

## 2

## Designing Brazilian institutional framework for Carbon Capture, Use and Storage (CCUS) activities: the role of competent authority

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**CONTENTS:** *1 Introduction • 2 The first proposals for the definition of a competent authority for the activity of CCs in Brazil • 3 The role of competent CCUS authorities in the Brazilian Framework • 4 Discussion of a prospective proposal of an institutional framework • 5 Conclusion • 6 References.*

**ABSTRACT:** The Paris Agreement is regarded as a milestone for studying and analysing the behavior of countries and, consequently, of the institutions and agents involved in reducing carbon dioxide emission levels. Measures to assist in climate mitigation, such as carbon capture, use, and storage (CCUS) are mentioned in this article. The present work addresses the theme pertinent to defining Brazil's CCUS activities' institutional competencies. The methodology is analytical and qualitative. The research pointed out at least three possible paths to design the CCUS institutional framework in Brazil, from the possible amendment to the Constitution to the mere sublegal regulation. The most suitable path, considering the lowest cost, was the use of pre-existing frameworks and legal enhancement, empowering public agents to be endowed with regulatory and political power to encourage desired behaviours.

**KEYWORDS:** Paris Agreement • Climate Change Policy • CCUS • Institutional Assessment.

## **Formulação do arcabouço institucional brasileiro para atividade de Captura, Uso e Armazenamento de dióxido de carbono (CCUS): o papel da autoridade competente**

**SUMÁRIO:** *1 Introdução • 2 As primeiras propostas de definição de uma autoridade competente para a atividade de CCUS no Brasil • 3 O papel das autoridades competentes para o CCUS no panorama brasileiro • 4 Discussão de uma possível proposta de panorama institucional • 5 Conclusão • 6 Referências.*

**RESUMO:** O Acordo de Paris pode ser considerado um marco para os estudos sobre o comportamento adotado por países e, conseqüentemente, para o estudo das instituições e dos agentes envolvidos no objetivo de redução dos níveis de emissão de dióxido de carbono. Este artigo aborda o tema pertinente a definição de competências institucionais para a atividade de CCUS no Brasil. A metodologia adotada é a qualitativa e analítica. A pesquisa apontou pelo menos três caminhos passíveis de serem seguidos para a implementação do arcabouço institucional do CCUS no Brasil, desde a possível emenda à Constituição até a mera normatização infralegal. O caminho factível, como de menor custo, foi a utilização de marcos pré-existentes e aperfeiçoamentos legais, empoderando agentes públicos para que possam ser dotados de poder regulatório e político para incentivar comportamentos desejados.

**PALAVRAS-CHAVES:** Acordo de Paris • Política de Mudança Climática • CCUS • Avaliação Institucional.

## **Conception d'un cadre institutionnel brésilien pour les activités de captage, d'utilisation et de stockage du carbone (CCUS) : le rôle de l'autorité compétente**

*SOMMAIRE : 1 Introduction • 2 Les premières propositions pour définir une autorité compétente pour l'activité de CCUS au Brésil • 3 Le rôle des autorités compétentes pour effectuer les activités de CCUS dans le panorama brésilien • 4 Discussion sur une éventuelle proposition de panorama institutionnel • 5 Conclusion • 6 Références.*

**RÉSUMÉ** : L'Accord de Paris est un important point de repère historique quant aux études et analyses du comportement des pays et, par conséquent, des institutions et des agents impliqués dans la réduction des niveaux d'émission de dioxyde de carbone. Des mesures pour aider à l'atténuation du changement climatique, telles que la capture, l'utilisation et le stockage du carbone (CCUS) sont mentionnées dans cet article. Le présent travail vise à aborder le thème pertinent à la définition des compétences institutionnelles des activités du CCUS au Brésil. La méthodologie est analytique et qualitative. La recherche a mis en évidence au moins trois voies possibles pour concevoir le cadre institutionnel du CCUS au Brésil, de l'éventuelle modification de la Constitution à la simple réglementation infra-légale. La plus appropriée considérant le coût le plus bas est celle de l'utilisation des cadres préexistants et du renforcement juridique, responsabilisant les agents publics afin qu'ils puissent être dotés d'un pouvoir réglementaire et politique pour encourager les comportements souhaités.

**MOTS-CLÉS** : Accord de Paris • Politique Sur le Changement Climatique • CCUS • Évaluation Institutionnelle.

## 1 Introduction

The twentieth century was marked by global economic growth resulting from industrial and technological progress and the indiscriminate use of natural resources, such as fossil fuels in electricity, industry, and transportation models that revolutionized mobility and daily urban activities in large cities. However, there was an increasing concern that those activities' current benefits could compromise future generations' well-being, and problems caused by climate change needed to be addressed.

Political processes and discussions related to the use of natural resources and economic development embodied the Conference on the Human Environment, in the period between 5 and 16 June 1972, the Stockholm Conference, and, in the following decades, those concerning climate change were added by policymakers and began to demand more concrete actions from nations of the United Nations.

One of the most important treaties was the Paris Agreement, which entered into force on 12 December 2015 due to intergovernmental efforts to ratify the United Nations Framework Convention on Climate Change of the 21<sup>st</sup> Session of the Conference of the Parties (COP 21). It can be considered a diplomatic success as several nations begin to make efforts under the aegis of a legal instrument beyond diplomatic nature and bring obligations to the signatories (Klimenko *et al.*, 2019; Savaresi, 2016; Viñuales *et al.*, 2017).

Thus, the growing demand for solutions to mitigate Green House Gas (GHG) emissions at the global level has promoted the expansion of research to enable large-scale projects in industrial sectors to use Carbon Capture and Storage (CCS) technology and has brought the academia into supporting those improvements. Recently, there has been renewed interest in implementing CCS large-scale under a global strategy to tackle climate change issues (IEA, 2020a, 2020b).

