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Shifting to a just energy transition: The case of the regional coal energy system in the state of Santa Catarina – Brazil

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Abstract

Climate change is a threat and, if not addressed, will have devastating impacts on the environment and the Latin American economy. Brazil made a commitment at COP26 to mitigate 50% of its greenhouse gas emissions by 2030, using as a baseline the year 2005 and as a reference the Fourth National Inventory of Emissions. The economy of the south of Brazil, especially of the southern part of the State of Santa Catarina, has an important carbon chemical complex and is strongly impacted by the production of mineral coal. Abruptly ending production and consumption based on the coal economy would impact the daily life, culture, work, and income of the region's thousands of inhabitants, directly or indirectly. The federal government and the government of the state of Santa Catarina, are concerned with the conduct of the energy transition. This paper aims to analyze the state policy of just energy transition to a low carbon economy in the south of the state of Santa Catarina from the perspective of regional innovation systems, considering national and state Acts. Its methodology is qualitative content analysis. Its findings were analyzed based on documental data of news which is the underlying framework to relate them to the regional innovation system.

Sustainable and Responsible Business Track

1. Introduction

The academic literature consents that to keep global warming to 1.5°C above pre-industrial levels, the world must achieve carbon neutrality by 2050. Nearly 90% of global electricity generation by 2050 must come from renewable sources. To achieve this goal, wind and solar capacity will have to quadruple in the next eight years, according to the International Energy Agency – IEA (Bouckaert et al., 2021). Sustainable development goal 7 of the UN 2030 Agenda is not by chance but aims to ensure universal, reliable, modern, and affordable access to energy services. One of the Brazilian indicators for the target concerns the percentage of the population with access to electricity, and another refers to the percentage of the population with primary access to clean fuels and technologies (IPEA, 2019). To demonstrate advances in the government's attitude towards combating climate change, Brazil committed at COP26 to mitigate 50% of its greenhouse gas (GHG) emissions by 2030, using as a baseline the year 2005 and as a reference the Fourth National Inventory of Emissions. An analogous commitment to the one assumed when the Paris Agreement on climate change was signed.

Unlike sustainable development, which is a concept based on false consensus (Hornborg, 2009). Just transition offers a new space for developing an interdisciplinary transition-sensitive approach to exploring and promoting (1) distributional, (2) procedural, and (3) restorative justice, termed here as a new triumvirate of tenets (McCauley & Heffron, 2018). 'Just transition' approaches have played a central role in the interface between climate mitigation and socio-economic transformations (Bouzarovski & Haarstad, 2019; Martiskainen et al., 2020). Likewise, a just energy system would be "a global energy system that fairly disseminates both the benefits and costs of energy services and one that has representative and impartial energy decision-making" (Dall-Orsoletta et al., 2022). The regional innovation system approach has become a widely used framework for examining innovation dynamics across space and crafting policies to promote the innovation capacity of regions (Tödtling et al., 2021). The dominant focus has been on technological and business innovation, enhancing competitiveness and economic growth in areas. In the face of persistent environmental and social challenges such as climate change, environmental degradation, growing inequalities, and poverty (Coenen & Morgan, 2020). Regional innovation systems and policies appear fit to analyze a just energy transition policy.

The economy of the south of Brazil, especially of the southern part of the State of Santa Catarina, has a critical carbon chemical complex and is strongly impacted by the production of mineral coal. Several factors motivated the development of the local coal industry, among them the national process of import substitution and the strength of large regional economic groups (Heidemann, 1981). Over the years, the Jorge Lacerda Thermoelectric Complex (857 MW) was established and strengthened.

Energy justice is, above all, a matter of public policy. Abruptly ending production and consumption based on the coal economy would impact the daily life, culture, work, and income of the region's thousands of inhabitants, directly or indirectly. For this reason, the Federal Government enacted, in January 2022, Act no. 14,299, which deals with the institution of the economic subsidy to concessionaires of the public service of small electric energy distribution and creates the Just Energy Transition Program (TEJ). At the same time, the State of Santa Catarina government, thoughtful of an equitable distribution of costs and benefits of transition towards a low carbon emission economy, enacted the State Act n. 18,330, instituted the Just Energy Transition State Policy and the Just Energy Transition Hub in the South of the State of Santa Catarina. In this scenario, innovations must occur for a low-carbon economy to be established. Indeed, some key organization and institutional dimensions providing regional innovation systems emerge.

A significant problem when theorizing on the subject is what a regional innovation system would look like in reality (Markusen, 1999). Besides, to understand innovation properly, one must value the fundamental role of spatial proximity and concentration in the change process, as the location matters when it comes to innovative activity (Asheim & Gertler, 2005). Much progress has been made, yet transitions are under-theorized regarding how different spatial levels shape transition processes and interact with each other (Mattes et al., 2015). There is a lack of emphasis on spatiality in the dominant debates on sustainability transitions (Mattes et al., 2015). Regional innovation systems help fill this gap by analyzing how organizations are engaged in interactive learning within an institutional environment (Cooke et al., 1998).

Based on the above context, our research question is How the state policy of just energy transition can contribute toward a low carbon economy in the south of the state of Santa Catarina from the perspective of the regional innovation systems approach compared with news vehicles? This paper aims to analyze the state policy of just energy transition to a low carbon economy in the south of the state of Santa Catarina from the perspective of regional innovation systems, considering national and state Acts. Its methodology is qualitative content analysis. Its findings were analyzed based on documental data of news which is the underlying framework to relate them to the regional innovation system.

In addition to the analyses of innovation, policy, firms, and technology coal news, the local coal industry will likely be strongly regionalized. Notably, the region- and technology-specific institutional setup of innovation activities, frequently call it “regional innovation systems” greatly impacts the likelihood of innovation creation, adoption, and application (Cooke et al., 1997). The local news media about the Coal industry in Santa Catarina, may act as a facilitator by diffusing information, providing coordination, and mobilizing public and private support for novelty implementation and experimentation (Ozgun & Broekel, 2021). By circulating information on what is happening in the coal industry in Santa Catarina, news media disseminate collective expectations, thus building relations and contributing to connecting relevant stakeholders. In the following sections, this research provides a review of recent concepts of just energy transitions in the global south and regional innovation, their theoretical foundations, and assumptions. In the next section, the methodology is described. After that, an empirical case study of just energy transition policy involving the coal regional innovation system in the south of Santa Catarina. And finally, the article concludes with a discussion of the findings of this research.

2. Theoretical Framework

The theoretical framework, as follows, addresses energy transitions in the global south and regional innovation systems.

