THE COAL CHAIN

Colombian Coal
an Energy Source for the World

ISBN 958 - 97750 - 0 - 4

Libertad y Orden

REPÚBLICA DE COLOMBIA

MINISTERIO DE MINAS Y ENERGÍA

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Pre-Press
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Printed by
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Translated by
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Made in Colombia

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PRESENTATION

It is satisfactory for the Mining Energy Planning Unit UPME, to present the document “The Coal Chain in Colombia” to society in general, and especially to the agents in the mining industry.

With this publication, we hope to contribute a useful instrument of reference regarding the stages of exploration, exploitation and beneficiation, transformation, transportation, uses, exportation and other data about coal in the national environment; in addition, we provide information about the global market of this resource, as well as reserves, prices and qualities, in order that it becomes a technical referent for mining and academic management.

It is written for trade and mining organizations, reserve holders and mining licensees, mining operators, consultants, the Academy and investors.

It is the time to stimulate the establishment of productive chains of coal in the different coal mining districts, where value is added and competitiveness and productivity is increased in order to encourage the entry of capital and technology to guarantee a competitive and profitable industry.

CARLOS ARTURO FLÓREZ PIEDRAHITA
General Director

INTRODUCTION

Colombia is the country which has the greatest coal reserves in Latin America. It has potential reserves of 16,992 Million tons (Mt) of which 7,063 are proved or measured, 4,571 Mt are probable or indicated, 4,237 Mt are inferred and 1,119 Mt are hypothetical resources. On the other hand, it is the sixth exporter of coal in the world, with a share of 6.3% which is equivalent to 50 Mt of coal a year.

With the current rate of exploitation, the measured reserves of coal in Colombia guarantee more than 120 years of production. This is enough to participate on a large scale on the international market and to supply the internal demand.

Coal, a generating source of foreign currency and employment, accounts for 47% of the national mining activity and represents 1% of the Colombian gross national product with a little more than $3.4 trillion pesos. In recent years, coal has consolidated itself as the second national exportation product after oil and it is estimated that under the current market conditions, between the 2010 and 2015, it may exceed oil exportation.

In the 80s the great investments in the projects of El Cerrejón and El Descanso, in the departments of La Guajira and Cesar respectively, significantly increased the production of thermal coal which reached 53.6 Mt in the year 2004 when the price reached a peak of US$80 per ton.

On the other hand, coking coals and anthracite (of higher quality and prices), located in the Cundiboyacense Altiplano and in Norte de Santander, have had an interesting development although production in 2004 was only 3.4 Mt. Current prices per ton range from US$100 to US$132 for the first and for US$82 to US$110 for the latter.

Due to the above, it is the time to encourage the establishment of productive chains of coal in the different mining districts where value is added to coal and its byproducts, and where an adequate development of transportation and port facilities is promoted in order to increase competitiveness and to induce a greater productivity.

This document analyzes The Coal Chain, starting with the national characteristics such as reserves, production, consumption and exportation, along with the classification, main uses, qualities and aspects of the global and national markets.

ABBREVIATIONS

A	Anthracitic
BTU	British Thermal Units
cal	Calories
Cz	Ash
Cf	Fixed carbon
ha	Hectares
Kcal	Kilo calories
kg	Kilogram
km	Kilometers
km2	Square kilometers
kton	Million Tons
lb	Pounds
M	Metallurgic
M$	Million Pesos
m3	Cubic Meters
MJ	Megajoules
MV	Volatile Material
MBTU	Million British Thermal Units
Mm3	Million Cubic Meters
Mt	Million Tons
MTOE	Million Tons of Oil Equivalent
MUS$	Million Dollars
PC	Calorific Value
St	Total Sulfur
T	Thermal
TEC	Tons Equivalent to Coal
TEP	Tons Equivalent to Petroleum
TJ	Terajoules
t	Tons
US$	Dollars

ACRONYMS

ASTMD	American Society for Testing and Materials
BP	British Petroleum
CARBOCOL	Carbones de Colombia S.A.
DANE	Departamento Administrativo Nacional de Estadística
DGM	Dirección General de Minas
DNP	Departamento Nacional de Planeación
ECOCARBÓN	Empresa Colombiana de Carbones
ECOPETROL	Empresa Colombiana de Petróleos
IEA	U.S. International Energy Agency
IFI	Instituto de Fomento Industrial

INGEOMINAS	Instituto Colombiano de Geología y Minería
MINERCOL	Empresa Nacional Minera Ltda.
MME	Ministerio de Minas y Energía
SAMINAS	Servicios y Asesorias Mineras Ltda.
UPME	Unidad de Planeación Minero Energética
USGS	Servicio Geológico de los Estados Unidos

CONVERSION FACTORS

1 Mega	10 6
1 kilo	10 3
1 t	1000 Kg
1 lb	453.59 g
1 lb	0.453514739 t
BTU/lb	0.55555 kcal/kg
kcal/kg	1.8 BTU/lb
MJ/kg	429,923 BTU/lb
BTU/lb	0.002336 MJ/kg

1. OVERVIEW

A mineral is a homogenous natural substance, of inorganic origin with a definite chemical composition, and in general, with a crystalline structure; therefore, we can exclude substances generated by the transformation of organic material in reducing environments such as coal, petroleum, and fossil resins. This origin associated with geological processes, has led various authors to classify materials with hydrocarbons as minerals; however, it turns out to be more adequate to refer to these as energetic materials and this is the sense that is used in this document.