Concerning CCS in Brazil, studies over the past decade have provided information on the legal system, possible configuration among sectors with high GHG emissions, as well as civil liability (Almeida *et al.*, 2017; Costa; Musarra, 2020; Costa *et al.*, 2018; Moreira *et al.*, 2016, 2018; Musarra *et al.*, 2019; Romeiro, 2014).

Moreover, as for Brazil, they highlighted that a challenge to be faced and overcome is the acquiescence of a specific legal framework of CCS, and the current issues have focused on the theme analysing the Brazilian CCS technology policies. Results on the legal framework in developing countries such as studies on civil liability regarding the storage of carbon dioxide and the ownership of the injected

molecule (Morbach *et al.*, 2020; Musarra *et al.*, 2019) and on decommissioning of projects (Almeida *et al.*, 2017) indicate the need to adapt to the reality of each territory (Romeiro, 2014).

However, a relatively small body of literature is concerned with the competent authority's role, and the Brazilian CCS institutional framework has not been appropriately investigated. Understanding the definition of competencies and the institutions and agents' behaviour involved in GHG national emissions can help policymakers' better deal with implementing the challenge of new storage projects in terms of economic effectiveness.

Moreover, through appropriate authorities' designation to handle CCS, a suitable arrangement of the institutional system may diminish risks linked to policies, cross-chain, and storage liability risks (Rassool *et al.*, 2020; Zapantis *et al.*, 2019).

This paper provides an overview of the normative and institutional framework compatible with the distribution of gains, costs, and risks among the CCS economic chain. It will examine the relationship between the agents involved, as well as the allocation of legal responsibilities to each party associated (government, private sector, and consumers) and the adequacy of institutions for the development of CCS in Brazil, focusing mainly on negligence avoidance by the private sector and insertion of risks exogenous to the activity by the government.

The purpose is to highlight the role of both competent authorities for the CCS policy and the regulatory function, focused on legal assignment distribution as a path to reduce risk and incentivize the private sector to improve CCS large-scaled projects. In that context, the dilemma of multiple authorities, the inertia resulting from diffused interest in the public sector, and the recent cases of empowerment of authorities related to the economic sector will be investigated. Thus, the critical question is: which would be the competent body to authorize and regulate CCS activity in Brazil? The following section will briefly cover the Brazilian participation in the Paris Agreement under CCS activity's current legal gap. The third will concern the institutional framework of the competent authority in the Brazilian case. To this end, the fourth section will discuss the perceptions of this research for final consideration.

## 1.1 Institutional competences for CCUS in Brazil

The distribution of responsibilities, benefits and allocation of costs along production chains has been a complex function in societies seeking commitment to

climate change policies. All these attributes represent exogenous input variables in the decision-making of economic sectors that produce goods and services used by consumers and improve whole well-being status, despite the unwanted pollution via GHG emissions caused by it. However, the distribution of gains and losses has been set aside when formulating public policies.

Previous studies on institutions can help understand the effects of norms on society once they can be effective in diagnosing the opportunistic behaviour of agents under evaluation (Williamson, 1975).

Agents acting on the market, for some reasons, could need guardianship of the government to avoid unfair rules imposed by the majority of agents to the detriment of the community. Therefore, the government can occupy three positions, as the regulator, as a public policy implementing agent, and as a market agent (North, 1990; Williamson, 2005).

Economic efficiency means the transaction cost would be zero (Coase, 1937). As this hypothesis does not occur in the real world, the institutional model, as far as possible, is responsible for reducing it by inducing the behaviour of agents from the organization of society and the relationship between law and economy, using long-term rules based on contracts (Brousseau; Glachant, 2008; Williamson, 1985). These solutions have been associated with a possible tendency to increase individual profit in the short term, which means the government would be responsible for regulation and arbitrage of such agents (Hardin, 1968; Hodgson, 2003).

Institutional economy concepts support state action aiming at changing the behaviour of agents responsible for high-carbonized industries. These changes in behaviour are essential because institutional assessment should focus on concepts of allocative efficiency, especially as the global distribution of resources increases welfare state levels. The allocative concept brings about lower cost possible and sustainability, which means ensuring the welfare and sustainable development in an intergenerational way, to achieve the GHG emission reduction scenario with minimum transaction cost through improvements in Brazilian rules (North, 1990; Williamson, 1985).

Thus, there is a gap in a holistic legal framework defining the risks and responsibilities of CCS activity and the behaviour of the institutions and agents involved in the country's CO<sub>2</sub> emission levels.

There is an unambiguous relationship between sovereign countries' decisions and the implementation process that implies changes in final agents' behaviour

concerning GHG issues. What happens is that there is an immense possible pathway to be adopted, and reshaping institutional systems can define whether they will succeed in their targets.

As far as Brazilian legal frameworks are concerned, exploitation of natural resources counts with mature systems in mining, oil industry, and underground aquifer. They can be considered well known by stakeholders due to the institutional behaviour of governments, Parliament, local communities, and concessionaries for decades, beyond a well-defined authority dealing with policy implementation processes and with regulations.

Considering CO<sub>2</sub> storage in a geological formation, the absence of an institutional framework includes various uncertainties to the possible business, strong enough to keep potential investors away from it. Hypothetically, an agent who desires to deploy a CCS project in a region where previous concessions are in place, such as mining rights, will have to make agreements to ensure long-term rules. However, the position for CCS could be negative when comparing how developed both institutions are, oil and gas, and mining legal frameworks. A precisely analogous situation exists for the mining sector when it conflicts with the oil industry when both operate as extractive industries at the same site. Therefore, the practical result is the restriction of CCS activity only to dealers already established in the oil and mining sectors, in the areas where they have concessions.

Even for specific companies that need to use the activity, the absence of friendly rules poses too much risk to the viable CCS business. Thus, in Brazil, implementing a normative and institutional framework is a key factor to the CCS in selected sectors without high societal costs.

As a starting point, the European Union works as an institutional laboratory on CCS themes. In 2009, it was established as the primary legal framework for developing technology (IEA, 2009). The CCS Directive provided mechanisms to ensure environmentally safe geological storage, rules for transporting and choice of site, adequate liability for damage to health and property, and removing institutional barriers. In sum, it represented an important milestone for European climate change mitigation policies.

