

PROFILE OF COAL MINING IN SANTA CATARINA STATE (BRAZIL) AND ITS ENVIRONMENTAL IMPACTS

Introduction

This document presents a brief history of coal mining in Santa Catarina, a report of the activities related to pollution control undertaken by mining companies and by the Santa Catarina Coal Producers Association (SIECESC) and describes work to be undertaken for the recovery of the areas degraded by coal mining.

History

Coal mining was begun in Santa Catarina at the end of the 19th century by the British Tereza Cristina Railway Corporation which built the Dona Tereza Cristina Railroad, operated the first mines, and inaugurated the first stretch of track in 1885.

Since Santa Catarina coal was considered to be low quality because of the high quantity of sterile material in the coal veins, the high content of ash and sulfur and the difficulty of mining and principally transportation, the company did not profit from the enterprise, which led the English to discontinue the exploration. Given this situation, the Federal Government passed the concession to Brazilian concessionaires who began the coal mining industry.

With increased demand for coal during the First World War, the Santa Catarina product saw its first significant increase in production, an epoch in which the rail lines in the southern part of the state were extended and new mining companies were created.

The second impulse in Santa Catarina coal production came during the Getúlio Vargas Government, which made the use of Brazilian coal mandatory and with the construction of the Companhia Siderúrgica Nacional (CSN), in the municipality of Volta Redonda in Rio de Janeiro State, in 1946. In 1931, the government determined that 10% of coal used at the plant would be Brazilian and increased this quota to 20% in 1940.

Over the next 60 years there were profound changes in the sector and at the beginning of the 1970's there were activities at 11 mining companies, most belonging to local owners.

Coal production received new stimulation with the petroleum crises of 1973, when attention focused once again on the use of Brazilian coal. Nevertheless, in 1985 the coal sector began to be deregulated and subsidies were gradually removed for production, transport and use of domestic coal. In the early the 1990s, a Federal Government decree revoked the Getúlio Vargas Law that required Brazilian iron companies to buy domestic coal. The electrical generation was the only market left for coal, and was not enough to offer financial stability to the companies. This plunged the sector and the entire southern Catarina region into deep crises until late 1996.

With the expansion of the electrical generating network in the region, and the addition of unit C with 350 MW capacity at the Jorge Lacerda Power Plant complex, a new phase of activity began in the southern part of the state in 1996 and the increased consumption offered financial stability to the coal companies. Technical studies have been conducted in order to introduce new concepts and technologies to the region's mining companies, giving priority to environmental recovery and protection, labor health and safety and investments in technological improvements at the mines.

The current government, in conjunction with universities, companies and the regional community, began a process of technical-scientific valorization of coal without environmental harm, and requested that Funcitec – the Science and Technology Foundation of Santa Catarina – conduct a “Preliminary study about opportunities for the valorization of coal in Santa Catarina” to indicate possibilities to add value to Santa Catarina coal, considering its characteristics and based on suitable and innovative technical concepts.

Characterization of the Reserves

Coal is the largest source of non-renewable energy in the country. Its reserves represent about 50% of Brazil's fossil fuels energy reserves followed by nuclear fuel with 27% and petroleum with 8%. The balance is comprised of natural gas reserves, bituminous schist and peat turf.

Of a total of 32.3 billion tons of known coal reserves, Santa Catarina has more than 10% (3.4 billion tons) and is thus considered the largest Brazilian Run of Mine (ROM) coal producer and the second in sellable coal.

Santa Catarina coal has physical-chemical characteristics that are distinct from other coal found in the world. It has a high degree of ash, 42%, and sulfur, 2.2%. Its maximum energy value is 4,500 kcal/kg and 21% of the volatile material.

There are currently 12 companies mining coal in the State, with 10 of them represented by SIECESC – Santa Catarina Coal Producers Association. Together they operate nine underground mines, 3 small open-air mines and 8 plants to extract and process tailings. The principal consumer of the member companies of SIECESC is the Jorge Lacerda Electrical Generator Complex that purchases 200 tons per month of CE4.500.

The Santa Catarina Coal basin is located in the southeastern portion of the state in a polygon of approximately 1,200 km², including 24 municipalities which correspond to a population of 659,000 inhabitants. It encompasses portions of the Tubarão, Araranguá and Urussanga River Basins which total approximately 9,000 km² and have a known length of 95 km and an average width of 20 km, within an area marked by coordinates 28°11' to 29°03' south latitude and 49°10' to 49°37' west longitude (Figure 1).

