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STRUCTURING CONCEPTS AND TOOLS FOR FORMATTING A MARKET OF DECARBONIZATION IN THE ELECTRIC ENERGY SECTOR BRAZILIAN

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Abstract: This work aims to analyze the structures of decarbonization markets, conceptualizing some of the main incentive methods for sustainable practices, aiming at adapting the concepts to the Brazilian reality. The entry of renewable sources and sustainable energy development are inexorable for the future of an environmentally harmonious society. The international energy agency (EIA) estimates that 80% of the electricity demand in the US will be supplied by renewable energies [1]. Developed countries are leading this transition via policies that encourage sustainability. Vanguard nations in the energy transition lead the process due to active institutions and civil society that pressure governments in the pursuit of decarbonization of the matrix. Even renewable energy sources being the cheapest power generation plants in much of the world [1] the structuring of markets and pro-decarbonization tools can accelerate the process of energy transition. Centrally organized policies can be capital in rapid change by establishing a more sustainable society during the shift to a clean matrix. This work aims to show established methods for accelerating the decarbonization of the Brazilian energy matrix, conceptualizing some of the main incentive methods. These methods will be described and analyzed with international examples of successful applications of the measures in question, and analyzed in the light of existing sustainable policy initiatives in Brazil. In conclusion, policies more adherent to the reality of the country are established. Formatting a carbon mechanism is a challenge given the interaction with numerous agents from different productive sectors. If properly implemented, carbon pricing will provide a pathway to a sustainable society. Being an incentive for public agents, companies and consumers to make changes in investments, expenses and behaviors towards more environmentally efficient alternatives.

Keywords: Carbon Pricing, Decarbonization Strategies, Energy Trade Systems, Renewables Energy, Sustainability.

IINTRODUCTION

AND

n December 2015, the Paris Agreement was adopted by the United Nations Framework Convention on Climate Change (UNFCCC). This means that, from then on, the world has a new global agreement to combat climate change. The overriding objective of the Paris Agreement is to keep global average temperature rise well below 2°C above pre-industrial levels and to strive to limit temperature rise to 1.5°C. This objective is associated with the level of climate change that, understood by governments as minimally safe, would enable satisfactory economic development for nations [2]. The implementation of the Agreement represents an important step in the reorientation of the world economy. Economic growth will have to decouple, once and for all, from rising emissions. Making room for decarbonization policies aimed at sustainable development and a transition to more efficient and renewable energy consumption. The externalities of energy consumption without commitment to sustainability, brought great environmental challenges. An externality is characterized by the impacts (positive or negative) generated by the performance of an activity on parts not directly related to the activity, which are not reflected in its costs.

In recent years, the foundations have been laid for a transformation towards a low-carbon economy. Several countries, including Brazil, started paths towards the neutrality of carbon emissions, with emissions linked to energy generation as one of the main fronts to achieve the goal. The Brazilian electricity sector has a significant share of renewable energies and

low-emission sources of greenhouse gases in the country's electricity supply. Renewable energies, mainly hydroelectric, wind and photovoltaic, added to nuclear energy reach an impressive 85% of sources that do not emit greenhouse gases (GHG) in the Brazilian electricity matrix [3]. The Brazilian electricity sector has also progressively developed instruments and planning and management practices that consider the environmental benefits of sources that include positive socio-environmental aspects throughout the decision-making process in order to expand its sustainability standards. The conversion of Provisional Measure nº 998, into Law nº 14.120/2021, of 03/01/2021, represented a great advance for the electric sector, consolidating important changes in the sense of reducing subsidies and bringing benefits to the electric energy consumer. Among its advances, the legal command for the Federal Public Power to define guidelines for the implementation of mechanisms for the consideration of environmental benefits in the sector, in consolidating important changes in the sense of reducing subsidies and bringing benefits to the electricity consumer. Among its advances, the legal command for the Federal Public Power to define guidelines for the implementation of mechanisms for the consideration of environmental benefits in the sector, in consolidating important changes in the sense of reducing subsidies and bringing benefits to the electricity consumer. Among its advances, the legal command for the Federal Public Power to define guidelines for the implementation of mechanisms for the consideration of environmental benefits in the sector, in consonance with mechanisms to guarantee security of supply and competitiveness. Which culminated in Decree Nº 11,075, of May 19, 2022, which establishes the guidelines for a regulated and multisectoral carbon market in the country.