Even though the CCS technology in the EU is still being developed, fewer advances have been observed. In line with the theme, the definition of a specific and detailed instrument as far as possible is more effective than the establishment of dispersed and excessively discretionary instruments (Kapetaki *et al.*, 2016), in

which the dichotomy between the concentration of power in monocratic authority and the fragmentation of competence between specialized bodies was not well solved. Despite that, pilot projects have been executed to evaluate the dissipation of resistances concerning the effectiveness of the instruments used for CCS (O'Connor *et al.*, 2017).

Regarding competent authorities on the current Brazilian CCS institutional framework, it is possible to consider fewer insights from previous research on institutions.

Old institutionalism suggests the government has a hierarchical function, as a meta-institution above the others, dedicated to regulatory competencies to keep the evolutionary path of current institutions and to look for conflict resolutions on reasonable terms within desirable changes (Bateira, 2010; Hodgson, 2003; Veblen, 1994).

New Institutional Economics suggests that contracts can deal with solutions between parties, and given that the majority of agents could not process information holistically and make decisions under rational choice theory, the government has to regulate them to potentialize advantages of path dependence through time (Fouquet, 2016; North, 1990; Williamson, 1985). Therefore, from both institutionalism aforementioned, the federal public agency is inferred for regulation rules (Costa, 2014).

An alternative path through institutions promotes the minor enhancement of rules and allows agents to cooperate to an independent management of resources. Institutional Analysis and Development advocates that local users are competent to reshape institutions as an expected evolutive consequence and adequate them to the communal needs, in which centralized government would be responsible for complementary rules and incentives instead of regulating any possible path just considering that individuals are always assuming predatory behaviour (Ostrom, 2011, 1990). It emerges formulating and implementing policy functions, besides planning and incentivizing CCS activities, under a competent authority, excluding regulating roles.

This section summarized institutional literature that supports designing the CCS framework, the current status of Brazilian normative, and the path to the governmental activities into two groups: general regulation and policies to incentivize the CCS deployment. The next topic focuses on previous studies attempting to distribute responsibilities between existing public agencies in Brazil.



## 2 The first proposals for the definition of a competent authority for the activity of CCS in Brazil

The previous study of Research Centre for Greenhouse Gas Innovation (RCGI) has focused on the various elements of the CCS framework in Brazil. It has been concentrated on the evaluation of several legal, regulatory, and institutional mechanisms that could be inserted in the Brazilian framework of CCS, which pointed out that given the multifaceted aspects surrounding a project and the long-term responsibility of CO<sub>2</sub> storage establishing a specific competent authority could ideally be the most appropriate approach (Romeiro, 2014). Nevertheless, since there is no significant demand for pilot projects, the federal government has neglected the establishment of a robust framework, the definition of a regulatory authority, and the distribution of responsibilities to the ministerial authorities in charge of implementing the policy process for CCS activity in Brazil.

Using theoretical methods to transpose practices and habits from one economic sector to another, a regulatory framework has been proposed, including critical issues and appropriate steps for CCS projects (Costa, 2014). In order to achieve a better understanding of the mechanism proposed by it, Costa (2014) analysed a future CCS framework by comparing it to the natural monopoly on natural gas (NG) and oil sector, as well as oil industry regulation in Brazil. She suggested the National Agency of Petroleum, Natural Gas and Biofuels (ANP) as the competent authority for regulation, such as in Australia. Alternatively, the establishment of a new regulatory agency would fall within the scope of the Ministry of Science, Technology, and Innovation (MCTI) due to its relation with the climate change policy<sup>1</sup>.

Even prior research had already indicated that ANP was a candidate for executing governmental duties because of its expertise in the oil sector. However, it highlighted the necessity of clarifying the whole CCS chain's competent authorities in Brazil (Câmara *et al.*, 2011).

Through interviews with experts, Araujo (2019) described some suggestions that ANP would be suitable for regulating CCS activities in Brazil since it has been responsible for regulating the oil industry under Article 8 of Petroleum Act *in verbis*:

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1 Despite the engagement of climate issues by this Ministry, it does not result in expertise in the daily regulation of climate change in the economic sectors since there are insufficient instruments to deal with short-term needs for implementing incremental changes in the policy agenda.

Art. 8º ANP will aim to promote the regulation, contracting, and supervision of economic activities that are part of the oil, natural gas, and biofuels industry, with:

IX- enforce the good practices of conservation and rational use of oil, natural gas, its derivatives and biofuels and the preservation of the environment;

X - stimulate research and the adoption of new technologies in exploration, production, transportation, refining, and processing. (Brasil, 1997, own translation).

Moreover, Araujo (2019) informed that some experts argued that ANP had both expertise and experience on similar procedures and activities of CCS, for instance: (i) regulation and supervision of hydrocarbon pipelines and reservoirs; (ii) access right to storage of NG; and (iii) execution of bids for the granting of exploratory blocks, based on legal, technical and economic criteria which allow governance practices concerning Brazilian market's natural resources. Nevertheless, Romeiro (2014) asked whether ANP could make a suitable figure as the competent authority to develop some aspects, such as the conflict of interest between the activities already regulated by the agency or the capture risks by one or more chains.

Several stationary sources, such as steel and cement, do not operate under a concession regime in the GHG capture activity. Therefore, they do not need to be supervised by the regulatory agency. Equally, thermopower plants and stationary hydrocarbon production units are regulated by federal agencies, despite the fact that only stationary hydrocarbon production units are under the legal jurisdiction of ANP to regulate carbon dioxide capture.

It would be appropriate to have the ANP as a regulatory body on the transport stage only when pipelines regulated by it carry out GHG gas. Such pipelines could be converted from methane to carbon dioxide, though the obligation would be concluded at the end of the concession contract or after the decommissioning stage. Consequently, on the hypothesis of converting old pipelines to carry carbon dioxide, it could be inferred they will need a new public call for granting the access right and would emerge the need to have legal enhancements to establish this new competence for ANP. Alternatively, transporting CO<sub>2</sub> by tanker trucks and ships could be done by using the current legal framework and out of the oil sector's regulatory regime.