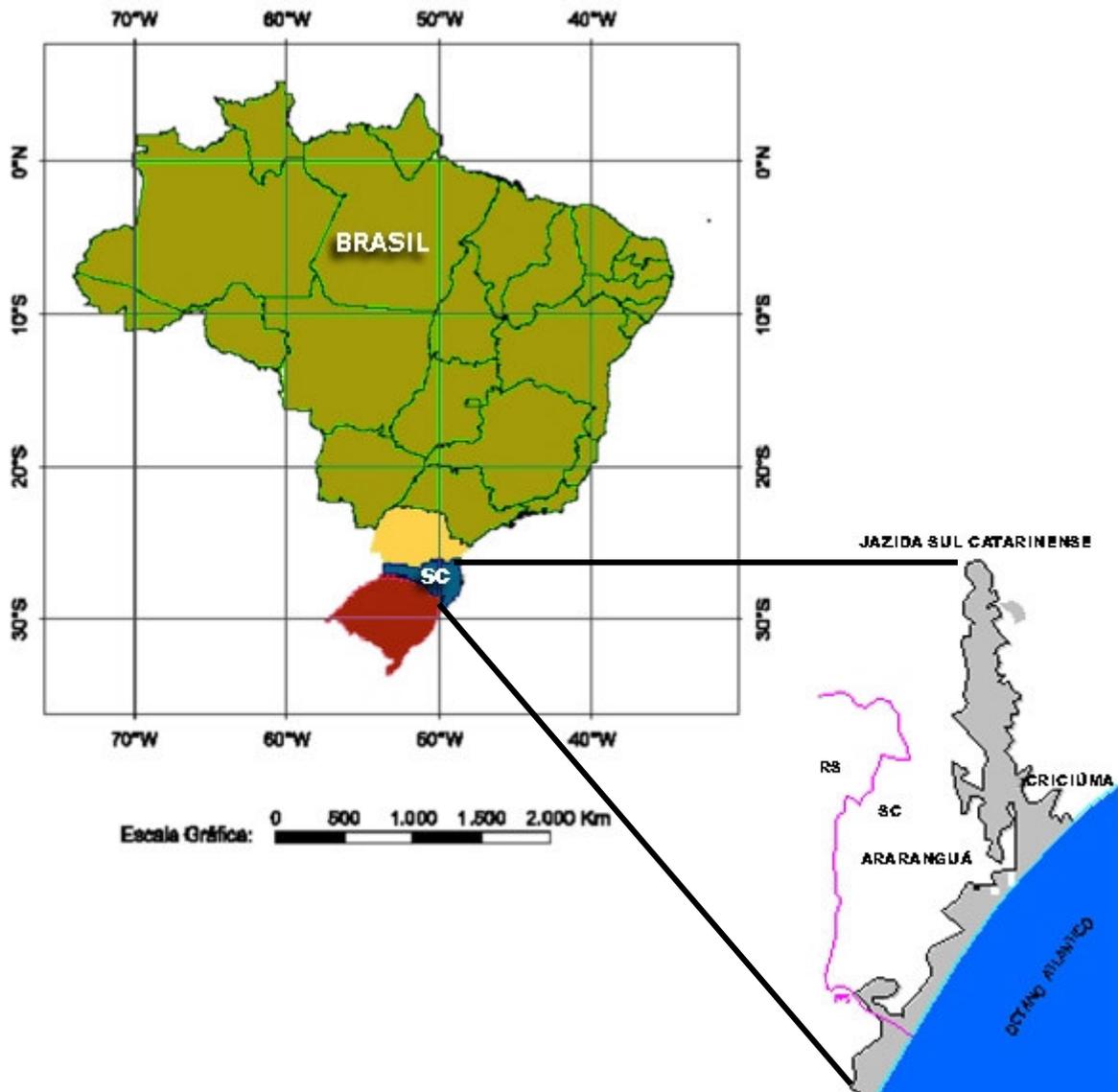


Figure 01: Geographic location of the Southern Santa Catarina Coal Basin.

Production of ROM by State (tons)				
Year	Paraná	S. Catarina	R.G. do Sul	TOTAL
1990	219,880	7,484,098	3,808,556	11,512,534
1991	269,350	6,684,243	3,463,434	10,417,027
1992	255,697	5,531,404	3,483,014	9,270,115
1993	273,341	6,044,844	3,306,372	9,624,557
1994	304,659	5,699,942	3,748,101	9,752,702

1995	254,643	4,988,321	3,882,582	9,125,546
1996	262,414	3,547,697	3,937,857	7,747,968
1997	222,636	4,464,877	4,233,193	8,920,706
1998	95,083	4,468,689	4,056,307	8,620,079
1999	91,652	4,484,073	4,495,140	9,070,865
2000	142,615	6,639,019	4,733,416	11,515,050
2001	219,235	7,193,189	3,814,258	11,226,682
2002	252,093	5,959,933	3,822,283	10,034,309
2003	296,644	5,329,023	3,464,173	9,089,840

The Environmental Impact of Coal Mining

For many years coal mining was the largest productive activity in southern Santa Catarina. In the past, coal mining was executed with little environmental care and was the principal cause of water pollution in the region.