Coal, which is a compound composed mainly of carbon, hydrogen, nitrogen, oxygen and sulfur, originates from physical and chemical transformations of great accumulations of plants deposited in marshy (swamps), lacustrine or deltaic environments.

One of the most widely accepted classifications for coal corresponds to the American Society for Testing and Materials (ASTMD-388-777), shown in Table 1, which is divided into four classes according to the properties referring to the composition of the plants, and the pressure and temperature conditions (the degree of metamorphism) that they were subjected to during their formation.

TABLE 1. Classification of coals

Type	Fixed Carbon (%)	Volatile Material (%)	Moisture Content (%)	Calorific Value (Btu/lb)	Calorific Value (MJ/Kg)	Calorific Value Kcal/Kg
Anthracite	86 - 98	1	< 15	>14,000	>32.6	>7,780
Bituminous	45 - 86	32	15 - 20	10,500-14,000	24.5 - 32.6	5,800-7,780
Subbituminous	35 - 45	50	20 - 30	7,800 - 10,500	18.2 - 24.5	4,300- 7,780
Lignite and Peat	25 - 35	96	> 30	4,000 - 7,800	9.3 – 18.2	2,200 – 4,300

Source:American Society for Testing and Materials (ASTMD-388-777)

Calculations (MJ/kg y kcal/kg) UPME 2005

DEFINITIONS 1. Classes and uses of coal

- ***Anthracite***: or hard coal, with a high carbon content (86% to 98%), a low volatile matter content and a calorific value of more than 32.6 MJ/Kg (14,000 BTU/lb). It is used as fuel in the generation of heat or steam in thermal and steel and iron industries. It is also used in the manufacture of synthetic rubber, dyes and purification of water for human consumption (filters).

- ***Bituminous Coal***: this type of coal has a lower carbon content and a lower calorific value than other anthracitic coals. Because of the way they are used, they are known as coking coals which are used in the process to obtain steel, and thermal coals used in the production of steam to generate electric power.

- ***Subbituminous coal***: with a lower calorific value than other bituminous coals, its carbon content is between 35% and 45%. It has a high content of volatile matter, and some have coking powers. It is used in the generation of electric power and industrial processes.

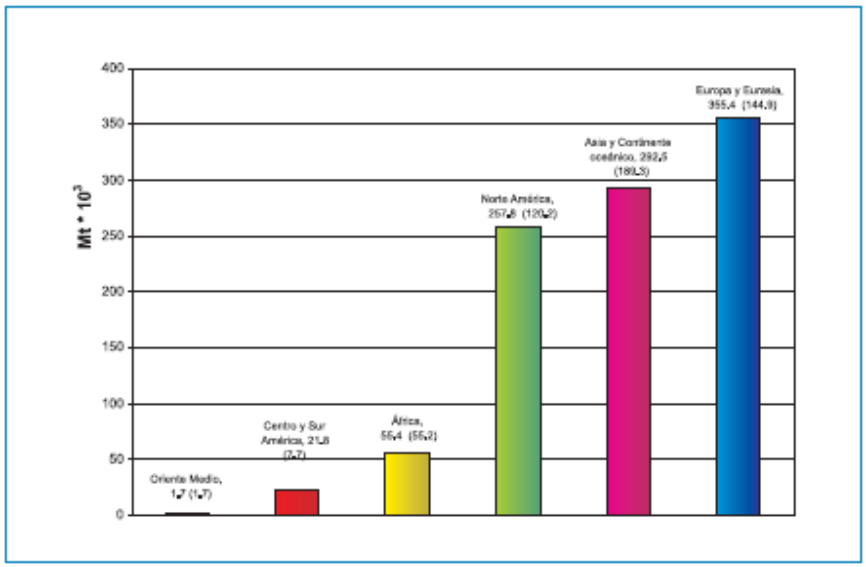
- ***Lignite and Peat*** : these are coals with high moisture and high ash and volatile material content; therefore, they have a low calorific value. They are used to generate heat (heating systems), electric power, for some industrial processes where it is required to generate steam, and more recently, briquettes have been made with lignite and peat to be burned in ovens.

Besides the generation of electric power, gassification and production of coke, coal is used in the production of benzol, oils, tar and, by means of liquefaction, as a petroleum substitute.