2.1 Energy Transitions in the Global South

A world without fossil fuels seems highly desirable but getting there will require economic sacrifices and patience (Smil, 2016). Climate change is a threat and, if not addressed, will have devastating impacts on the environment and the Latin American economy. On the other hand, energy efficiency is of great importance as these are the critical element for production, serving communications, computing, consumption, and industry. Unfortunately, around the globe, an energy matrix heavily dependent on the burning of fossil fuels predominates, and large-scale transitions to low-carbon systems represent a new challenge linked to socio-environmental impacts (Foxon, 2011; Sorrell, 2015; OECD, 2015; Mattes et al., 2015; Geels, 2018). Therefore, in the Anthropocene age, the urgent need to de-carbonize our energy systems can be at odds with taking questions of social and environmental justice (Kumar, Höffken, & Pols, 2021).

The energy model is intrinsically related to most aspects of everyday life, so changing in relation to energy involves rethinking how we consume, produce, work, organize ourselves, socialize and live (Akizu et al., 2017). In addressing sociotechnical transitions, relevant interdependent and co-evolving entities combine to form economically significant and geographically extensive systems that, over time, become increasingly stable and resistant to substantial transformation (Rip & Kemp, 1998; Uhrun, 2000; Geels, 2002; Marcon Nora & Alberton, 2021). Sociotechnical transitions, among which energy transitions are included, are political processes, as individuals and groups will disagree about their desirable directions and about appropriate ways to guide the process (Geels, 2004; Markard et al., 2012). When it comes to infrastructure, energy may be the one with the greatest range of interactions and environmental impacts (Reis & Santos, 2014). There will be winning and losing views as the result of these transition processes (Köhler et al., 2019; Marcon Nora et al., 2022). As climate change is scientifically supported by research, the pressure for a just energy transition becomes more intense. Energy democratization implies responsibility for today's society and for future generations. Access to energy is currently a measure to promote quality of life, dignity, and social well-being (Akizu et al., 2017; Marcon Nora & Alberton, 2021).

Transition processes are permeated by uncertainties, so they are not completely predictable (Geels & Schot, 2007; Forbord & Hansen, 2020). Edgerton (2007) proposes a post-contextual approach to the energy transition, where the author highlights the importance of perceiving local narratives as valuable for the fair and just representation of a “big picture”. There is a risk that the major reform of the energy sector in European countries and North America will contribute to the widening of neo-colonial inequalities in the global South and threaten its ecological and social sustainability. It is precisely the population groups that contribute the least to the climate crisis that are most likely to suffer the consequences of economic change (Becker, 2021). Due to social inequalities and geographic differences, especially in the case of the global south, it is necessary to consider that the energy transition goes far beyond energy. It involves sets of interests of different actors, with values and legitimate visions that need to be observed in the process (Marcon Nora et al., 2022).

In Santa Catarina, under the terms of State Act n. 18330/22 the Just Energy Transition was defined as a process of change and drive towards a low carbon emission economy, through the equitable distribution of the costs and benefits of this transition, ensuring the socioeconomic inclusion of the regions linked to the impacted production chain. The same State Act defines the Just Energy Transition Plan as a set of integrated actions and strategies for all segments of society impacted by the change in an economic development model aimed at transforming the State's production chains to mitigate environmental impacts and carbon neutrality, with productive and equitable results, promoting the generation of jobs that ensure people's quality of life and improving environmental conditions in the application territories (Brasil, 2022c).

2.2 Regional Innovation Systems

The role of the policy must clearly transcend the conventional policy of Science Technology and Innovation and innovation systems, as social challenges need to be addressed broader. Due to the widening of the goals, actors and affected groups, it seems important that policy actors take account of a more complex innovation landscape (Tödtling, et al., 2021). Thereby, the analysis of the innovation system aims to describe innovation and economic changes with the system's structural elements, functions, or phases and identify its potential weaknesses (Schaffrin & Fohr, 2017). Coenen, Benneworth, and Truffer (2012) affirm that the perspective of analyzing the innovation system and attempting to explain the Competitive advantages of specific countries, regions, or sectors in terms of the interaction of actors, technologies, and institutional infrastructures in particular to the context. This advantage arises in the process of evolving structural conditions, networks of firms, knowledge institutes, and

public authorities, together with an intense concentration of financial and human capital, methods of knowledge flows, institutional learning, and exchange of context-specific and tacit knowledge (Schaffrin and Fohr, 2017; Dobusch and Schœßler, 2013; Bessant et al., 2012; Cooke, 2012; Asheim and Coenen, 2006).

The regional innovation system (RIS) is a common way of explaining a region's development and competitiveness based on innovation system activities and processes. Regional innovation system research is grown and owes to the globalized economy, the competitiveness, the traditional regional development models and policies, and the successful clusters of firms and industries in many regions around the world (López-Rubio et al., 2020). The application of the innovation systems to a subnational area (regional or even local) was carried out to mitigate the most severe problems related to the national scale (Cooke et al., 1997). Thus, the approach of the regional innovation system has become a widely used framework for exploring the dynamics of space innovation and for designing policies to promote regions' innovation capacities (Tödtling et al., 2021; Asheim et al., 2019).

The notion of regional innovation systems is not a closed concept. Still, it is usually understood as a set of related public and private interests, formal institutions, and other organizations that function according to organizational and institutional arrangements and relationships that lead to the generation, promotion, and dissemination of knowledge (Doloreux, 2003). A regional innovation system is proposed as a system in which enterprises and organizations “systematically engage in interactive learning in an institutional environment characterized by integration (Irshaid et al., 2021). Cooke et al. (1997) and Asheim et al. (2016), in their approach, identified three institutional forms that promote systemic innovation at the regional level: Governance, social and culture aspects, and resources. Additionally, Cooke et al. (1997) found that RIS has two main perspectives related to regional autonomy. The first is developing policies and managing finances and investments towards innovation; the second relates to the cultural basis for systemic potential.

Regional innovation systems are crucial for an organization's competitiveness based on geographical concentration: they provide local collective competition goods (Le Galès and Voelzkow, 2001). Therefore, turn into networks of actors that are not only geographically but also socio-culturally embedded and institutionally stabilized. RIS are an appropriate framework to structure the relevant factors and actors that shape the energy transition in a particular region (Mattes et al., 2015). In this context, the promotion of regional innovation systems enables the support of the implementation (Calvo-Gallardo et al., 2022). Therefore, it is considered a key factor for successfully shifting towards a low carbon economy in the coal regions in transition, such as the south of Santa Catarina.