Other regions that initiate decarbonization projects can be used as examples for formatting a mechanism. Metcalf [4] verified the impacts of carbon taxes on GDP growth and employment in Europe, using World Bank empirical data collected since the early 1990s. GDP growth and job creation are not statistically significant, there is no evidence to support the opposite, that is, that taxes have negative effects on GDP growth and job creation. So, an energy transition via decarbonization mechanisms can lead to sustainable development without significant economic impact on societies that apply decarbonization policies.

MDECARBONIZATION METHODS

Emissions of greenhouse gases are commonly divided into 3 main scopes, based on the definition suggested in [5] which has as segregation the degree of management of the companies. Type 01: Scope 1 GHG emissions are those that occur directly from an organization's facilities. They are highly manageable by the company and can be easily accounted for. These are the emissions generated in the preparation of services or products provided by the company in its facilities, or even the emissions arising from the fleet managed by the companies. Type 02: Scope 2 emissions are indirect GHG emissions associated with the electricity, steam or heat used in the productive processes of an organization. They are not apparent in the agent's day-to-day productive activities, they are not easy to count but are associated with the primary sources of resources used in productive activities. Type 03: Scope 3 refers to emissions from activities not performed directly, but indirectly impacted by the influence of the organization in its value chain. Mainly emissions associated with activities performed by stakeholders in the value chain, either before or after the core activity of the

company in question.

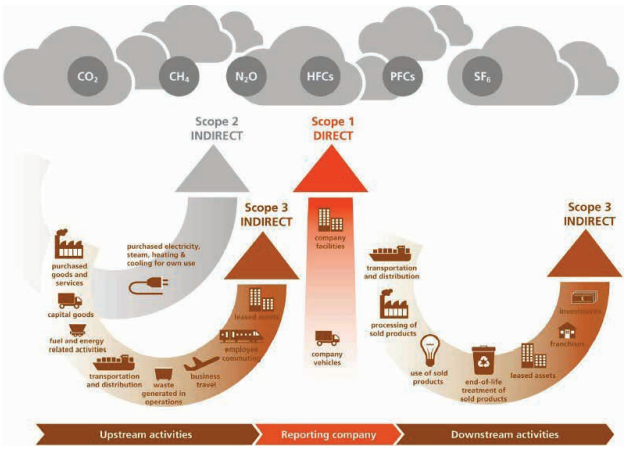

Fig. 1. Scope of Issue. Adapted from [5].

In the studied literature, there are different approaches to promote the reduction of greenhouse gas emissions, a first macrodivision is about the form of action of the proposed policy, which can be considered direct or indirect [6]. Such approaches range from those that are more explicit about the direct control of the emission reduction targets imposed on the activity, to those that are based on market mechanisms, which penalize or benefit agents in more lenient ways, based on a commitment, combining some level of incentives or financial penalties, acting indirectly in the issuance of each sector. It is important to emphasize that the tools are not mutually exclusive, and can be used together in several situations, to accelerate the reduction in specific sectors or to promote the independence of smaller regions within a country, respecting global goals. The main methodologies studied are described.

A. LEGAL IMPOSITIONS

They consist of specific laws or regulations that require a certain reduction in emissions associated with predetermined activities, severely penalizing agents in case of non-compliance. It is a direct measure, quite interventional in productive activities. Impositions ignore the fact that different agents have different sensitivities and associated productivity costs to reduce emissions. Therefore, this policy does not take into account the specificity of each agent, those who have different incentives to pollute or avoid pollution, without a financial rationale for agents to seek innovative solutions to reduce the overall cost to reach the goal in a shared way. Goals can be achieved using this tool, but in a non-optimized way, disregarding a joint action by the market for a community allocation. This policy can produce quick results for decarbonization, but it may not be sustainable in the long term, leading to an effect known as emission leakage. Emissions leakage refers to the situation that can occur when, due to costs related to climate policies, companies transfer their activities to other jurisdictions with more lenient regulations.

Ultimately, this could even lead to an increase in global GHG emissions. And alteration of the social-economic scenario of the region.