The change in the morphology of the land, the removal of the vegetation, the random disposal of solid waste, the increased erosion and the instability of the slopes and opening of underground caves caused soil degradation. In addition, the seepage of waste deposits, principally due to the intense rains in the region, generate acid drainage from the mines that reaches the region's rivers and streams, aggravating the complexity of the problem.

The poorly maintained piles of rejects, without proper care for compacting, impermeable covering and replanting also lead to processes of spontaneous combustion, causing problems of air pollution. The tailings also create acid runoff in addition and lead to the siltation of the rivers and streams near the piles.

While coal mining has been prosperous, the improper management of residues generated by the exploration and processing of coal, in some cases still practiced today, has resulted in acid mine drainage which has contaminated water and soil with sulfuric acid and toxic metals. The consequences of this pollution are still found in the regional environment and affect the population.

The acid drainage from the mine comes from the natural oxidation of sulfated minerals (principally pyrite), found in the coal layers in its bedrock, when in contact with the air and water.

It is estimated that in the Santa Catarina Coal region there are nearly 786 km of rivers affected by acid mine drainage in the Araranguá, Tubarão and Urussanga River basins, comprising approximately 6.7%, 2.0% and 12%, respectively, of the total length of the rivers of each basin or nearly 4% of the total lengths of the rivers in the three river basins of 19,694km.

The contamination of the water resources is due to acid drainage from mines in 134 strip mine sites with a total of 2,964 ha, 115 waste deposit areas with a total of 2,734 hectares, 77 sites of 58 hectares with acidic pools and hundreds of underground mines.

The environmental problems are the result of 120 years of mining activity and other pollution sources. In 1980 the Santa Catarina Coal Region was

designated a “Critical National Area for Pollution Control and Environmental Conservation” by Decree no. 85.206 of Sept. 25, 1980.

Due to this grave situation, the Federal Attorney General filed suit in 1993 against the federal and state governments and coal companies, seeking environmental restoration of the areas affected by coal mining in addition to termination of the environmental degradation by the active mines. In the year 2000, a federal judge in Criciúma, SC ordered that the government and mining companies establish a recovery project in six months to be implemented over three years, and that it encompass the damage caused by coal mining in the entire coal region in the southern part of the state.

Thus, based on the need to create a basic management structure to guarantee the implementation of the Environmental Recovery Plan with an Integrated Management System, a Presidential Decree of December 14, 2000 created a Management Committee for the Environmental Recovery of the Coal Basin of southern Santa Catarina state. The purpose of the committee is to organize, coordinate and supervise the activities for environmental recovery of the coal region in Santa Catarina state. The principal responsibilities of the committee are to:

- Stimulate public and private participation;
- Increase the efficiency of recovery, improve communication and integrate the parties involved;
- Broaden recovery, by providing incentives to industrial activities and mining in degraded areas;
- Maximize the use of existing funds and resources and explore new financing resources;
- Coordinate efforts at scientific and technological research for environmental recovery;
- Assist in efforts for economic strengthening and sustainability of mining activity to guarantee the private resources for the environmental recovery;
- Avoid duplication of activities, making the best use of resources and giving priority to actions of greater environmental effectiveness.

Currently, the environmental recovery activities undertaken in the Santa Catarina coal basin follow three principal lines of work:

The **first** is being undertaken by the mining companies that are conducting recovery projects of their environmental damages and implanting environmental management systems that include treatment systems for acid mine drainage, suitable to the conditions found at each operating mine unit.

The **second** involves projects on the scale of the entire coal basin (1: 100,000), and includes efforts to analyze the surface and underground water resources through monitoring of their physical-chemical and bacterial characteristics, geological and structural mapping, a survey of openings of abandoned mines and identification of all the existing pollution sources.

These projects are being executed in national accords with government organizations such as: the Mineral Technology Center (CETEM), the Geological

Service of Brazil (CPRM), the National Department of Mineral Production (DNPM), the Santa Catarina state Environmental Foundation (FATMA); high school institutions such as the Benefit Association of the Santa Catarina Coal Industry (SATC); higher education institutes such as the University of the Far South of Santa Catarina (UNESC), the University of Southern Santa Catarina (UNISUL), the Federal University of Santa Catarina (UFSC) and the Federal University at Rio Grande do Sul (UFRGS) and is coordinated by the Environmental Nucleus of the Union of Coal Mining Companies of Santa Catarina State (SIECESC).

The projects intend to identify critical areas that generate pollution related to coal mining and to prepare the recovery projects in the degraded areas on a conceptual, basic and executive level.