The carbon dioxide storage phase could be suitable for the ANP as a regulatory authority only when it happens on oil fields or in mature reservoirs before the decommissioning process. Other cases in which storage is executed in exhausted fields, for instance, could demand specific bidding for granting the right of access to the storage of carbon dioxide and would need legal improvements. Finally, storage options that remained, such as saline aquifers or coal formations suitable for CCS projects, would not fit the ANP's regulation.

Although CCS large-scale projects remained related to the oil industry, in its model, it was pondered that, in the long-term, it could be viable to implement BECCS nearby Parana Basin as a path to developing the CCS industry (Moreira *et al.*, 2016).

Accordingly to the previous proposed, a National Committee for CCS activities would be divided as follows (Romeiro, 2014):

- i. For the capture of CO<sub>2</sub>, a member of the National Electric Energy Agency (ANEEL) would be responsible for regulating the capture activities on thermal power plants, and a representative of the ANP, responsible for regulating the activities of capturing CO<sub>2</sub> on oil fields. For the remaining sectors, there is no definition of who will be competent.
- ii. For the transport stage, representatives of ANP, the National Land Transport Agency (ANTT), and the National Waterway Transport Agency (ANTAQ) would be responsible for the oil industry, road transport, ships, and cabotage modals, respectively.
- iii. For GHG storage, ANP, National Mining Agency (ANM), and National Water Agency (ANA) would be involved in the oil fields, the coal deposits, and the saline aquifers.

Despite the attempt to build a legal, regulatory, and institutional framework that seems sensibleness in conceptual terms, some models have neglected institutional changes. The studies would have been more interesting if they had included how institutions work in major emitting sectors and if they had explored the challenge of dealing with many actors with divergent interests in the same area (Câmara *et al.*, 2011; Costa *et al.*, 2014, 2018; Romeiro, 2014).

The following section presents a perspective of effectiveness and institutional assessment of the CCS framework, inferring that it implies improvements in GHG capture by large-scale sources in Brazil.

### 3 The role of competent CCUS authorities in the Brazilian Framework

The pioneering works in the last decade represented considerable advances in studies related to the CCUS activities' legal, regulatory, and institutional frameworks. Under these bases, assessing what was proposed from the perspective of effectiveness is possible.

Separating public burdens under a project assessment can improve how the private sector-owned industrial stationary sources of GHG see CCS as viable. For that, pointing out who is responsible for executing policies and guidelines and those that will keep regulatory power are vital questions to shape institutions in favour of deploying new projects.

The study of Costa (2014) contributes to that. However, it fails to reshape guidelines and policy authority, does not attempt to provide suitable solutions for civil liability at the end of the project, and avoids indicating appropriate authorities for key sectors of the capturing phase.

On the opposite side, the excess of agents linked to the regulatory agency may compromise the overall result.

The conflict of interest between technical representatives and the vital need for consensus in decisions may lead to delays in the approval of projects depending on each member's manifestation. For instance, suppose an agent brings more demand to its link location. Regarding those concerns, discussions about competent authorities' rules can contribute to achieving better answers.

#### 3.1 The definition of guidelines for CCUS activities: the role of competent public policy and regulation authorities

The first role is related to guidelines, implementing policies, and improving CCUS activities through its chain.

The agents responsible for implementing industrial policies affected by climate change are the primary candidates to be elected as the competent authorities for CCS policies' implementation. In general, they are expected to be involved with legislative negotiations to formulate legal obligations, propose miscellaneous incentives, maintain engaged ancillary governmental agencies under its supervision, and other pairs of the same hierarchy.

The figure of governmental planning also keeps a close relationship with the authority mentioned above. Those duties allow decision-makers to have a broad

view of prospective scenarios, economic assessment of consequences for CCS on the internal market, or even increase of costs and its spillover into adjacent sectors (for instance, once GHG capture increases costs of energy, those sectors where the cost of energy impacts the price of the final product will be reasonably affected). The competent authority can do planning functions for policy implementation or any specialized agency directly linked to it. Therefore, we can classify them as Political Competent Authority (PCA).

Regarding the CCS chain, as a rule, it can act in the early phases of deployment, deal with different stationary sources of GHG, and establish rules and guidelines to distribute associated costs, avoid rent-seeking behaviour, or guarantee imposition of costs on certain groups. A myriad of instruments is well known by literature, such as cap-and-trade, command and control rules, carbon tax, carbon market, carbon pricing, and tax incentives (Allison *et al.*, 2017; Compernelle *et al.*, 2017; Gomes *et al.*, 2009; Honegger; Reiner, 2018).

The next step deals with transporting carbon dioxide from the capture phase to the geological storage reservoir. Major studies pointed to a correlation between pipelines operated by the oil industry and CCS transport facilities (Healey *et al.*, 2019; Hodgkinson, 2014; Santibañez, 2014), and natural monopoly regulation that allows multiple users to have equitable access to its resources (Hauge; Sappington, 2010; Mitchell; Woodman, 2010; Veljanovski, 2010).

Then, the figure of the Regulatory Competent Authority (RCA) emerges, to promote regulation patterns and rules in order to balance costs in the CCS business chain and between agents, to ensure the maintenance of long-term contracts, to distribute potential gains of scale and technology applied, observing guidelines and legal obligations negotiated by PCA (Baldwin *et al.*, 2010; Geske, 2015).

Under the RCA, the transport phase means that legal and institutional frameworks are wholly incorporated into national jurisdiction, avoiding the gap for adjudication of conflict between entities.

Geological storage and the final destination phase represent a fundamental challenge to CCS projects once long-term and civil liability inputs uncertainties sufficient to the growth of costs without other technical motivation than the legal and institutional framework.