COAL IN THE WORLD

2.1 Global Coal Reserves

Coal is the most plentiful fuel in nature with 984,453 Mt in global reserves measured at the end of 2003, of which 52.7% are anthracitic and bituminous coals and 47.3% are subbituminous and lignites (World Energy Council, 2003). 96% of these reserves are concentrated in fifteen countries with the greatest reserves in North America and Asia, as shown in Graph 1.



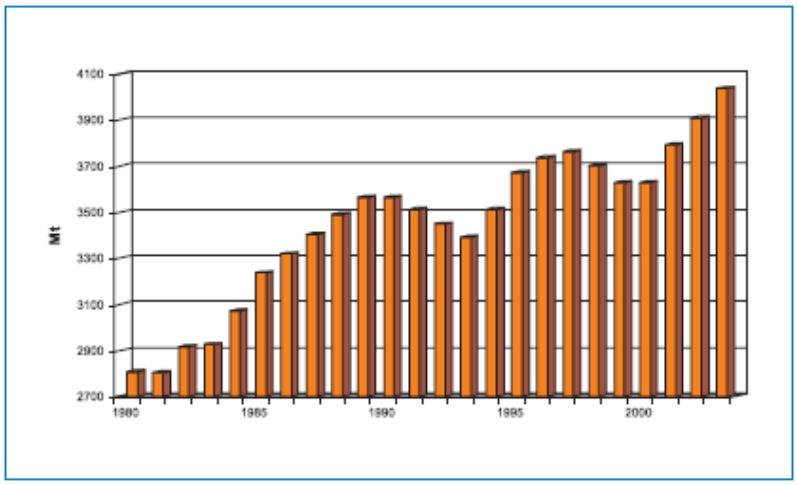
Source: British Petroleum, Statistical Review of World Energy, 2004.

Figure 1. Proven global coal reserves (Mt*103), anthracites and bituminous coals appear in parenthesis

According to the current levels of production and consumption, global coal reserves, which are larger than all fossil fuels, will be enough to meet the demand during the next 200 years.

2.2 Global Coal Production

As shown in Graph 2, in the last 24 years, the production of coal has had a dynamic growth represented by a variation of 43.8% surpassing 4,000 metric tons in the year 2003.

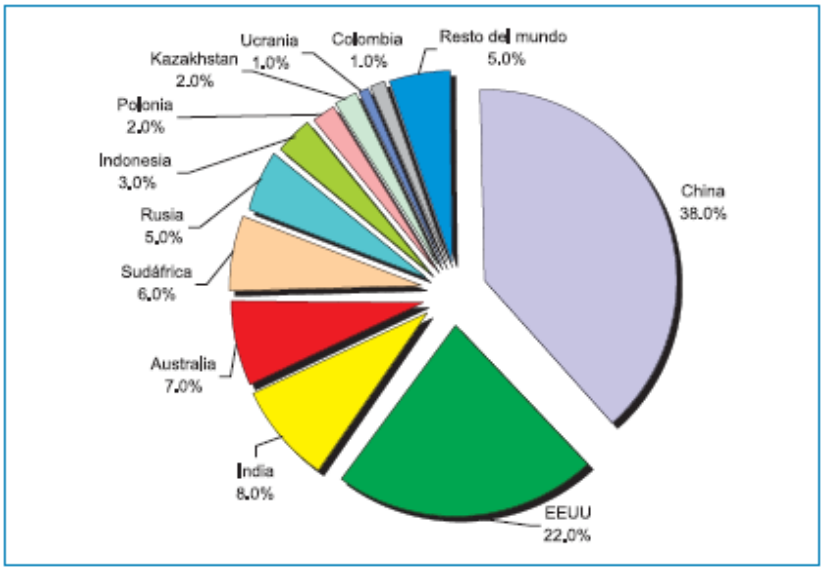


Source: U.S. International Energy Agency –IEA- (2004)

Figure 2. Global Coal Production (1980 – 2003).

The main coal producers are: China, the United States (USA), India, Australia, Russia and South Africa, which account for 82% of global production.

Graph 3 shows the percentages of production during 2003, where Asian countries and North American countries (the United States and Canada) play important roles; Colombia has a comparatively low percentage of production.



Source: IEA (2004)

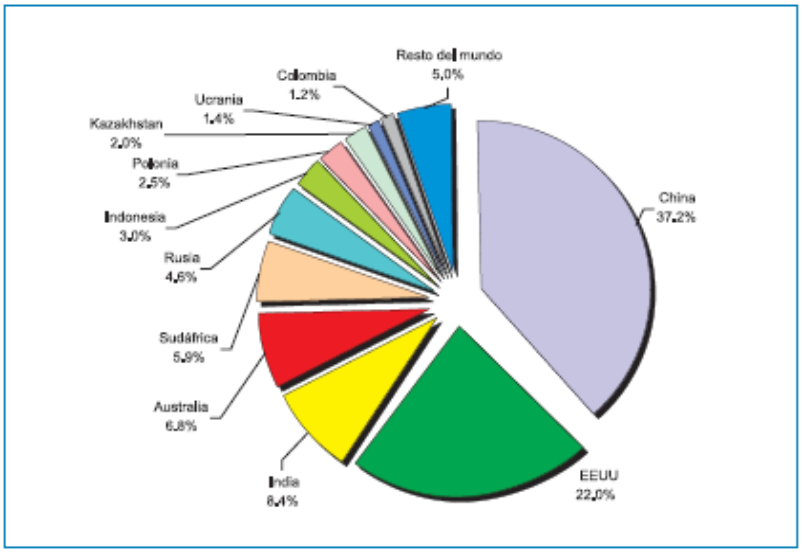
Figure 3. Global Coal Production by Country (2003)