3. Method

The methodological approach involves three stages as follows. First, it will be characterized by the theoretical foundation of energy transitions in the Santa Catarina coal sector; Global South perspective; Energy Transitions and RIS approach. Secondly, based on the documentary research we analyze the actors that are involved in the Santa Catarina coal sector. And finally, the founding principles and organization logic evidenced in the document collection related to the RIS approach for this research will be characterized, as shown in figure 1.

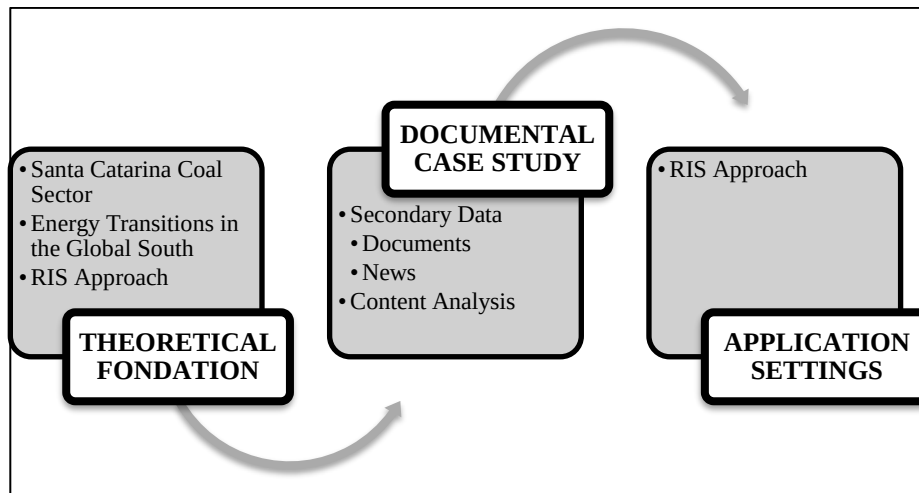


Figure 1 - Research Method
Source: The Authors (2022)

The research aims, from the perspective of regional innovation systems, to understand how the regional coal power system can contribute to a just energy transition to a low-carbon economy. Therefore, the investigative strategy is a documentary case study, focusing on the southern region of the State of Santa Catarina, in southern Brazil. Secondary data were collected from official reports, current legislation, and news published in the mass media on the subject. Afterward, the documents were sorted, and a content analysis was carried out to organize and identify categories of analysis in the light of regional innovation systems.

The documents identified come from several sources. In order to analyze the panorama of the just energy transition in the State of Santa Catarina, southern Brazil, the research addressed two legislations published in the year 2022: The Federal Act n. 14,299/2022, which creates the Fair Energy Transition Program (TEJ) and State Act n. 18,330, which institutes the State Fair Energy Transition Policy and the Fair Energy Transition Hub in the South of the State of Santa Catarina and establishes other provisions. Still, we consider the Federal Decree n. 11.124/2021, which deals with the Council of the Fair Energy Transition Program and the Transition Plan in Brazil.

In addition, considering the need to understand the views of different actors on the subject, research was carried out on news published in the media containing the expressions "just energy transition" + "coal" + "Santa Catarina". Google presented, in the news option, approximately 310 results (0.31 seconds) in July 2022. To filter the results, the following criteria were considered: adherence to keywords, most recent, and most visited media. The news was filtered, and the records were made until reaching a saturation point, in which the narratives began to be repetitive on the subject. In Appendix 1, we list the 71 articles and media that made up the analyzed portfolio.

The National Energy Balances of the Brazilian Energy Research Company (EPE) for the years 2020 and 2021 were also added to the portfolio. And the EPE report on the 2030 National Energy Plan: mineral coal.

4. Results & Discussion

The following items provide an overview of the coal situation in the South of the State of Santa Catarina, demonstrate the general idea of the fair energy transition policy for the State, the South of the State as a locus of innovation and a transition guided by public policy within a regional innovation system.

4.1 Santa Catarina Coal Sector: regional coal energy system Shift to a low carbon economy

Coal exploration in Brazil began at the end of the 19th century, however without practical results, and intensified in the context of the First World War, when in fact the exploitation of coal in an industrial character began (Heidemann, 1981). In 1988, with the promulgation of the new Constitution of the Federative Republic of Brazil, stricter controls were introduced for the exploitation of mineral coal, which until then, did not follow any specific control. The coal industry, the basis of the socioeconomic development of the south of the State of Santa Catarina, directly involves eight main municipalities, namely: *Criciúma, Treviso, Içara, Forquilha, Cocal do Sul, Urussanga, Siderópolis, and Lauro Müller*. In Santa Catarina, the total area explored, according to statistical data from the Union of the Coal Extraction Industry of the State of Santa Catarina, for the year 2020, is 1,625 km², corresponding to 9.6% of the national reserves of open-air and underground mines. There are more than ten mining companies operating in the region. This coal is commonly used in the country to supply thermal power plants (for electricity production) and as a raw material to produce steel coke. Pyrite tailings from coal extraction, when treated in chemical units, give rise to iron oxide, sulfur, sulfuric acid, and nitrogen fertilizers. The gases from coal distillation are sources of other substances, such as ammonium sulfate, toluene, benzene, tar, naphthalene, xylene, and light naphtha - for this reason, there is an important carbon chemical pole in the southern region of Brazil. According to the Brazilian Association of Mineral Coal (ABCM), coal mines in Santa Catarina employ around eighty percent of the national workforce for the segment. In 2020, the Santa Catarina coal sector was responsible for revenues of approximately US\$134 million and generated 2508 formal jobs (SIECESC, 2020).

The world is moving towards the decarbonization of the economy. Investment in the Santa Catarina mineral coal park seems to be in the throes of the energy transition. It is necessary, however, to understand the context that makes the country adopt a public policy of subsidizing coal. In the assessment of the ABCM, whose representative is from the south of Santa Catarina, the energy transition cannot eliminate fossil sources and replace them with renewable ones. ABCM believes that the focus should be on decarbonization, that is, on reducing net emissions. Coal-fired plants represent only 1.7% of all installed capacity in the electricity sector in Brazil. The percentage corresponds to a total power of 3 GW. For ABCM, the complete replacement of fossil sources with renewable sources is a mistake from a technical point of view, since thermal plants, powered by coal and natural gas, are responsible for maintaining the reliability of the electricity sector. Wind and solar sources are intermittent, and therefore would be unable to provide energy at any time of day (Poder 360, 2022).