B. EMISSION TAX

The decarbonization tool, via the creation of an emissions tax, seeks to reduce emission levels by establishing a price per unit of CO2e, or tCO2e emitted. Also called a carbon tax. In general, this measure is carried out with a view to reducing the consumption of fossil fuels, limiting the intensity of emissions of each gas, for different productive sectors, and taxing proportionally to the agent's emission level. This is a mechanism governed by the price of the tax charged and the agents' sensitivity to it, where there are no guarantees about the level of resulting emission reductions. The price charged for the tax must be high enough to induce a minimum level of abatement, but not so high as to cause adverse consequences for the economy and public acceptance. One of the biggest challenges for policy makers

is the valuation of the tax. The revenue from the policy can be used for actions that aim to impact the environment in a positive way, or it can be redistributed to agents with lower emissions through tax relief.

The concept of an emissions tax can be demonstrated using the example of Sweden. The Swedish tax appears as the highest in the world, corresponding to approximately EUR 114/tCO2e in 2021. The tax is levied on the consumption of fossil fuels, mainly for heating and transport, and is calculated based on the carbon intensity of each fuel. Currently, the tax covers 40% of national GHG emissions. There are sectors exempt from taxation since its inception, in order to protect economic competitiveness. However, most of the exempt sectors were covered by the European Emissions Trading System - EU ETS, which will be explored later. The main criticisms of the method are precisely about the existence of exemptions. The first is about the efficiency of taxation policy, which is hampered by the fact that certain sectors are outside its scope of regulation. For example, the steel and construction materials industries are exempt from the tax. The critics defend the reduction of the rate value and the increase of its sectorial scope, in order to guarantee greater efficiency. The second major criticism is that industries covered by the tax have a significantly higher cost associated with their emissions than those not covered by the tax, which are under the scope of the EU ETS (as permit prices never, until 2020, had exceeded the carbon tax). Causing the reduction of competitiveness, of the international market, of the Swedish companies encompassed by the mechanism. The positive effects pointed out are that there is no evidence of adverse effects of the tax on the overall economic growth of the country. In fact, the average annual GDP growth from 1991 to 2018 was 2.2%, against 2.5% in the USA. Since the implementation of the tax, a 27% reduction in greenhouse gas emissions is estimated, mainly attributable to reductions associated with residential heating, the transport sector and industry [7].

C. EMISSIONS TRADING SYSTEM

The emission trading system or Energy Trade System (ETS), has as its principle to establish a permitted level of emissions per agent, and to create a market for exchanges for these allowances for emissions, in order to achieve a global goal of reducing emissions. over the years.

I also call it the cap and trade system, or, Cap and Trade. Allowances and targets must be reviewed at set periods of time, called control periods. The control period is the period at the end of which permits must be canceled in proportion to the verified emissions of the regulated agent. According to international experience, one year is usually adopted.

Trading in an emissions trading system can be negotiated (a) via periodic auctions and (b) via bilateral trade between agents – which may or may not take place in an organized environment for trading. Price caps can also be adopted, through mechanisms that insert or remove market allowances, guided by price triggers to avoid a distorted economic signal.

Different sectors receive different levels of allowances, based on benchmarks that are used to define the amount of allowances, per produced unit, that will be allocated free of charge to different agents in a sector (or activity) of the economy. If your emissions are found to be below their respective allowances at the end of the period, they are settled. In addition, agents must buy credits if their emissions exceed the level of allowances, also called allowances. Allowances can also be retired, an agent can voluntarily cancel their allowances. This way, the agent voluntarily contributes to a more ambitious goal of the mechanism and drives the reduction of

emissions.

A difficulty in the cap and trade system is the treatment of renewable power plants. Because their generation is not associated with the emission of greenhouse gases, renewable generators – especially wind, solar and hydroelectric – do not have obligations under an emissions trading system and, therefore, do not receive emission allowances in these mechanisms. As a result, being unable to participate in the mechanism, in some markets, these generators are eligible for the origination of emissions offset credits (offsets). In this case, each MWh of electricity produced by these generators could originate a fraction of a compensation credit, proportionally to some reference emission factor – in tCO2e/MWh. So these offsets can be acquired by 'polluting' agents that have exceeded the emission targets.