2.2.1 Global Thermal Coal Production

In 2003, global thermal coal production reached 3,542Mt (IEA, 2004) with an annual growth of 1.96% during the analyzed period (1980 - 2003). Colombia was eleventh with 47Mt (see Graph 4).

The global offer of exportable thermal coal during 2003 was 531 Mt, which has grown at an average annual rate of 6.73% and is lead by Australia (18.81%), Indonesia (16.97%), China (15,03%) and South Africa (13,45%). Colombia ranks sixth with an exported volume of 46 Mt, which corresponds to 8.61% of the global total exported.

On the other hand, the annual growth rate of global thermal coal demand is 6.59%, which allowed going from 117 Mt in 1980 to 502 Mt in 2003, Asian countries (Japan, Korea, China Taipei) being the ones who have increased their demand by close to 35.66%. European countries have maintained their current level in the order of 106 Mt and account for 21.12% of global importations: North America (USA and Canada) import a little more than 38 Mt, which equals 7.57%.



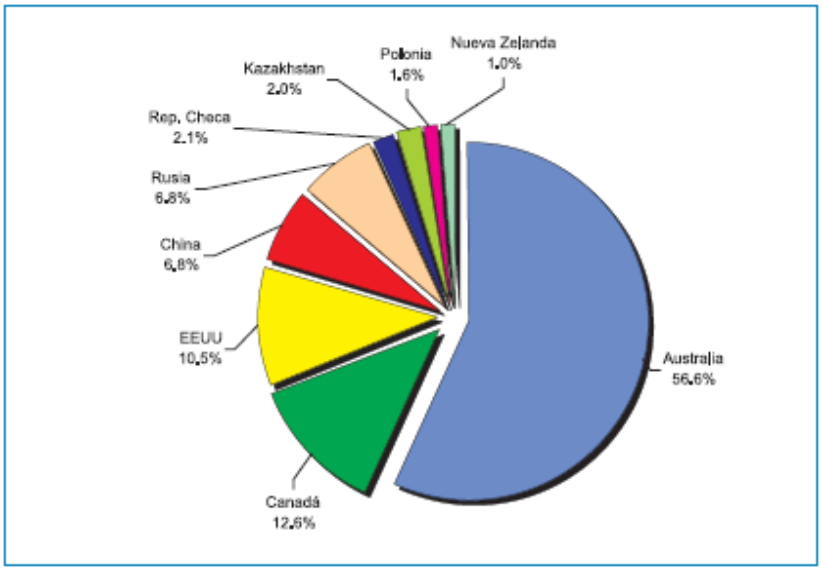
Source: IEA (2004)

Figure 4. Global Thermal Coal Production (2003)

2.2.2 Global Production of Coking Coal

Global Production of Coking Coal has maintained an average of 506 Mt, with a maximum of 543 Mt in 1995 and a minimum of 475 Mt in 1983 and 2001. 74% of this production has been concentrated basically in China, Australia, Russia and the United States.

Colombian production of coking coal reaches 1.3 Mt, which represents 0.26% of the world total, but it is projected to increase to over 1.9 Mt.



Source: IEA (2004)

Figure 5. Global production of coking coal (2003)

The exportable offer was 30 Mt. in 2002, with an average annual growth of 2.5% in the period analyzed. The greatest productions were between 2000 and 2002. This is also led by China (45.18%), followed by Poland, the countries of the old Soviet Union and Japan, which account for close to 38.87%.

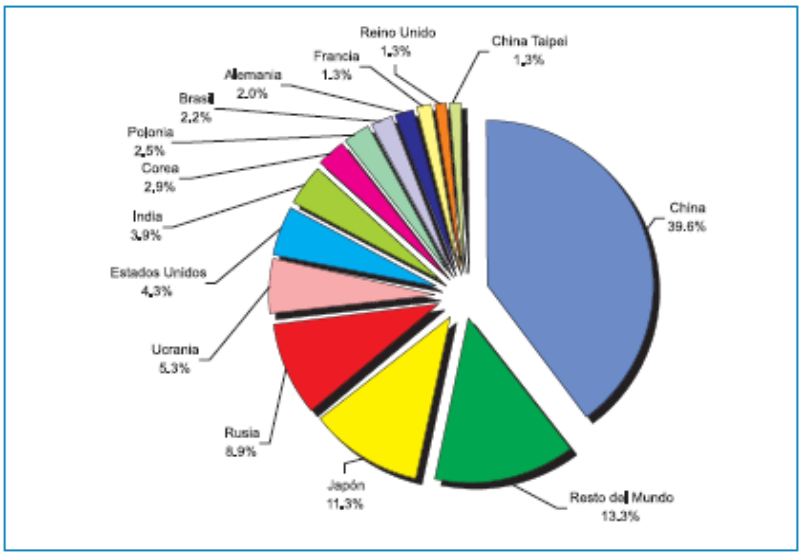
Global demand, which in 2002 was 26 Mt, is led by European countries with 43.89%. Germany is the world´s biggest importer with 27.48% of the total.