Scholars criticize the coal industry not only for the direct impacts on the health of mine workers, but for the environmental consequences and the health of the population in general, considering that it generates air pollution that is difficult to control and with long-term effects (Nascimento, 2012; Teixeira, 2016; Hoelzel & Cardoso, 2020). After several lawsuits, a Project for the Environmental Recovery of Degraded Areas (PRAD), under the execution of the Geological Service of Brazil, was carried out from 2015 to 2019 involving a large part of the municipality of Treviso in the State of Santa Catarina for the rehabilitation of more 1,100 hectares of areas degraded by coal mining, and over 1,000 km of water resources impacted by acid mine drainage. They were piles of manure with little coal tailings and a lot of acid mine drainage contamination. The main polluting source of watercourses in the south of the State of Santa Catarina is the extraction and processing of coal (Nascimento, 2012). The recovery of part of the degraded vegetation cover does not exhaust the project and the concern with the effects of mining requires constant environmental monitoring (Hoelzel & Cardoso, 2020).

4.2 Energy Transition Policy in Santa Catarina – A coordinated process: From an Ideal Model to the Real one

Although the objective is to decarbonize, this process cannot be carried out without considering the region's history, culture, and economy, otherwise, it will cause major social problems. It is known that in transition arenas there is a diverse range of interests that are amalgamated and directs the paths of socio-technological changes adopted, often interests and values of a subjective character and difficult to perceive. In 2021, the Ministry of Mines and Energy concluded studies to evaluate coal-fired thermoelectric generation and coal mining activities in the state of Santa Catarina, in conjunction with federative entities, sectoral agents, and civil society, which highlighted the importance of considering social, economic, and environmental aspects in the region's energy transition.

The effective objective of the Brazilian government and the State of Santa Catarina, confirmed in the legislation and international commitments signed, is to move towards an energy transition that is fair for the population, beneficial to the environment, democratic, and safe. It turns out that different groups have different views on how to achieve this goal. The path that the elected representatives took gave rise to the public policy of energy transition established in Federal Act n. 14,299/2022 (Brasil, 2022a) and State Act no. 18,330/2022 (Brasil, 2022b).

The regulatory Decree 11.124/2022 of the fair energy transition policy proposes that the collegiate promote the energy transition in the region, observing the environmental, economic, and social impacts of the energy transition, with a focus on sustainable social development and aligned with carbon neutrality, to be obtained in compliance with the goals established by the Federal Government. According to Decree 11.124/2022, the Council for Just Energy Transition Program will be composed of 11 members and coordinated by one of the two appointed by the Civil Office of the Cabinet of the President of the Republic. The other indications will come from the ministries of Regional Development, Environment, Mines and Energy, the government of Santa Catarina, the ABCM, the Association of Municipalities in the Santa Catarina Coal Region, the Interstate Federation of Workers in the Coal Extraction Industry in the South of the Country, and the Union of the Coal Extraction Industry of Santa Catarina (Brasil, 2022c). The state's policy-oriented transition will have to include the carbon dioxide capture program, as it is the solution for fossil fuel thermoelectric plants and not their extinction.

It will be the task of the Council for the Just Energy Transition in Southern Brazil, more precisely in Santa Catarina, to propose the creation of programs for the diversification and economic repositioning of the region and of the portion of the population currently employed in coal mining and power generation activities, as thermoelectric energy from coal. Also, to take advantage of local vocations and existing infrastructure in the region, such as the Tereza Cristina Railway (which passes through the municipality of Tubarão) and the Port of Imbituba. In sum, A just Energy Transition Policy in the region seeks to ensure that the substantial benefits of a green economy transition are shared widely while supporting those who start to lose economically – be they local industries, communities, workers, or consumers.

4.3 Southern Santa Catarina as a locus of Innovation

A regional innovation System is not necessarily confined to a particular challenge (Tödtling et al., 2021). Instead, it constitutes the wider regional framework, reflecting the capacity of regions to address various and partly interrelated challenges. An example would be the environmental problem of climate change and the socio-economic problem of fighting unemployment in the coal region in the south of Santa Catarina. Based on the seven principles to realize a just transition to a low-carbon economy proposed by Atteridge & Strambo (2020), that emphasizes that regions facing decarbonization can and must prepare for inevitable changes on

the horizon with critical investments, policy reforms, and inclusive dialogue. Some aspects demonstrate this panorama. Seven are covered in the following paragraphs.

First, State Act no. 18,330/2022, proposed by the state government, actively encourages decarbonization by accelerating the transition to carbon neutrality in COP26. It brings the economic movement of coal to the state and is the proxy for alternatives for the sector, such as TEJ. It also brought the international alliance decreeing the end of energy from the mineral at COP26. Second, avoid creating of carbon lock-in and more losers in these sectors, such as the new management of the Jorge Lacerda Thermoelectric Complex, which intends to maintain jobs and the economic perspective of this region. All that is possible because the public and private sectors, employees, and the community join forces to invest in other forms of support for the carbon-intensive industry. Third, global warming affects Santa Catarina with 50°C heat tornadoes. Support affected regions with adequate plans and actions to address this problem. The main goal is to find innovative solutions that involve clean technologies, new business models, and integrated public policies, with priority being given to all those involved, attracting investments, and accelerating the generation of jobs in the regions.

Fourth, support workers, their families, and the wider community are affected by closures or downscaling. The State act aims to prepare Santa Catarina for the probable termination, by 2040, of the coal-fired thermoelectric generation activity. The coal activity in Santa Catarina is of fundamental importance to many people's lives and several cities. Its sudden and disorganized interruption will mean unemployment and severe financial crisis. Fifth, clean up environmental damage, and ensure that related costs are not transferred from the private to the public sector. Through the state act, the necessary conditions to suppress, minimize or compensate for the social and environmental impacts that directly or indirectly come from the activities developed in the Fair Energy Transition Poles are possible. Sixth, address existing economic and social inequalities. To the president of ABCM, "decarbonizing is necessary. We are not going to end up with fossil fuel, we are going to decarbonize it. The plan is fundamental for this and will be coordinated by the Civil House". He also says, "it is up to us, as a society, to make this happen. Less inequality, protection of the environment and everything else linked to the Sustainable Development Goals".

Finally, seven, ensure an inclusive and transparent planning process. For example, the law that creates the state policy for a fair energy transition seeks to reconcile the maintenance of jobs and the sustainable development of production chains in line with global trends in the energy transition. This program aims to implement measures over the next 18 years to reduce greenhouse gas emissions, such as carbon dioxide, and gradually replace coal-fired generation until the complete closure of coal thermoelectric activity in the state in 2040. In sum, the search for a just transition is not an easy way of dealing with the complexity and difficulties inherent in significant social and economic changes. This approach makes it more complex and requires the effort of all stakeholders. However, failure to make a fair transition can mean that policies do not have the broad community support and economic support needed to bring about necessary changes.