There are also international agreements including: an accord between CETEM and Canada National Resources (CANMET) for the exchange of technology in recovery of areas degraded by mining; the agreement between SIECESC and the U.S. Energy Department in Clean Coal Technology; the agreement between the environmental agencies of Santa Catarina and Pennsylvania states to exchange experiences in recovery of areas degraded by coal mining. In the past there was an agreement between DNPM and the equivalent German agency that led to significant advances in the practices and procedures of coal mining inspection in Brazil.

The **third** line of action is technological training that seeks to develop knowledge for development, and application of control and recovery technologies of existing degraded areas, adapting them to the characteristics found in the Catarina coal region.

Attempts are also being made to train local technicians, engineers and geologists who act in coal companies and consulting companies by means of a graduate course in the Graduate Program in Mine Energy, Metallurgy and Materials (PPGEM) at the Federal University at Rio Grande do Sul - UFRGS with emphasis in subjects such as: methodologies for environmental diagnosis and diagnostics, geochemistry, geostatistics and hydrology simulation, effluent treatment and treatment of acid mine drainage among others. This program now has 26 students who are concluding the initial phase of course work and initiating the research phase for their master's dissertations.

Within this technology training program The Mineral Technology Center (CETEM) is developing passive treatment projects for acid mine drainage and dry coverage for active waste deposits.

This knowledge will be made available by the creation of the Documentation Center and the Coal Information Network (CDRIC) in agreement with the Santa Catarina Technology Foundation (FUNCITEC) and soon will be implanted at the library of the Assistance Association of the Santa Catarina Coal Association (SATC).

The procedures currently used in mining activity have significantly reduced the environmental impact caused by extraction and processing of coal, and opportunities have been identified for improvements that would allow the rational use of this mineral, with consequent environmental benefits.

The use of Santa Catarina coal is now nearly exclusively limited to the production of electrical energy, meaning it is not being utilized at its complete

potential given the technological alternatives that now exist that make possible new applications. This creates opportunities for the scientific and technological development of new applications to be conceived as a function of the characteristics of the coal's components.

New opportunities have been created by the interest expressed by some Brazilian steel companies to consume Brazilian coal and form partnerships with the coal extracting companies for the development of joint projects. Another possibility has been created by the growing cost of natural gas that is causing the brick and tile industry to shun the use of natural gas and to seek alternatives in the gasification of coal produced in the region.

Valorization of Coal and its By-Products

Although Santa Catarina coal has some physical-chemical characteristics that create restrictions to its industrial use, its composition does allow, based on suitable technical concepts, its economic use in various industrial sectors, providing it with increased value as a raw material.

The realization of the "Preliminary Study about the alternatives for the valorization and use of Santa Catarina coal" indicated the following possibilities for use:

1. Electrical generation;
2. Pyrolysis and gasification;
3. Coal-chemical industry;
4. Use of residue and environmental management of processes.

The use of coal for electrical generation can be a strategic option, considering that the Brazilian energy matrix is predominantly based on hydroelectric power. Electrical plants involving technologies for burning oil, natural gas and pulverized coal account for less than 19% of the total energy. New coal technologies are in different stages of development.

In addition to electrical generation, other routes to industrial use, or for creating energy from coal can be cited by their importance: pyrolysis, the initial stage of the process of converting coal into coke to be used in furnaces and metallurgy, and gasification, in which coal is converted into synthesis gas, used to obtain a series of chemical products, or simply as fuel.

The gasification of coal is not practiced in Brazil, although initiatives have been taken in this direction, the most recent by Santa Catarina brick and tile companies. Considerable investments were made by the Federal Government to undertake coal gasification during the petroleum crises of the 1970's, although there were some important results, the developments in the world petroleum market limited advances in this direction.

The coal-chemistry industry is based on processing of coals via pyrolysis or gasification and includes the transformation of the constituents of coal (volatile elements, tar and ammoniacal waters) to obtain a range of chemical materials that can be used in various areas of economic activity, such as the production of fertilizers, pharmaceutical products and others. The coal-chemical industry offers

opportunities to obtain chemical materials from gas and the sub-products of coking, in addition to other processes of coal transformation.

With any of these technologies, the viability of utilizing coal on a large scale will always depend on the correct environmental treatment along the entire productive chain, due to its high polluting potential if proper care is not taken.

Finally, burning coal in industrial companies and for electrical generation causes the emission into the atmosphere of particulate matter and gases, in addition to vapors of other elements, that once recovered, would be of industrial interest.

The options presented are not all of the possibilities for the rational use of coal, they are only a few of the promising opportunities for new lines of business that add value to Santa Catarina coal through the utilization and valorization of residues and that can contribute to improved environmental conditions.

Actions of interest

Considering the national policy to insert coal into the Brazilian energy matrix; the intention of the state government to support the valorization of coal and its by-products; and the effort made by the coal industry to bring its operations into conformity with legislation, reduce environmental impacts and recuperate their environmental damages.

Preparation of the Document

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