2.2.3 Global Production of Coke

Coke, a product or residue obtained from the distillation of several coals, is a porous and not very dense solid with a blackish gray color which burns without a flame and has a great calorific value. It mostly contains carbon (92%) and the rest ash (8%) and is used primarily as a reducing agent in the iron and steel industry.

Global production of coke was 354 Mt in the year 2002, with an average annual decrease of 0.28% between 1980 and 2002. China is the leader with 39.63% destined in great part to internal consumption and the surplus to exportation. Japan follows with 11.17%, the countries of the old Soviet Union with 14.15% in Europe with 7%.

The main producer of coke in America is the United States, which in 2002 produced close to 15 Mt, followed by Brazil with 7.7 Mt, with shares of 4.29% and 2.18% respectively.



Source: IEA (2004)

Figure 6. Global production of coke (2002)

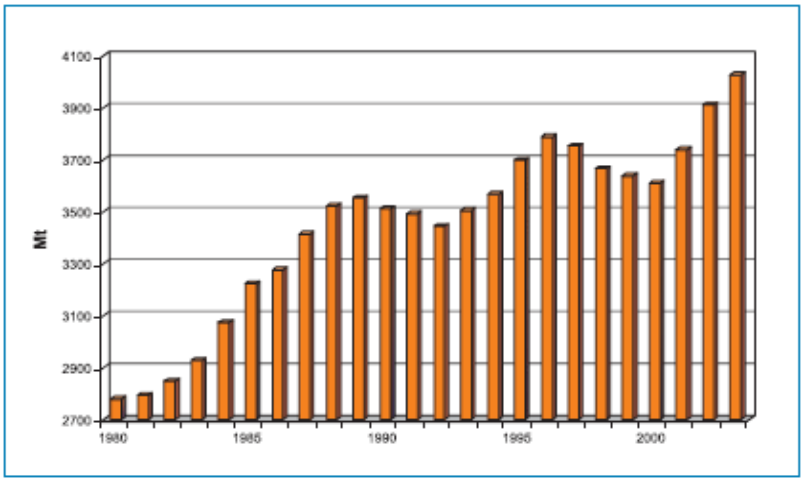
The exportable offer, with an average annual growth rate of 2.5% in the period analyzed, was 30 Mt in 2002. The greatest productions were between 2000 and 2002. This is also led by China (45.18%), followed by Poland, the countries of the old Soviet Union and Japan, which account for close to 38.87%.

Global demand, which in 2002 was 26 Mt, is led by the European countries with 43.89%: Germany is the world´s biggest importer with 27.48% of the total.

2.3 Global Coal Consumption

As it was mentioned, coal is the second primary source of energy due to its plentiful supply and the policies adopted by industrialized countries, which produce close to 80% of the energy required from these fossil fuels, especially after the petroleum crisis of the 60s.

The behavior of global coal consumption (Graph 7) shows similar characteristics to production; it has maintained an annual average of 3,449 Mt between 1980 and 2003, reaching a maximum in 2003 with 4,028 Mt (44.89% more than in 1980), of which 87% corresponds to thermal coal and the remaining 13% to coking coal.

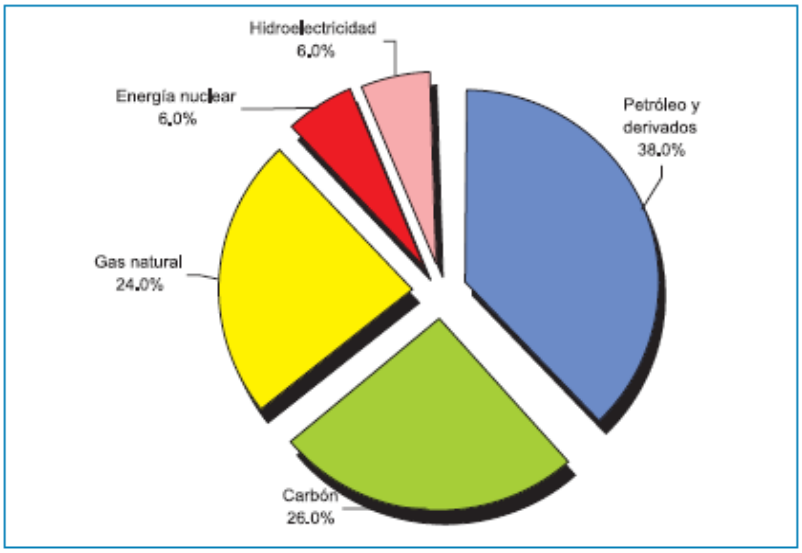


Source: IEA (2004)