4.4 Toward policy challenge oriented to a regional coal energy system

To analyze the state policy of just energy transition to a low carbon economy in Santa Catarina from a regional innovation systems perspective. The starting point is the broad perspective that views the two subsystems as being embedded in an institutional and organizational support infrastructure for innovation between the knowledge application and exploitation subsystem and the knowledge generation and diffusion subsystem (Asheim et al., 2016). This RIS of coal in Santa Catarina is systemic due to the networks and interactions between the actors, such as the public and private sectors, employees, and the community.

The actors that generate new Knowledge, technology, and innovation and diffuse these innovations throughout the regional “social fabric” to strengthen the existing knowledge base that promotes mediating technology organization is the Foundation for Support to Research and Innovation of Santa Catarina – FAPESC. Public research organizations are the High Education institutes in the regions such as UNESCO, University of Southern Santa Catarina – UNISUL, Federal University of Santa Catarina – UFSC, and Santa Catarina Federal Institute – IFSC. Workforce mediating organizations such as Social Service of Commerce -SESC, ACMB, and Federation of Industries of the State of Santa Catarina - FIESC. Focuses on incentives for scientific research, innovation, and technologies that lead to the transition of the state energy model to renewable, sustainable, and low-carbon fossil fuels.

The actors that apply Knowledge and exploration of the subsystem through the absorption of new Knowledge, technology, and innovation from the outside for adaptation to local needs are the contractors, *ABCM*. Industrial companies include *Diamante Energia*, *Eletrobras*, *Complexo Jorge Lacerda*, *Engie*, and *Petrobras*. The main collaborators, *SIECESC*, and competitors such as the pole of *Parana State* and the pole of *Rio Grande do Sul State*, and the actors of the regional policy subsystem such as the Federal and State government, Executive Secretariat for the Environment – SEMA, Secretary of State for Sustainable Development – SDE, Institute for the Environment – IMA, Regional Development Bank of the Far South – BRDE, National Development Bank – BNDES, Santa Catarina State Development Agency S.A. – BADESC, Secretary of State for Finance – SEF, Secretary of State for Infrastructure and Mobility – SIE, General State Attorney’s Office – PGE, and Executive Secretariat for National Articulation – SAN. That focuses on compliance with climate goals through the application of the Just Energy Transition in a staggered and equitable manner, as shown in figure 2.

After the creation of the Just Energy Transition (TEJ) program in Santa Catarina, a legislative proposal intends to extend the initiative to the other two southern states of the country (*Paraná* and the *Rio Grande do Sul*), which have their carbon industry. An amendment presented in Provisional Measure 1.078/2021, which establishes the conditions for financial operations to distributors, proposes the creation of the TEJ to promote transition in the regions and foster innovation in the local energy sector. The possibility of closing thermal plants also mobilized the president of the Parliamentary Front for the Defense of Mining and from the Carbochemical Pole in the Campaign Region in the Legislative Assembly of the neighboring state of Rio Grande do Sul and the authorities of the municipality of Candiota (RS).

The importance of all energy sources for the sustainability of the Brazilian energy matrix. Also, it gives rise to new businesses that take advantage of the mineral coal, such as tourism and innovation ecosystems. And it is of particular interest that the development of products is projected to be zero carbon. The development of the District of Innovation is the first project of the Energy Transition of the South of Santa Catarina, which will be focused on developing low-carbon technologies and aligned with the Sustainable Development Goals (ODS). Besides, the presentation of the project to attract national and international investments to establish an innovation district together with the physical facilities of the SATC Technology Center. So, too, is the plan of expansion and innovation of *Jorge Lacerda Thermoelectrical*.

We propose paying close attention to the dynamics of the state act to ensure that the RIS promotes research, development, and technological innovation for application in the Just Energy Transition Poles.