The tool has proven to be efficient in several locations, the main difficulties have been the sensitivity of permit prices and the treatment of offsets. Prices must be high enough to provide an incentive to meet targets, but not so high that they are burdensome.

too many agents in liquidation periods. Compensation via renewable generation brings the possibility for agents who have not reached the targets individually to buy reduction certificates. Some countries have imposed limits on the purchase of offsets by agents to avoid the indefinite purchase of reduction certificates.

D. CLEAN ENERGY CERTIFICATES / CARBON OFFSETS

A clean energy certificate is a market instrument that represents each MWh produced from renewable electricity generation, which can be claimed by its holder. Certificates are issued when one megawatt-hour (MWh) of electrical energy is generated and delivered to the electrical grid from an environmentally friendly energy resource. Activities with a positive environmental impact can be certified and used to reduce voluntary emission targets. The demand for electricity certificates arises when energy suppliers and large consumers are required to purchase certificates for a certain proportion, or totality, of their electricity consumption.

Certificate issues can be carried out without a well-established local market, global certification bodies can certify projects with positive impacts and these certificates can be traded on a voluntary basis, and are mainly purchased by energy consumers who believe that the acquisition of this energy generates value for an independent company in a regulated market.

A carbon offset is a reduction in greenhouse gas emissions used, for accounting purposes, to offset emissions made elsewhere. A carbon offset credit represents a reduction in greenhouse gas emissions equivalent to one tonne of carbon dioxide (tCO2e). Carbon offset credits are created according to certification standards, which provide guidelines and requirements that project developers must follow to originate such credits. Once created, credits can be sold freely on the market. It may be desirable to use audits to prevent double counting: that the same MWh of electrical energy is used to generate clean energy certificates in different mechanisms – such as different voluntary mechanisms.

E. SUBSIDIES FOR RENEWABLE ENERGIES

One method for decarbonizing the matrix is the establishment of subsidies for renewable energy generation projects. Whether this subsidy is a source of additional revenue or expense exemption, offered by the government for selected technologies that promote the energy transition. This can be done through

discounts on network tariffs, tax exemptions, better financing conditions, direct payments proportional to energy production. These policies can be very important to initiate the development of sustainable technologies in a given region, but they must have a determined period in order not to create asymmetries in the market.

AND EXPERIENCE INTERNATIONAL

Several countries, mainly the most developed ones, have one or more decarbonization initiatives implemented. Figure 2, adapted from [5], shows the policies in force in different locations.

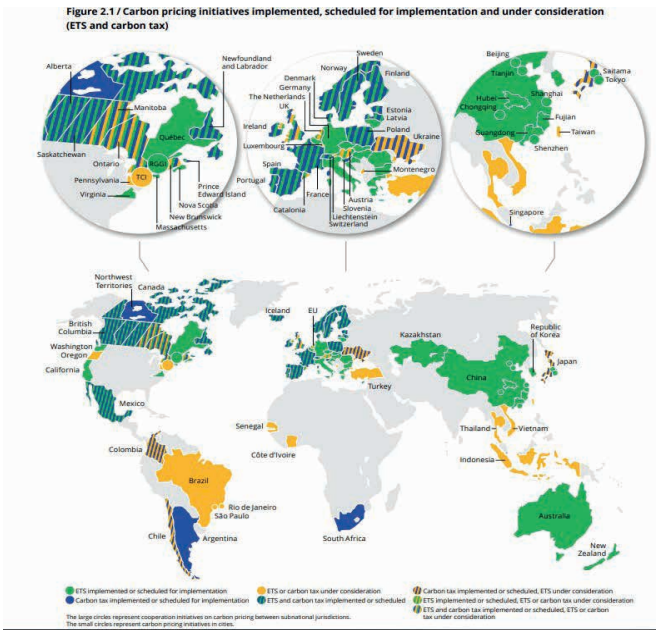

Fig. 2. Scope of Issue. Adapted from [5].

Many European countries, for example, have in addition to the emissions trading system in effect throughout the region, the EU ETS, some other specific policy. Below we will give some examples of policies implemented successfully.