Figure 7. Global consumption of coal (1980 – 2003)

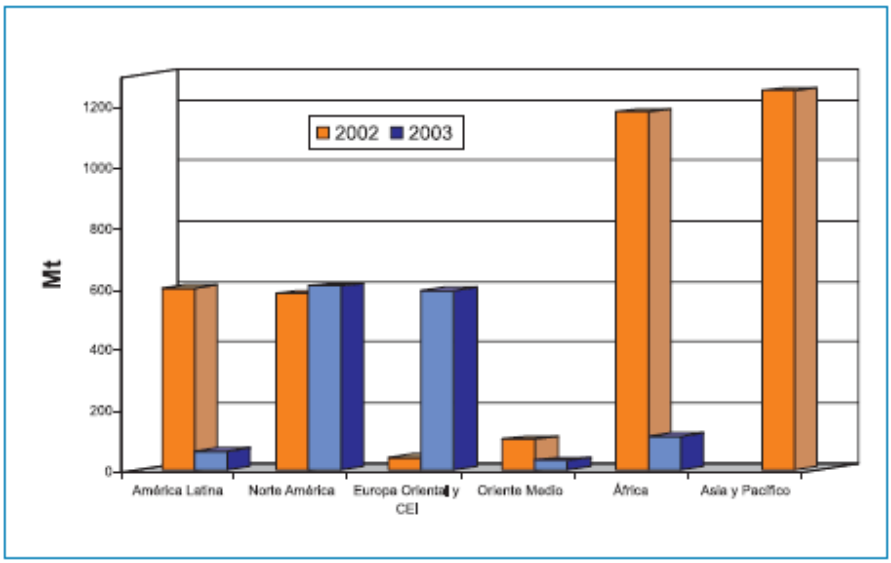
The greatest consumers of coal in 2003 were China (35%), the United States (21.75%), India (9.01%), South Africa (4.17%) and Japan (4.02%).

During 2003, global consumption of primary energy, taking into account oil, natural gas, coal, nuclear resources and hydroelectric power, was 9.741 billion tons of oil equivalent (BTOE). Graph 8 shows how the percentage of the demand of these sources of energy is led by petroleum and its by-products with 37.33%, followed by coal with 26.47% and by natural gas with 24%.



Source: British Petroleum (2004).; UPME (2004)

Figure 8. Global consumption of primary energy by type of fuel (2003)



Source: British Petroleum (2004); UPME (2004)

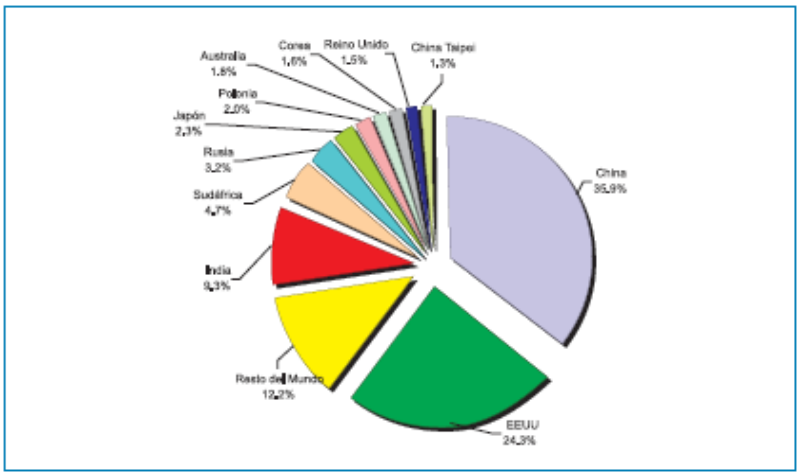
Figure 9. Regional consumption of coal for the generation of electric power

Between the years 2002 and 2003, an increase of 2.6% in the consumption of energy was recorded when it went from 9,494 MTOE to 9,741 MTOE; coal had the greatest increase with 6.89% (166 MTOE), while the growth in the consumption of oil, natural gas, nuclear energy and hydroelectric power was 2.08%, 2.02%, -6.55% and 0.40%, respectively.

As shown in Graph 9, in 2003, the greatest consumers of coal for the generation of electric power were Asia (50.7%), North America (23.8%), Eastern Europe and the Commonwealth of Independent States (CIS) (20,8%). Latin America´s share was 0.7%, of which 90.4% were concentrated in Brazil, Colombia and Chile.

2.3.1 Global Consumption of Thermal Coal

Consumption of thermal coal, which is mainly required in the generation of electric power, reached 3.512 Mt in 2003, with a growth of 56.37% compared to 1980. Asia accounted for 41.06% of the consumption followed by the United States (24.3%) and India (9.28%).