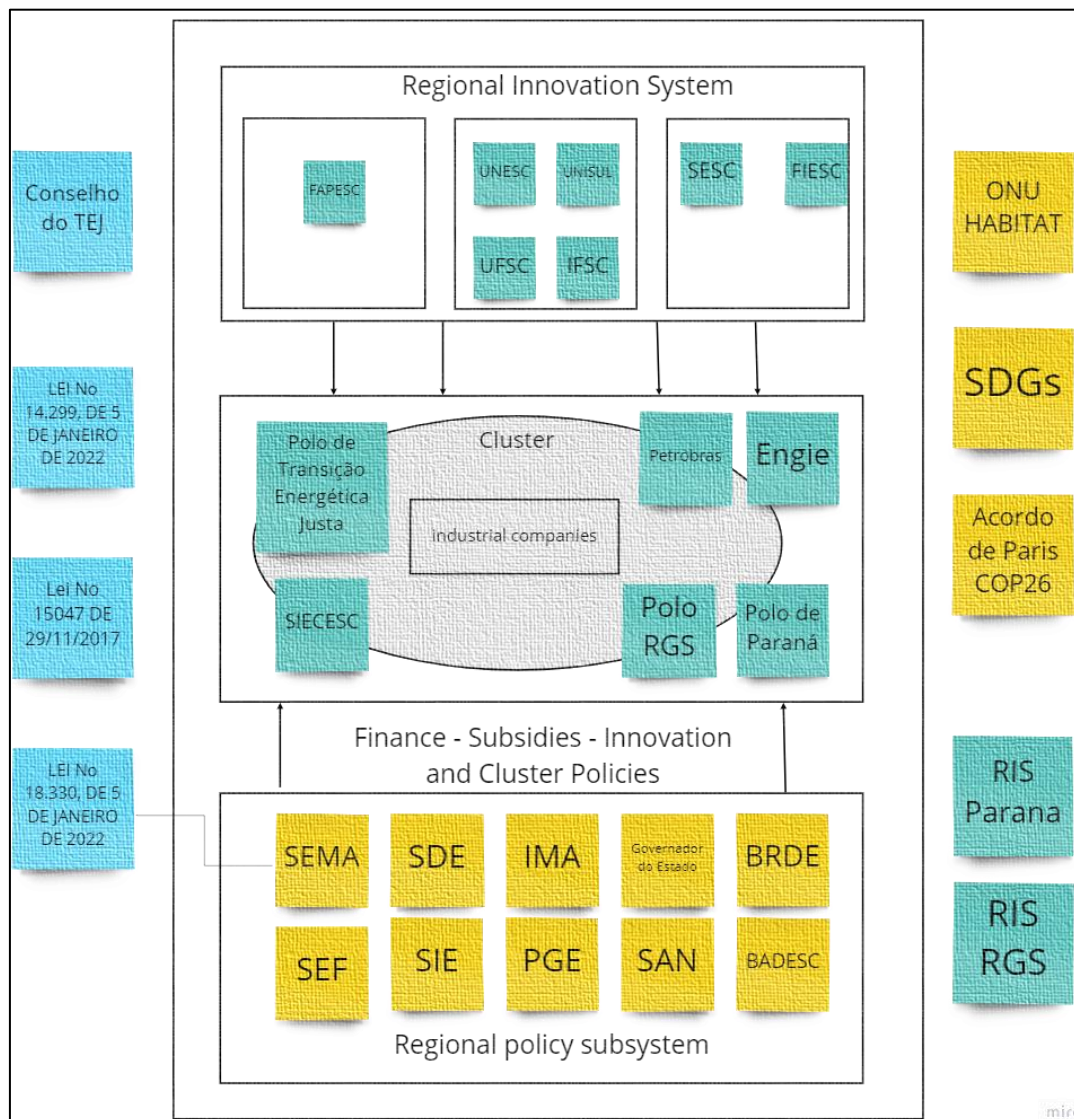


Figure 2 - Regional Coal Energy System
Source: The Authors (2022)

Furthermore, to put the economic, social, and environmental development, seeking reconciliation between the exercise of economic freedom and property rights, with the rational and sustainable exploration of two natural resources and the preservation and restoration of two ecosystems and two essential ecological processes. Additionally, it focuses on social protection for those affected, giving viability the conditions to suppress, minimize or compensate for the social and environmental impacts that directly or indirectly come from the activities carried out in the Just Energy Transition Poles. Their upscaling in the region is pivotal for broader change. Calling for the reproductive agency could also be essential for consolidating change (Baekkelund 2021), underpinning the coal region of Santa Catarina's wider diffusion of challenge-oriented innovations.

5. Conclusions

The innovation process cannot be understood as the result of an individual effort, it is undoubtedly a collective process. The set of institutions whose interactions determine the innovative performance of companies and local society can be recognized as a regional innovation system. The aim of this paper, through qualitative methodology, was to analyze the

state policy of fair energy transition to a low carbon economy in the south of the state of Santa Catarina from the perspective of regional innovation systems, considering national and state laws. We verified that this objective was achieved, having drawn an overview of what the laws consider fair energy transition and delineated the context of the region, through bibliographic analysis and news extracted from digital newspapers.

It appears that, despite the controversial alternative chosen by the legislator, there are elements indicative of an economic and environmental tradeoff of great importance in the region. Abrupt suppression of the coal industry would potentially harm workers. There is a lack of robust statistical elements to allow the interruption of operation of coal-fired thermal plants in the region, and perhaps their permanence is sustained much more by the lack of data than by the real need for their operation for the entire period deferred in the law. This does not mean that the State should subsidize a dirty and inefficient energy source. The policy in force recognizes the need for a set of actions and mechanisms that prioritize and facilitate the processing of processes related to efficiency projects and energy generation from renewable sources.

It is recommended, for future studies, to deepen in the field, starting from these elements collected in the media for direct contact with the population and local organizations.

References

- Atteridge, A. and Strambo, C. (2020). Seven principles to realize a just transition to a low-carbon economy. *SEI policy report*. Stockholm Environment Institute, Stockholm.
- Akizu, O., Urkidi, L., Bueno, G., Lago, R., Barcena, I., Mantxo, M., Bazurko, I. & Lopez-Guede, J. M. (2017). Tracing the emerging energy transitions in the Global North and the Global South. *International journal of hydrogen energy*, 42(28), 18045-18063. <https://doi.org/10.1016/j.ijhydene.2017.04.297>
- Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: regional innovation systems. In *The Oxford handbook of innovation*.
- Asheim, B. T., Isaksen, A., & Trippel, M. (2019). Advanced introduction to regional innovation systems. In *The Oxford handbook of innovation*.
- Asheim, B. T., Grillitsch, M., & Trippel, M. (2016). Regional innovation systems: Past–present–future. *Handbook on the Geographies of Innovation*.
- Asheim, B. T., & Coenen, L. (2006). Contextualising regional innovation systems in a globalising learning economy: On knowledge bases and institutional frameworks. *The Journal of Technology Transfer*, 31(1), 163-173.
- Baekkelund, N. 2021. “Change Agency and Reproductive Agency in the Course of Industrial Path Evolution.” *Regional Studies* 55 (4): 757–768. doi:10.1080/00343404.2021.1893291
- Becker, A. (2021). *A transição energética e a guerra pelos recursos do Sul global*. Available at: <https://www.ihu.unisinos.br/categorias/614980-a-transicao-energetica-e-a-guerra-pelos-recursos-do-sul-global>, Access: 29 jul. 2022.
- Bessant, J., Alexander, A., Tsekouras, G., Rush, H., & Lamming, R. (2012). Developing innovation capability through learning networks. *Journal of economic geography*, 12(5), 1087-1112.