The access to geologic traps as natural resources must be regulated to address critical issues, including the risk of carbon leakage post-decommissioning phase, the indiscriminate process of licensing access, contractual regulation to improve best practices and prevent losses of right unselective process of access to a license,

contractual rules to incentive best practices and loss of rights, unrestricted technical access to essential facilities, and how long-term liabilities will be transferred from the operator to the public authority (Allinson *et al.*, 2017). Those rules provide defined rules addressing environmental, health, and safety concerns, strictly related to regulation and RCA.

This section has summarized the policy and regulatory roles and consequential authorities, PCA and RCA. Considering these perspectives, the next section, with the proposal derived from the pioneer studies, attempts to design those roles into an institutional framework for CCS in Brazil.

### 3.2 Designing the prospective institutional framework

The challenge for designing an adequate institutional framework for GHG reduction has to take into account the number of economic sectors involved, the rigidity of current institutions that need to be slightly changed and upgraded under pre-existent lock-in on industrial sectors, oil industry, and energy systems (Hansson; Bryngelsson, 2009; Tvinnereim; Mehling, 2018; Unruh, 2000). In terms of effectiveness, the prospective horizon and undertakings that can implement the CCUS activity must be evaluated, considering that a small number of projects are candidates to be deployed in the coming decades.

Considering these perspectives and pioneering studies, this section proposes that the improvement and arrangement of a reflection on existing institutions' quality should undergo three paths. It also means that adopting current institutions figures as a reasonable choice, more than a scientific option. As an option, it cannot be motivating to counter possible disruptive processes of forming new institutions disconnected from existing ones to accelerate the CCUS development.

### 3.3 First path: via an existing framework

The first path refers to the current framework applied to any CCUS project. The formation of legal and institutional frameworks acquiesces to the normative applied to it.

As a mainstay, constitutional law condescends to carbon storage rules, incentives, or even delegation, resulting in the absence of priority rules concerning underlying conflicts between agents dependent on natural resources since the same geological

structure can be prospectively interesting in mining, oil, water, or CO<sub>2</sub> storage. Thus, the constitutional, legal or normative framework is applied transversely and depends on hermeneutic interpretations.

Regarding the Brazilian Federal Constitution of 1988 (CF), it is possible to deduce that the Union<sup>2</sup> has the right to use the subsoil, including the geological potential for sequestration of any kind of fluid (such as carbon dioxide or disposal of waste), as an ancillary activity reliant on significant sectors.

In theory, CCS as an accessory activity would avoid increasing costs of those activities using geological traps to obtain economic profit. Institutionalism supports that contracts can play an important role by having adjoining rules and property rights complementary to constitutional and legal constraints, which would remain prevalent in private agreements (Brousseau; Glachant, 2008; Stone, 1986; Williamson, 1979). Consequently, mining and oil codes could give sustenance to CCS during the prior phase, and only the federal government would have the competence to legislate about geological sequestration of carbon dioxide, notably based on energy and mining industries, preventing subnational entities from having a relevant role regarding this competence, on the storage phase.

Regarding the transport stage, on-premise of the current legal framework, where the absence of legal delegation results in RCA's weakness, PCA could fulfil it and operate both as regulatory and political authority, despite the fact that it is undesirable for other participants in CCS chain. Many governmental agencies are candidates to participate as competent authorities along the life cycle, and the energy sector has built the know-how to deploy linear infrastructure under regulatory frameworks.

The agency responsible for regulating the electricity sector has implemented concession contracts to expand and operate high voltage transmission lines between regions testing regulation and unbundling standards appropriate to prevent rent-seeking behaviour and its resulting increasing costs (Hauge; Sappington, 2010; Veljnavoski, 2010). However, transferring this experience to a CCS institutional model is delicate due to the notable difference between an embryonic and well-established industry.

Likewise, the oil industry inputs backgrounds replicable to CCS to distribute long-term gains and obligations. The natural gas (NG) pipeline industry has been

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<sup>2</sup> In Brazil, the term 'Union' refers to the Federal Government. Consequently, natural resource regulation is formulated by the Federal Legislative Branch and implemented by the Executive Branch.

working on concession and authorization regimes, sharing legal duties with the federal government and subnational states. In contrast, institutional frameworks of liquid fuels and crude oil pipelines are related only to federal agencies. Nevertheless, both cases are covered by legal regimes considerably consolidated and trustworthy to private agents involved.

The closest lesson applicable to CCS is based on iron ore pipelines in Brazil. There are few projects in operation, which were developed without a specific legal framework that could deal with complexities inputted by world-class ore prospects under the environmental authority's licensing regulations. General roles denote RCA and partially PCA figures covered by competent environmental agencies from the Union and subnational states when legislation is absent. Thus, it assumes public duties and *ex-ante* and real-time regulation of the CCS transport phase.

Brazil has implemented a CCS kind project coupled with carbon dioxide transport by using Enhanced Oil Recovery (EOR). This model was observed in the Miranga mature onshore field, in Bahia State. The operator opted to convert the transfer pipeline from carbon dioxide to the Natural Gas (NG) (Santiago-Camaçari pipeline) and return to the EOR-CCS business several years later (Lavergne *et al.*, 2007).

In order for that to happen, the operator requested infrastructure reclassification via the Authorization no. 257/2002, which resulted in transferring RCA from the Environmental Agency of Bahia State to ANP. To restart the CO<sub>2</sub> storage, a new licensing and authorization process had to be submitted to the State Environmental Agency, which implied that a type of twin project was under at least two competent authorities, directly involved in the transport phase, or adjacent to upstream and downstream NG chain.

The transport phase may represent a bottleneck in the chain regarding business and the physical carbon dioxide flow. Even though the comprehensive legal framework would better address its bottleneck, it is possible for current institutions to propose normative solutions.