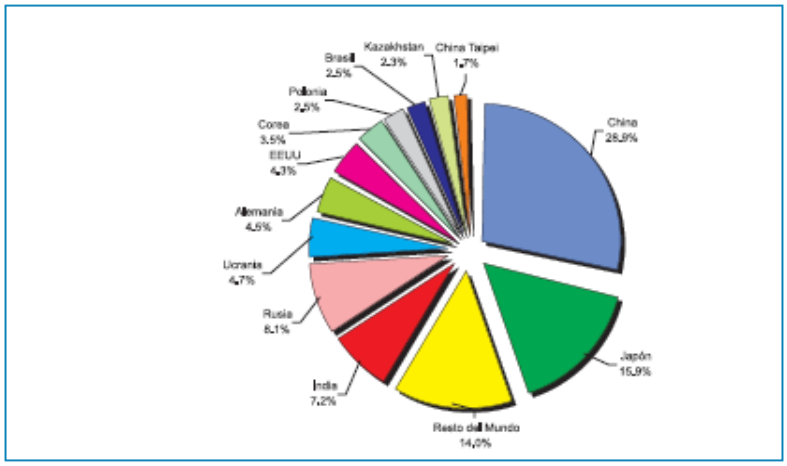
Source: IEA (2004)

Figure 10. Global Consumption of Thermal Coal (2003)

2.3.2 Global Consumption of Coking Coal

Between 1980 and 2003, the average consumption of this type of coal was 507 Mt, with a minimum of 466 Mt in 2001, even lower than the lows recorded during the 80s, and a maximum of 542 Mt in 1995.

In 2003, Asia consumed 258 Mt (50%) where China, the greatest consumer, consumed 92% of its own production and exported the remaining 8%. Russia, India, the Ukraine and Germany consumed 8.14%, 7.17%, 4.65% and 4.46% respectively.

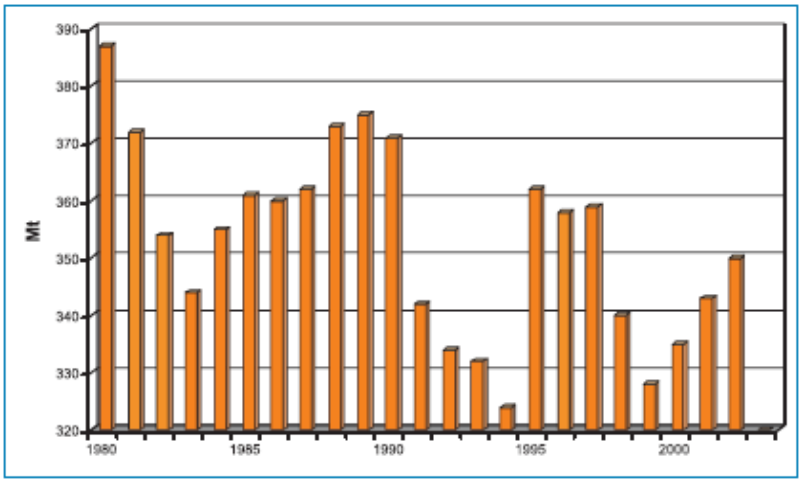


Source: IEA (2004)

Figure 11. Global consumption of coking coal (2003)

2.3.3 Global Consumption of Coke

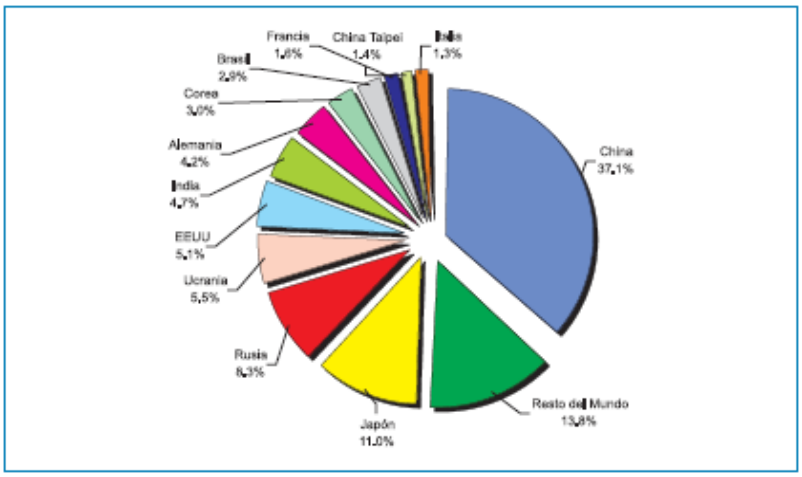
The average consumption of coke between 1980 and 2003 was 353 Mt, although it has been decreasing at an average annual rate of 0.38%, which led to a consumption of 37 Mt less than in 1980 (see Graph 12).