A. CANADA: EMISSIONS TAX AND EMISSIONS TRADING SYSTEM

The Pan-Canadian Carbon Pollution Pricing Framework, launched in October 2016, established national emissions pricing. It gives provinces and territories the flexibility to develop their own emissions pricing systems, while describing minimum criteria that pricing systems must meet at the national level. For provinces with GHG emissions above the threshold, the framework establishes the following options: (i) pay the carbon price to the Government through a tax on excess emissions or (ii) buy allowances from other participants. In jurisdictions that choose to adopt the federal system, funds are returned directly to governments.[8] In jurisdictions that have not met stringent federal standards for reducing carbon pollution, earnings are returned through carbon pollution pricing. The country mixes carbon tax mechanisms and a cap and trade mechanism.

With enough autonomy for the provinces to define regulatory targets, but always obeying the ceilings stipulated by the federal government. The result already obtained with the mechanism shows maintenance of emissions with GDP growth [9]

B. EUROPEAN UNION: EMISSIONS TAX AND EMISSIONS TRADING SYSTEM

Many of the European Union countries have established a system of taxation for carbon emissions. Targets vary for each participant and can be applied to different types of greenhouse gases, adapted to the reality of each member of the bloc.

The European Union Emission Trading System (EU ETS) is the current emissions trading system. The mechanism limits the total volume of GHG emissions from the European Union, it is the largest and oldest emissions trading system covering more than

12,000 industrial and electricity generation facilities in 31 countries [6]. Accounting for several periods of control and application phases that are increasingly audacious. In this mechanism, permit trading is unlimited and the use of offset credits has not been allowed since Phase 4. There are permit auctions carried out in a single round, with closed bidding and uniform price per agent. Fines are imposed and enforced for companies that fail to submit certificates on time. As the EU ETS moved into more ambitious phases,

C. CALIFORNIA: EMISSIONS TRADING SYSTEM

California emitted, in 2019, 418 MtCO2 of greenhouse gases [10], mostly due to the burning of fossil fuels for transportation, energy uses in industry and for the generation of electricity. The US state has ambitious targets for reducing emissions and has established an ETS as of mid-2011. Trading permits is allowed, while borrowing future control periods is prohibited. The use of offset credits is permitted, but currently restricted to a maximum of 4% of individual obligations and with restrictions on the origin of the source. A drop in GHG emissions has been observed after the application of the policies presented by the state government. [11].

D. MEXICO: CLEAN ENERGY CERTIFICATES

In 2014, with the modernization of the Mexican electricity sector, the country adopted a three-product configuration for its centralized auctions: energy, capacity and clean energy certificates. The country has established a renewable energy certification market. A support scheme aimed at increasing the production of renewable electricity. Renewable generators receive a certificate per MWh of production for a set period, which can be sold. The main objective of the certificates is to create a source of income for renewable generators, favoring investment return rates, and encouraging greater renewable participation in the generation matrix. Since certificates are traded separately from capacity and energy, excess or lack thereof does not directly impact prices.

of other products

Fig. 3. Permission Pricing Worldwide [11].

IINITIATIVES OF THEMMARKETBBRAZILIAN

Brazil has initiatives aimed at decarbonizing the energy matrix, and any new proposition of mechanisms must evaluate the interactions with existing policies, as well as seek the positive and negative points of each mechanism. Some are commented below.

A. RENOVA BIO

Law No. 13,576, of December 26, 2017, was created to comply with the terms of the Paris Agreement, and may establish guidelines for Renova Bio, a mechanism to encourage the production of biofuels in the country. The National Energy Policy Council (CNPE) for the commercialization of renewable fuels, and then the National Petroleum, Natural Gas and Biofuels Agency, defined individual mandatory targets for each fuel distributor based on their market share.

Establishing minimum percentages for the acquisition of biofuels in the form of CBIOs.

CBIOs are certificates issued by producers

and importers of biofuels regarding their production and efficiency, which can be negotiated bilaterally with fuel distributors. The purchase of these certificates is a way to favor the growth of the biofuel industry. Each CBIO is equivalent to one ton of CO2e avoided. The National Council for Energy Policy establishes general targets for the commercialization of fuels. Next, the National Agency of Petroleum, Natural Gas and Biofuels sets individual mandatory targets for each fuel distributor based on their market share. Figure 4 shows the values traded and the daily average price traded for CBIOS B3.