The public sector can work as PCA in the network plan that tends to optimize the infrastructure facilities by linking the capture cluster to the storage fields, embracing a carbon cluster. In the Brazilian institutions, the Energy Research Office (EPE), a state-owned company dedicated to the governmental energy sector, may provide data and studies that allow the PCA to do the network plan for carbon transportation. In addition, gas patterns need to follow quality standards to access



carbon pipelines, other transport modals, and the storage fields in order to avoid operational and safety complications.

Alternatively, the public sector could deploy transport facilities under administrative policies that allow long-term contracts. The private sector designs, builds, finances, and operates an infrastructure through the legal framework of public-private partnerships (PPP) and reduces political risks related to RCA and PCA, since PPPs consider the collective needs of optimizing operation economically.

The capturing phase represents the most complex scheme to be regulated because each emitting source can respond differently to public incentives proposed by policy and regulatory paths, and the capturing cost matrix cannot automatically be imposed. For instance, the cheapest carbon captured on NG processing plants becomes a natural candidate to target regulatory emission patterns.

In contrast, thermopower plants, fertilizer, and steel industries could be overwhelmed by the same obligation of NG's industry. Despite that, the current framework indicates that government agencies responsible for regulating the economic sector are the leading candidates for RCA functions. On the hypothesis of legal absence, environmental agencies precariously fill this gap.

Regarding the PCA functions, the current legal framework application can reduce risks through infralegal standardization of the public administration's organization regarding executive coordination and obligations for each part-office agent.

This improvement could occur by executive order, in compliance with the National Climate Change Policy established by art. 84 of the Brazilian Federal Constitution and Law no. 12.187, of 2009, segmenting tasks and duties between federal agencies, like RCA, and their related ministries, as PCA. The leading authorities involved are the Ministries of Mines and Energy (MME) and of Environment (MMA), subsidized by EPE when the prominent sector is energy. The MCTI would address the remaining issues.

The result is a CCS assembly of norms corresponding to adding fragments of governmental rules performed by its agencies and fulfilling several institutional framework's needs while preserving sectorial agendas considered the main activity.

From this perspective, competent authorities that deal with capture projects to decarbonize electricity generated by fossil fuels are Aneel and environmental agencies. At the same time, oil and NG production are regulated by ANP as an adjacent activity to concession, production sharing, or onerous cession contracts in force, without the need for changes in current contracts.

Thereby, CCS activities would be subject to ANP's regulatory standards for the disposal of waste from oil activities in geological structures near oil infrastructure located in exploration areas. Long-term risks will be considered within the framework of oil regimes and their concessions.

Remnant emitting sources, such as cement, steel, and fertilizer industries, remain under the environmental agency umbrella. However, governmental decisions to obligate them to capture carbon dioxide could be postponed due to the lack of incentives or the complexity of arranging an efficient mechanism to avoid predatory competition in the international market.

In summary, it is inferred that the current CCS framework implies that it would be necessary to evaluate a reasonable way to determine the technically competent agents beyond environmental authority for each CCS project or each enterprise. The burden would be the absence of patterns that could result in preferential treatment for a project over another, even in the same activity, or notably divergent decisions, such as refusing CCS operation to an oil field but granting it to another equivalent. Table 1 provides a brief first path.

Table 1: CCUS arrangement based on the legal framework in force.

<b>Suitability</b>	Short-term, based on institutions linked to CCS
<b>Regulatory Competent Authority</b>	ANP (oil and NG industry), Aneel (electricity), and IBAMA or subnational environment agency (remained GHG large-scale industrial plants)
<b>Political Competent Authority</b>	Federal Executive Branch (MME, MMA, and MCTI) and Subnational States' Governments, subsidized by EPE and other sectorial agencies.
<b>Long-term Liability</b>	ANP, provides regimes of oil and NG frameworks via concession
<b>Remark</b>	Political changes input high risk (obstacle to long-term development). Each CCS project will be dependent on the licensing of the person responsible for emissions maturation projects)

Source: authors.

### 3.3.1 Second path: establishing an institutional framework by Law

This path tends to improve what could not be done via institutional arrangement, without the legal enhancement of a bill deliberated by the Brazilian Parliament.

The main challenge is defining the ministerial coordinator board under the CCS Directive on the executive branch, which also has to be settled. Many agents would act together, submitted to a ministerial directive coordination, run by the political authority responsible for coordinating actions between ministries.

In terms of executive coordination, in the PCA function, choosing one of the ministries that is in charge of main sectors, such as mining, energy, or industry, could be questionable since its demands could overshadow other areas, such as agriculture or general environmental themes. For this reason, PCA candidates are those of the Civil House of the Presidency of the Republic or another with a similar neutral position. They could be monitored to assess how effectively CCS rules have been implemented, via ministerial coordination.

Despite coordination issues, the PCA needs the technical and political capacity to coordinate sectoral conflicts and to articulate and implement incomplete tasks that, as a result, will effectively convert individual actions into a general system of CCS.

A new legal arrangement may provide rules to order RCA precedence considering where and who will be GHG capture plants' object, reasonable penalties, and small incentives to the private sector. Consequently, it may reduce the number of agencies involved in these phases and the uncertainties linked to RCA's agents' decisions.

Furthermore, uncertainties arising from the sequestration stage may be reduced by pointing to a unique RCA system considering the lowest improvement required on the current institutional framework, rising costs, and potential conflicts between agencies.

The leading candidates are mining and oil regulatory agencies due to legal regimes they have experienced for decades and the knowledge they developed dealing with concession contracts and authorizations for using natural resources set aside in geologic formations. As long as the cheapest sources to be captured and stored are in oil and NG industry and biofuels, the candidate seems to be ANP. However, conflicts caused by the overlap of concession areas in the underground water, mining, and oil sectors must be solved by regulatory agencies, such as Mining (ANM), Water (ANA), and ANP.

Nevertheless, it is highlighted that geologic formations available for carbon storage, as a rule, are not coincident with the targets for mining activities or underground water, mainly due to the physical conditions required to keep the carbon dioxide in the supercritical fluid in stable conditions, generally deeper than 800 meters. This geological environment is not the target for aquifers for human uses.

