be considered as a major requirement in the public budget as well as its potential fiscal implications. In addition, it is essential to encourage the demand for forest products by the industry, which was identified as the main barrier for this value chain.
- Urea volatilization inhibitors: the cost for the producer would be around 50 USD/tn, above the price of common urea. Estimating an average annual consumption of 2,160,000 tons of urea for the period 2020-2050, the cost of the technology would represent, at current values, 108 million dollars per year, considering a 100% adoption rate by agricultural production.

- PGPR technologies: there are several products and their cost ranges around USD 5/ha. Considering the projected increase in the area cultivated with cereals and soybeans, the average area for the period 2020-2050 would be 42 million hectares. A scenario of total adoption of these technologies would represent a maximum annual investment value of US$210 million.
- The adoption of Biochar in 60% of the national fruit growing area at an annual dose of 5 tn/ha, would imply a production of 1.68 million tons of Biochar per year. With the current technology, an investment of approximately one million dollars is required for a production plant of 1,000 tons/year of Biochar. This would imply a maximum investment of US$1.68 billion, which could be significantly reduced in larger scale plants or with new production technologies by 2050.
- In livestock, improvement scenarios consider the promotion of good practices that would imply, in a certain way, a "zero cost" for the producer, but not for the State, which must invest in such programs through institutions and organizations (INTA, SENASA, etc.).

It is possible to achieve decarbonization by 2050 with available mitigation options and capture technologies and the reallocation of a significant portion of current investment flows towards less carbon intensive practices. *The identified transformations are challenging in terms of capital investment requirements and require the development of financial and public policy instruments.*

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