- Bouckaert, S., Pales, A. F., McGlade, C., Remme, U., Wanner, B., Varro, L., & Spencer, T. (2021). *Net Zero by 2050: A Roadmap for the Global Energy Sector*. Available at: <https://www.iea.org/reports/net-zero-by-2050>, access on 22. Jun. 2022.
- Bouzarovski, S., & Haarstad, H. (2019). Rescaling low-carbon transformations: Towards a relational ontology. *Transactions of the Institute of British Geographers*, 44(2), 256-269.
- Brasil. Presidência da República (2022a). *Lei 14.299, de 05 de janeiro de 2022. Altera as Leis n°s 10.438, de 26 de abril de 2002, e 9.074, de 7 de julho de 1995, para instituir subvenção econômica às concessionárias do serviço público de distribuição de energia elétrica de pequeno porte; cria o Programa de Transição Energética Justa (TEJ); e dá outras providências*. Available at: <https://www.in.gov.br/en/web/dou/-/lei-n-14.299-de-5-de-janeiro-de-2022-372226134> Access: 10 jan. 2022.
- Brasil. Presidência da República (2022b). *Lei n. 18.330, de 05 de janeiro de 2022: Institui a Política Estadual de Transição Energética Justa e o Polo de Transição Energética Justa do Sul do Estado de Santa Catarina e estabelece outras providências*. Available at: http://leis.alegsc.sc.gov.br/html/2022/18330_2022_lei.html, Access: 08 jul. 2022.
- Brasil. Presidência da República (2022c). *Decreto n. 11.124, de 07 de julho de 2022. Dispõe sobre o Conselho do Programa de Transição Energética Justa e o Plano de Transição Justa*. Available at: <https://www.in.gov.br/en/web/dou/-/decreto-n-11.124-de-7-de-julho-de-2022-414059189>, Access: 09 set 2022.
- Calvo-Gallardo, E., Arranz, N., & Fernandez de Arroyabe, J. C. (2022). Contribution of the Horizon2020 Program to the Research and Innovation Strategies for Smart Specialization in Coal Regions in Transition: The Spanish Case. *Sustainability*, 14(4), 2065.
- Cooke, P., Uranga, M. G., & Etxebarria, G. (1998). Regional Systems of Innovation: An Evolutionary Perspective. *Environment and Planning A: Economy and Space*, 30(9), 1563–1584. <https://doi.org/10.1068/a301563>
- Coenen, L., Benneworth, P., & Truffer, B. (2012). Toward a spatial perspective on sustainability transitions. *Research Policy*, 41(6), 968-979.
- Coenen, L., & Morgan, K. (2020). Evolving geographies of innovation: existing paradigms, critiques and possible alternatives. *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography*, 74(1), 13-24.
- Cooke, P. (2012). Relatedness, transversality and public policy in innovative regions. *European Planning Studies*, 20(11), 1889-1907.
- Dobusch, L., & Schüßler, E. (2013). Theorizing path dependence: a review of positive feedback mechanisms in technology markets, regional clusters, and organizations. *Industrial and Corporate Change*, 22(3), 617-647.
- Dall-Orsoletta, A., Ferreira, P., & Dranka, G. G. (2022). Low-carbon technologies and just energy transition: Prospects for electric vehicles. *Energy Conversion and Management: X*, 16, 100271.
- Doloreux, D. 2003 Regional innovation systems in the periphery: The case of the Beauce in Québec (Canada). *International Journal of Innovation Management*. 7 (1): 67-94.
- Edgerton, D. (2007). Creole technologies and global histories: rethinking how things travel in space and time. *Journal of History of Science and Technology*, 1, 75–112.
- Forbord, M., & Hansen, L. (2020). Enacting sustainable transitions: A case of biogas production and public transport in Trøndelag, Norway. *Journal of Cleaner Production*, 254, 120156.

- Foxon, Timothy J. (2011). A coevolutionary framework for analyzing a transition to a sustainable low carbon economy. *Ecological Economics*, v. 70, n. 12, p. 2258-2267.
- Geels, Frank W. (2004). From sectoral systems of innovation to socio-technical systems. *Research Policy*, v. 33, n. 6-7, p. 897-920, set. <http://dx.doi.org/10.1016/j.respol.2004.01.015>.
- Geels, Frank W. (2018). Disruption and low-carbon system transformation: Progress and new challenges in socio-technical transitions research and the Multi-Level Perspective. *Energy Research & Social Science*, v. 37, p. 224-231.
- Geels, Frank W.; Schot, Johan. (2007). Typology of sociotechnical transition pathways. *Research Policy*, v. 36, n. 3, p. 399-417, abr. <http://dx.doi.org/10.1016/j.respol.2007.01.003>.
- Heidemann, E. E. (1981). *O carvão em Santa Catarina (1918-1954)*. Dissertação apresentada para conclusão do Curso de Pós-Graduação em nível de mestrado em História do Brasil da Universidade Federal do Paraná, Curitiba. 127p.
- Hoelzel, M., & Cardoso, A. T. (2020). *Relatório executivo 2020: Ação 125 F. Implementação da recuperação ambiental da bacia carbonífera de Santa Catarina*. Available at: http://dspace.cprm.gov.br/bitstream/doc/22006/1/rel_sintetico_bacia_carbonifera_2020.pdf , Access: 09 ago. 2022.
- Hornborg, A. (2009). Zero-sum world: challenges in conceptualizing environmental load displacement and ecologically unequal exchange in the world system. *International journal of comparative sociology*, 50(3-4), 237-262.
- IPEA – Instituto de Pesquisa Econômica Aplicada. (2019). *Objetivos de Desenvolvimento Sustentável*. Available at: <https://www.ipea.gov.br/ods/ods7.html> , Access: 06 jul. 2022.
- Irshaid, J., Mochizuki, J., & Schinko, T. (2021). Challenges to local innovation and implementation of low-carbon energy-transition measures: A tale of two Austrian regions. *Energy Policy*, 156, 112432.
- Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A. & Wells, P. (2019). An agenda for sustainability transitions research: State of the art and future directions. *Environmental Innovation and Societal Transitions*, 31, 1-32.
- Kumar, A., Höffken, J. I., & Pols, A. (2021). Dilemmas of Energy Transitions in the Global South: *Balancing Urgency and Justice* (p. 182). Taylor & Francis.
- Marcon Nora, G. A., & Alberton, A. (2021). Sociotechnical Transitions Towards Sustainability in a Multilevel Perspective: overview and future perspectives. *Revista de Gestão Social e Ambiental*, 15, e02784-e02784.
- Marcon Nora, G. A., Alberton, A., & Ayala, D. H. F. (2022). Stakeholder theory and actor-network theory: The stakeholder engagement in energy transitions. *Business Strategy and the Environment*.
- Markard, Jochen; Raven, Rob; Truffer, Bernhard. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, v. 41, n. 6, p. 955-967.
- Markusen, A. (1999). Fuzzy concepts, scanty evidence, policy distance: the case for rigor and policy relevance in critical regional studies. *Regional Studies*, 33 (9): 869-884.
- Martín-Vide, J., Vallvé, M.B. (1995). The use of rogation ceremony records in climatic reconstruction: a case study from Catalonia (Spain). *Climatic Change* 30, 201–221. <https://doi.org/10.1007/BF01091842>