Environmental agencies consider that the federal government and subnational competencies defined through ordinary laws tend to judicial litigation. Hence, environmental licenses remained under the rules mentioned above.

Ongoing research indicates that the federal government members acknowledge the importance of the Paris Agreement for the climate change challenge, and how it may impact their daily activities. Nevertheless, who would be responsible for strategic coordination and followed obligations derived from COP-21 remains vague (Araujo, 2019).

Brazil's ten-year National Energy Expansion Plan, published by the Ministry of Mines and Energy, provides a projection for energy demands and indicates the expansion of the energy sector under general guidelines policies, which encompass wind, solar, biomass, or NG thermal power plants (Brasil, 2020).

However, a governmental strategic planning is absent among eligible use of CCS to achieve GHG emission reduction targets. Moreover, it neglects the potential benefits of CCS projects and, thus, does not allow the perspective of having the energy sector as a path to deploy carbon sequestration for hard-to-abate industries nor its contribution to Brazilian NDC. Therefore, it is inferred that the energy sector portfolio has prioritized upcoming expansion through mature sources, overlooking alternative decarbonized sources even accoupled with the CCS technology.

Through the NG transport sector's expertise, the transport phase may define both PCA and RCA guidelines to reduce their cross-chain risks. Nevertheless, Brazilian experience demonstrates that the potential co-optation by NG distribution agents increases cross-chain and political risks, which could be fixed up by a second-best policy choice, such as establishing a State-Owned Enterprise (SOE) for carbon dioxide activities or an innovative regime for this phase.

Another complex risk that must be reduced is long-term liability during and after the storage phase (Rassool *et al.*, 2020). Legal rules proposed via a new institutional framework for CCS may delimitate uncertainties and provide guidelines for monitoring systems, third-party audit, liability transferring process from private to public sector, insurance, guarantees to be covered, or even for a cost cap after decommissioning of the storage site.

Alternatively, a private-public arrangement of agents may have assumed the long-term liability of carbon dioxide leakage occurring after injection on the reservoir, which makes it possible to use the SOE as a mechanism to share costs between government and storage upstream chain, since it results in reducing risks (including financial ones) and cost of CCS projects.

Thus far, a well-defined legal framework may decrease risks via PCA and RCA, liability rules, and the CCS guidelines. Additionally, it could reduce the possibility of divergent decisions or the degree of discretion of governmental agencies. On the other hand, there is effectiveness in vertical coordination activities in ministerial subjects, even if policymakers ignore the intersectoral gains. Table 2 provides a brief second path.

Table 2: New legal system for CCUS, based on an ordinary bill.

<b>Suitability</b>	In the long-term, based on sectors and enhancement of institutions
<b>Regulatory Competent Authority</b>	ANP (priority on the whole chain), ANM (for coal), Aneel (capture on thermopower plants), ANA (underground aquifer), IBAMA or subnational environment agency (Capture on remained GHG large-scale industrial plants), SOE (complementary activities).
<b>Political Competent Authority</b>	Federal Executive Branch for main activities, and Subnational States Governors.
<b>Long-term Liability</b>	Legal framework, ANP regulation, or SOE. Possibility to have judicial litigation until Supreme Court establishes a precedent.
<b>Remark</b>	Political risks reduced, despite verticalizing the oil sector chain due to high inter sector contractual costs.

Source: Authors.

### 3.3.2 Third path: constitutional reform

The third path refers to the possibility of constitutional changes. In this case, treatment via the Brazilian Federal Constitution would be granted so that a single independent agency becomes responsible for the entire CCS chain. At that point, it

may avoid PCA functions via a committee made up of several agents, and RCA might be shared only with one environmental agency. Consequently, costs and benefits could be under the competence of a single competent authority, highly specialized in CCS projects.

Therefore, a Directive Committee would maintain political guidelines under CCS legal framework and institutions related to NDC and climate change. In addition, liability standards would be better defined to avoid litigation, which reduces political and long-term risks for CCS.

A monocratic authority would be established to deal with grants, legal regime and to implement the use of the geological potential for storage of any fluid or carbon dioxide for industries in which costs make capture business impeditive due to the impossibility of verticalization, which causes CCS to be an interdisciplinary subject under the tutelage of a single authority. Table 3 provides a summary of these choices.

Table 3: Institutional Framework based on a single competent authority.

<b>Suitability</b>	In the long-term, dependent on the legislative process in the Legislative Branch.
<b>Competent Regulatory Authority</b>	Independent RCA and environmental authority.
<b>Competent Political Authority</b>	Federal Executive Branch, via Directive Committee.
<b>Long-term Liability</b>	Reduced by constitutional rules and legal guidelines.
<b>Remark</b>	Financial risks decrease due to the institutional framework imposed via Constitution. May allow contractual costs reduction for GHG large-scale emitters like industrial plants.

Source: Authors.

## 4 Discussion of a prospective proposal of an institutional framework

Defining competencies between agents involved in CCS activities may reduce long-term political risks and transform uncertainties along the CCS chain in business cases.

As an infant industry, CCS depends on how the legal system distributes incentives and penalties, how the arrangement of competent authorities effectively improve the technological path concerning climate change, and how to build it feasibly in terms of cash flow along with the phases of the CCS project, pondered by business risks, which means market failures of financial risks in all steps of the process (Havercroft, 2019; IEA, 2020b, 2019).

A diversity of monetary incentives has been used to improve CCS large-scale projects, such as tax credit, carbon tax, grant support, or SOE on high export countries (GCCSI, 2021). In general, they have already been established under institutional frameworks, with competent authorities appointed by governments and main guidelines known by current players. Therefore, the deployment of its projects results from the risk reduction of institutions and affordable legal incentives.

### 4.1 Governmental competence distributions between agencies: the problem of multiple players

A missing puzzle piece can represent the current institutional framework for CCS in Brazil.