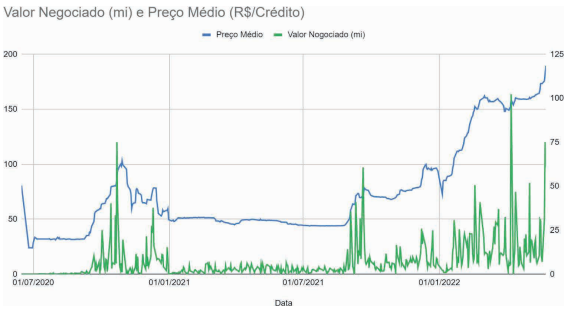

Fig. 4. Prices and Trading Value of CBIOs.

B. PROINFA

The Incentive Program for Alternative Electric Energy Sources (PROINFA), created by Law No. 10,438, of April 26, 2002, was the first initiative for the entry of independent producers of renewable sources into the electricity matrix. The first stage of the program provided for the contracting of 3.3 MW of capacity, distributed equally among wind sources, small hydroelectric plants and biomass, with energy sales contracts for a period of 20 years and with costs shared among all consumers in the National Interconnected System, except for Low Income. For 2022, a cost of approximately R$ 6.38 billion is expected to maintain the program, with an average cost of contracted energy of R$ 569.89/MWh, of which R$ 435.37/MWh for small hydroelectric plants, R$ 738.16/MWh for wind and R$ 348.07/MWh for biomass. The high values are explained by the feasibility of technologies, at the time incipient in the matrix, and by the indexation by IGP-M. The validity of the contracts expired from the beginning of 2026, but Law No. 14,120, of March 1, 2021, brought the possibility of extending the contracts in exchange for consideration, such as price reduction and indexation adjustment, if interested to entrepreneurs.

C. DISCOUNT ON TARIFFS FOR USE OF THE TRANSMISSION SYSTEM

Created by Law No. 9,427, of December 26, 1996, it consists of a 50% to 100% discount on tariffs for the use of the transmission/ distribution system (TUST/TUSD) of energy generators from renewable sources that meet certain limits of power installed or injected into the network. These discounts are extended to consumers who purchase this incentivized energy by promoting exemption from payment of the wire usage fee. The average subsidies to these generators are calculated in the table 01. It can be noted that in 2020 the total discounts were around 5 billion reais and enabled the generation of approximately 11 average GW of incentive energy, showing the maturity and relevance of the market.

year	Discount (bi R$)	Generation (GWm)	R$/MWh
2015	1,1	5,6	19,6
2016	1,3	6,8	19,1
2017	2,2	8,1	27,2
2018	3,7	9,6	38,5
2019	3,5	11	31,8
2020	5	10,9	45,9

TABLE I - DTOTAL DISCOUNT ANDBEFFECTGWRONG BYsUBSIDIUM

This market maturity was confirmed by Law 14,120, of March 1, 2021, which establishes the end of discounts on tariffs for the use of transmission and distribution systems. New

plants with 12 months after the entry into force of the Law, and that start commercial operation within 48 months after obtaining the grant - that is, the last generators eligible for the discounts must start their commercial operation by March 1, 2026.

D. IREC AND REC BRAZIL

Renewable Energy Certificates (RECs) are market instruments that certify the production of renewable energy followed by its injection into the electrical grid. The three most widespread REC standards are the North American REC, the European Guarantees of Origin and the international REC standard (I-REC). One certificate is equivalent to 1 MWh of renewable energy injected into the grid. In Brazil, certification and auditing of I-RECs are carried out by Instituto Totum.

These certificates can be issued by plants whose sources are hydroelectric, biomass, wind, solar and can be acquired voluntarily by consumers in the free or regulated market as a way of proving the use of renewable energies.

RESULTS

Each decarbonization mechanism has particular characteristics and must be adapted to the Brazilian reality and existing policies. So that the principles identified as desirable to guide the process of choosing and implementing some initiative in the Brazilian case are described. ANDIt is desirable that the mechanism be simple to administer and that the assessed environmental benefit be simple to quantify. The mechanism must benefit society, leading to a reduction in greenhouse gas emissions and/or greater use of renewable energy. The transaction costs involved in the interactions of the mechanisms must be the lowest possible, to promote a dynamic and efficient market. Incentive policies must have goals and a well-defined useful life. As seen in the international experience, incentive mechanisms work well when they have clear goals and a determined deadline. Being updated as the market matures and the analysis of results against pre-established goals.