- Mattes, J., Huber, A., & Koehrsen, J. (2015). Energy transitions in small-scale regions—What we can learn from a regional innovation systems perspective. *Energy Policy*, 78, 255-264. <http://dx.doi.org/10.1016/j.enpol.2014.12.011>.
- Le Galès, P., & Voelzkow, H. (2001). Introduction: the governance of local economies. In *Local production systems in Europe: Rise or demise?* (pp. 1-24). Oxford University Press.
- Martiskainen M, Sovacool B K, Lacey-Barnacle M, Hopkins D, Jenkins K E H, Simcock N, Mattioli G and Bouzarovski S (2020) New dimensions of vulnerability to energy and transport poverty. *Joule*, Doi: 10.1016/j.joule.2020.11.016
- McCauley, D., & Heffron, R. (2018). Just transition: Integrating climate, energy and environmental justice. *Energy Policy*, 119, 1-7.
- Mattes, J., Huber, A., & Koehrsen, J. (2015). Energy transitions in small-scale regions—What we can learn from a regional innovation systems perspective. *Energy Policy*, 78, 255-264.
- Nascimento, F. F. (2012). *Riqueza de macroinvertebrados bentônicos e qualidade da água do rio Morozini, no município de Treviso, Santa Catarina*. Available at: <http://repositorio.unesc.net/handle/1/1417>, Access: 09 ago 2022.
- Poder 360. (2022). *The energy transition is not about eliminating fossils, says Fernando Zancan*. Available at: <https://www.poder360.com.br/brasil/transicao-energetica-nao-e-eliminar-fossil-diz-fernando-zancan/>, Accessed on: 08 Aug 2022.
- SIECESC – Sindicato da Indústria de Extração de Carvão do Estado de Santa Catarina (2020). *Dados Estatísticos*. Available at: http://www.siecesc.com.br/pdf/dados_estatisticos_ano_2020.pdf. Access: 07 jul. 22.
- Rip, Arie; Kemp, René. (1998). Technological change. *Human Choice and Climate Change*, v. 2, n. 2, p. 327-399.
- Schaffrin, A., & Fohr, G. (2017). The local perspective on energy transition and innovation. *Innovation Networks for Regional Development*, 75-95.
- Smil, V. (2016). *Energy transitions: global and national perspectives*. ABC-CLIO.
- Reis, Lineu Belico dos & Santos, Eldis Camargo. (2014). *Energia Elétrica e Sustentabilidade: Aspectos tecnológicos, socioambientais e legais*. 2ª ed. Barueri (SP): Manole.
- Teixeira, C. D. (2016). *Composição da avifauna em diferentes estágios de sucessão da vegetação nas áreas em processo de reabilitação ambiental da Bacia do Rio Araranguá, Extremo Sul de Santa Catarina*. Available at: <https://www.lume.ufrgs.br/bitstream/handle/10183/170202/001044763.pdf?sequence=1>, Access: 08 set. 2022.
- Tödtling, F., Trippel, M., & Desch, V. (2021). New directions for RIS studies and policies in the face of grand societal challenges. *European Planning Studies*, 1-18.
- Unruh, Gregory C. (2000). Understanding carbon lock-in. *Energy Policy*, v. 28, n. 12, p. 817-830, out. [http://dx.doi.org/10.1016/S0301-4215\(00\)00070-7](http://dx.doi.org/10.1016/S0301-4215(00)00070-7).

Appendix 1

In the appendix, an example of the news data collection carried out for this research.

Title	Author/Link	Publication	Access	Keywords	Main Idea
Santa Catarina inicia transição para uso de energia limpa com novas leis	Autor: Karen Koppe. Veículo/Mídia: Ndmais. Link: https://ndmais.com.br/meio-ambiente/santa-catarina-inicia-transicao-para-uso-de-energia-limpa-com-novas-leis/	31.05.2022	01.07.2022	Baixo Carbono	No começo da notícia a autora apresenta as duas leis que foram sancionadas relacionadas ao TEJ. Logo, ela explica a tradição por trás da atividade carbonífera principalmente em SC, relacionando com as mudanças que devem ocorrer, e os impactos que podem acontecer a partir disso.
				Redução de Emissões	
				Energia Limpa	
				Leis	
				Transição Energética Justa	
Lei que cria a Política Estadual de Transição Energética Justa é sancionada	Autor: Renan Medeiros. Veículo/Mídia: SC Gov notícias. Link: https://www.sc.gov.br/noticias/temas/meio-ambiente/lei-que-cria-a-politica-estadual-de-transicao-energetica-justa-e-sancionada	07.01.2022	01.07.2022	Política de Transição Justa	Nessa notícia o autor fala sobre a nova política estadual do carvão, a lei que foi sancionada. Ele mostra qual é o foco dessa lei e como essa lei surgiu.
				Santa Catarina	
				Lei	
Sancionada política de apoio ao	Autor:.. Mídia/Veículo: Agência Senado. Link: https://www12.senado.leg.br/noticias/materias/2022/01/06/sancionada-politica-de-apoio-ao-setor-carbonifero-de-santa-catarina	06.01.2022		Carvão	Nessa notícia mostra um resumo da Lei 14.299 de 2022, além da
				Setor Carbonífero	
				Impactos ambientais	

setor carbonífero de Santa Catarina.			01.07.2022	Impactos socioeconômicos	importância do setor carbonífero em SC, e os impactos que essa lei pode causar. Na notícia também mostra mais detalhes da subvenção econômica desta lei.
				Política de Transição Justa	
				Energia Limpa	
Governador não tem data para criar grupo de transição do carvão	Autor: Rafaella Barros. Mídia/Veículo: PODER 360. Link: https://www.poder360.com.br/energia/governo-nao-tem-data-para-criar-grupo-de-transicao-do-carvao/	11.04.2022	01.07.2022	Plano de Transição Energética Justa	A autora inicia a publicação falando sobre não ter previsão da publicação do decreto que crie o conselho responsável pela elaboração do plano do TEJ em SC. Também fala que o plano do TEJ terá que contemplar o programa de captura de gás carbônico, pois ela é a solução para as termelétricas de combustíveis fósseis e não a sua extinção.
				Emissões de CO2	
				Santa Catarina	
				Combustíveis Fósseis	
COP-26: Paineis	Autor.: Veículo/Mídia: Estadão/Istoé DINHEIRO. Link: https://www.istoedinheiro.com.br/cop-	09.11.2021	01.07.2022	COP-26 Mudanças	A publicação fala sobre o debate na 26ª

crítica progra ma de carvão no sul do Brasil	26-painel-critica-programa-de-carvao- no-sul-do-brasil/			Climática	Conferência das Nações Unidas sobre as Mudanças Climáticas de 2021 (COP- 26), que teve como tema a transição justa para uma economia sem carvão no sul do Brasil.
				Transição Justa	
Brasil registr a maior expans ão da geraçã o em maio, puxada por termelé tricas	https://epbr.com.br/brasil-registra-maior- expansao-da-geracao-em-maio-puxada- por-termelétricas/	07.06.2 022	01/.08. 2022	Crise climática	O texto fala sobre promover uma transição energética justa para a região carbonífera do estado de Santa Catarina, observados os impactos ambientais, econômicos e sociais.
				Corrida global	

Table 1 - Sample of data collection

Source: Research data (2022)