In theory, any large-scale GHG emitter can be available to capture its carbon dioxide. Nevertheless, incentives to cover revamp costs for adapting the current facilities to capture carbon dioxide are quite rare or hidden in legislation. They are applicable only for elected sectors where the primary industry can integrate CCS within the matrix of costs. The consequence is the lack of potential projects beyond the CO<sub>2</sub>-EOR or the biofuels.

Moreover, authorization and environment license paths allow submitting a project for approval of at least two agencies establish under unhomogenized decision systems, which may result in a possible disagreement between similar projects.

Concerning the sequestration phase, the private sector may have to use an adjacent legal framework to access geologic traps, such as mining or oil regimes, and then submit a CCS project to be licensed.

Thus, the effect has been an incentive for the oil industry to maintain potential under its umbrella; however, it is vertically integrated, according to the first path and table 1. In this institutional framework, the long-term process may cause an unbalanced distribution of gains for renewable fuels and the oil industry, neglecting remained GHG large-scaled emitters.

## 4.2 Empowerment proposal of a unique competent agency

Establishing a single competent authority might also represent an initial challenge for policymakers and RCA. Brazilian regulatory experience indicates regulatory agencies as a path to struggling links along the economic chain, remaining silent for those private agents that can self-regulate properly.

The recent energy framework improvements point to the ANP as a possible authority (RCA) for storage and long-term liability, supplementary to the ANM and Federal Environmental Agency. A Directive Committee may be advised by governmental research agencies responsible for energy studies and geologic survey (EPE and CPRM, respectively) to keep the central authority focused on critical issues for CCS business.

The capture and transport phase may be the object of specific regulation as risks along the chain have the potential to increase costs in its stages (such as pollution costs), and market failures have been unsolved by self-regulation of the free market, including regulations patterns of free access.

Regarding the CCS technology, two possible mechanisms may potentially expand upstream activities. First, minor legal incentives could help increment the Internal Rate of Returns (IRR) for low-hanging fruits that have not already been in the CCS chain. In addition, establishing SOE to share costs between the whole societies through time, leaving a part of it with agents responsible for pollution activities.

There are advantages and disadvantages of having the public sector act as an agent in the CCS chain. The upside is the virtual reduction of uncertainties involving the cross-chain risk in which the agents in the capture or storage phase use their market power to overestimate the carbon price, catching rents from the rest of the chain due to market failure or uncertainties along the chain. The mechanism of using SOE would avoid it by virtually reducing the transport tariff (in the middle of the chain) and absorbing the long-term risks of carbon leakage post-closure of the site. The downside is the political risk of using the SOE to activities other than the CCS business, or even the potential capture of its board



and management that may increase the public expenditure and the potential corruption levels, which would make inviable the direct public intervention in the chain by public enterprises.

The most suitable path pointed is the second institutional framework (table 2), which could be enhanced by the potential reduction of the long-term risks in the third path (table 3) by changing constitutional rules that define the federative arrangement of the CCS, avoiding conflicts between the federal government and subnational entities.

Choosing the oil agency as the RCA for the capture and transport stage may increase the risk of the capture agent problem once it accumulates the whole regulation chain, overstating the importance of oil stakeholders in the CCS sector and discouraging the solely engagement of capture or transport agents.

Therefore, despite possible gains, undesirable consequences can be high incentives to verticalize CCS project phases focused on the oil industry.

## 5 Conclusion

The paper dwell on designing institutional framework paths to CCUS in Brazil and evaluates possible gains and costs to GHG emitters groups affected by them. The options described and analysed aim to see scenarios and extract the main factors that prevent or help CCUS implementation as a mechanism for reducing CO<sub>2</sub> emissions on large-scale industrial plants.

Three complementary paths have been proposed to design the CCUS institutional framework.

The first path was shaped under the current institutional framework, showing that multiple competent agencies have tasks to be fulfilled. However, they can have divergent interests, resulting in a strong barrier for CCUS projects related to other sources than biofuels and NG processing plants. The second path aimed at removing key barriers and allowing the addition of major emitter facilities adjacent to the oil industry or biofuels, under a verticalized chain. This makes it hard for GHG to reduce manufactures out of the solution, such as steel, cement and chemical manufacturing, unless they are able to form a partnership with major oil companies, with the proposal of using the SOE as a mechanism to reduce, distribute and gain through CCS chain and the entire life cycle of the CCS project. The third path aimed at minimizing litigation and long-term liability due to uncertainties of carbon dioxide

leakage from storage site and federative conflicts between the federal government, State members, and its related agencies.

The analysis supports the idea that competent authority for CCS may involve more than one agency in terms of regulatory duties and the hierarchical coordination of high-level policies. However, reasonable criteria indicate that incremental steps by sector can help agents better understand how private agents respond to Brazil's institutional changes. It is also important to focus on implementing the CCUS from the definition of the composition of agents involved and the division of responsibilities between them and propose mechanisms for structural reduction of the activity's risk.

Among them is the problem of the regulatory capture of the oil agency, which makes it hard to engage agents interested in developing transport pipelines or dedicated to capturing facilities solely out of the oil agency's scope. Therefore, once activities concentrate in this bureau, rules and mechanisms for dealing with the problem presented are essential for the success of the CCS in the sectors adjacent to the energy industry.

The institution of a SOE must consider the frameworks of governance and best practices of public expenditure to avoid politicians' misappropriation of the budget or of the decision-making process. In addition, the SCO, such as Petrobras and Equinor, cannot freely apply cash flow to low-profit assets. This behavior implies the need for legal enhancement, public regulation or intervention to make a private activity developed by the SCO as profitable as necessary so the company's engagement in the CCS business can be justified to the board.

Since the paper was limited to competent authority issues, it is unable to affirm whether those improvements will result in the CCUS chain's deployment in Brazil. The institutional political context between changes in governments and decision-makers must also be considered. Notwithstanding these limitations, it is inferred that reasonable competent authority under the institutional framework is essential to improve CCUS and allow net-zero carbon dioxide emission as a role.

The question raised by this study lies on how these factors change over time and how institutions could be reshaped to maintain positive effects on climate change mitigation policies.

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