A. LEGAL IMPOSITIONS

Decarbonization mechanisms via legal impositions are perhaps the simplest to implement, and with low feasibility costs. Once the legislation and/or regulation is approved, the mechanism will enter into force, and the targets established must be pursued by agents. However, this mechanism, almost authoritarian, does not allow for economic rationality among the agents and can bring great difficulties to some sectors with greater difficulty in adapting. It is an option for countries with incipient decarbonization energy policies, not being an interesting alternative for a country like Brazil that has well-established policies to encourage the development of the pro-decarbonization market, which began years ago. Care must be taken when determining the scope of regulation, that is, which sectors of the economy will be covered by the policy, mechanism in question. The definition of these sectors, as well as the expansion of the scope of regulation over the years, is part of the mechanism's planning.

B. EMISSION TAX

The emissions tax is a relatively simple way to implement a decarbonization policy. The main difficulty is in making the actors aware of the tax amount to guarantee the effectiveness of the mechanism. It has proven to be an important tool for reducing GHGs, however, verifying the results obtained using this method is a challenge for regulators, as it does not guarantee specific targets. It can be used as an auxiliary policy to accelerate the transition and be applied to specific sectors, as

it is used in several countries of the European Union. The policy must be well delimited so as not to interact with existing policies. For example, with the Renova Bio policy, where the taxation of fuel distributors must not be levied on the share of biofuels.

C. CLEAN ENERGY CERTIFICATES

The voluntary mechanism, in fact, already exists in Brazil as mentioned earlier. Therefore, the discussion hovers over a mandatory mechanism for the commercialization of clean energy certificates. For the implementation of a mandatory certificate mechanism of clean energy there is a need to establish an institutional arrangement to elaborate the rules, implement and supervise its functioning. Establishing minimum percentages of demands from electricity consumers for the acquisition of certificates. It is desirable that the design of these incentive mechanisms be based on a goal of penetration of renewable resources in the electricity generation matrix, since the limitation of GHG emissions by this mechanism becomes difficult. For an efficient practice, it is necessary that a maximum useful life be established for it, and that it be closed when reaching its target penetration of renewable resources. A challenge for the elaboration of the mechanism in Brazil is the large percentage that is already renewable in the country, which can generate an oversupply of certificates. To avoid such inconvenience, new plants from renewable sources, or cover other sectors not just the consumption of electricity, extending the need to acquire certificates for the energy demands of companies.

D. EMISSIONS TRADING SYSTEM

The emissions trading system has proven to be an effective mechanism when well adapted to market signals, and can be a good option for the Brazilian reality. For the implementation of an emissions trading system, it is necessary to establish an institutional arrangement to elaborate the rules, implement and supervise its operation. In a country with a high penetration of renewable electricity generation, such as Brazil, the mechanism must be intersectoral, covering the energy sector in a broad way, to avoid an oversupply of permits. Work must be carried out to define the levels of permissions by agent and by sector, carried out with great parsimony in the Brazilian market. The definition of benchmarks for defining allowances must be done in consultation with the national market, not just importing standards from other countries, given the particularities of consumption and emissions in Brazil. Another challenge is the treatment of offsets to avoid overcompensating market agents. Renewable power plants already in operation may be excluded from the possibility of compensation, encouraging the reduction of GHG emissions and stimulating the expansion of the renewable matrix for new permits.

CONCLUSIONS

Formatting a carbon mechanism is a challenge given its complexity due to the large number of agents involved. Especially for Brazil, where the electricity sector is already quite renewable. The work presented addresses the characteristics of the main methods and policies for decarbonization and cited the challenges of structuring a carbon pricing mechanism that considers the specificities of the Brazilian electricity sector. Based on international and national experiences, issues such as the sector's modernization process, correct signaling of prices, distributional and cost impacts. Another important topic discussed was the scope of pricing, highlighting the advantages of a multisectoral approach.

If properly implemented, carbon pricing will provide a long-term price signal. Being

an incentive for public agents, companies and consumers to make changes in investments, expenses and behaviors towards more environmentally efficient alternatives. These changes translate into CO2 mitigation, adaptation and sequestration actions, which will be more economically advantageous over time, fostering research, innovation and development of low-carbon products and processes, so that we can respect the greenhouse gas reduction targets. greenhouse effect.

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