Source: IEA (2004)

Figure 12. Global consumption of coke between 1980 and 2003

The greatest consumers of coke in 2003 were China with 126 Mt (36.2%), followed by Japan, (10.7%), Russia (8.1%), and the Ukraine (5.3%). In the American continent, the most important countries were the United States and Brazil, with shares of 4.96% and 2.80% respectively.



Source: IEA (2004)

Figure 13. Coke Consumers (2002)

2.4 Other Aspects of the International Market

There are three large markets for coal: Asia, Europe and the United States. The first is supplied mainly by Australia, Indonesia, Canada, South Africa and China, while the second is supplied by South Africa, Colombia, Australia, the United States, Poland and Russia. Occasionally, the United States supplies its own demand given that it has the reserves and that it has important factors such a s quality and infrastructure.

Coal is transported on roads, railways or rivers from the mines to the port of shipping and from there it is shipped to close to 200 ports dedicated to this activity. The most important ones are known as ARA (Ámsterdam, Rótterdam and Antwerp) which are the main entrance of coal into Europe. Other ports of shipping for coal are in Glandstone, Queensland in Australia, Richards Bay in South Africa, Qinhuangdo in China and Puerto Bolívar in Colombia, among others.

Coal may be negotiated by means of long-term contracts for periods of up to five years, or short-term contracts, which appeared in the 90s and whose negotiation is usually flexible, given the price, which is controlled by variables such as the relation between supply and demand, type of coal, quality, quantity and transportation costs to the port of shipping.

3. THE COAL CHAIN IN COLOMBIA

This chapter describes the main activities that comprise the Colombian chain of coal. Different stages are linked, and they go from mining exploration to the final uses of coal. In addition to the general aspects, the most relevant departmental characteristics are taken into account.

In Colombia, The Coal Chain may be explained in the following stages:

- Exploration - reserves and qualities.
- Exploitation – development and set up, preparation and production.
- Benefit – classification and washing of coal.
- Transformation, in the production of coke and other processes
- Transportation from the mine to the beneficiation site and the bulk storage areas (stock yards).
- Transportation, marketing, distribution and uses.

3.1 Exploration – Reserves and Qualities of Coal

The Coal Chain starts with the exploration stage, which consists of searching for coal seams whose geological conditions, such a potentiality and quality will be assessed.

In general, mining exploration cycles are associated with the economic trend of the moment, such as high international prices which explains the increase of this activity during 2004.

3.1.1 Coal Reserves

As it was pointed out earlier, Colombia has coal reserves of excellent quality, which are enough to participate in the international market for a long time. Measured reserves are 7,063.6 Mt which are located mainly in the Atlantic Coast region, where 90% of thermal coal is located and which in turn accounts for 98% of the coal in the nation.

95% of the reserves are located in the departments of La Guajira, Cesar, Córdoba, Norte de Santander, Cundinamarca, Boyacá, Antioquia, Valle del Cauca and Cauca.

Figure 14. Scheme of the Chain

Source: UPME

3.1.2 Qualities of Colombian Coal

The quality of coal refers to the physical and chemical properties described below (Coal Processing Consultants Ltd. 1980), which ultimately determine the final use of the material.

Moisture: it is presented as total, inherent, or equilibrium moisture, water hydration or decomposition water. It is important in purchase and sale contracts, in industrial process evaluation and control and in the handling and pulverization of coal. Ash (Cz): noncombustible residue of organic and inorganic origin.

Volatile materials (Mv): its content determines the yields of coke and its products and it is the coal selection criteria for gassification and liquefaction.

Fixed carbon (CF): it is a measure of solid combustible material, and it allows classifying coals and defining the combustion and carbonization process.

Total sulfur (St): guideline in the definition of toxic gases from the gassification and liquefaction processes.

Calorific value (PC): it represents the combustion energy of coal, hydrogen, and sulfur. It is the most important guideline in the definition of thermal coal purchase and sale contracts and in the classification of coals by rank.

Table 2 presents the quality of Colombian coals discriminated by regions reported by Ingeominas (2004).

According to the characterization studies carried out in coal producing zones of the country (Ingeominas, 2004), in the Eastern mountain range the best bituminous coals for thermal and steel and iron industries can be found along with anthracitic coals not only for internal consumption, but also for exportation; in the Western mountain range, in Córdoba, northern Antioquia, Valle del Cauca and Cauca, there are bituminous and subbituminous coals; in the Central mountain range there are bituminous coals in the coal producing zones of Antioquia and Antiguo Caldas and, not so widely known, in Huila and Tolima.

3.1.3 Coal Mining by Regions

Atlantic Coast

This region, which comprises the departments of La Guajira, Cesar and Córdoba, has the greatest thermal coal reserves in the country, whose exportation is facilitated by the fact that it is on the coastal zone. The coals of this region are bituminous, high in volatile matter content and good quality from the point of view of its calorific value which is estimated at 27.02 MJ/Kg (11,600 BTU/lb).

Figure 15. Coal formations in Colombia

TABLE 2. Quality of Colombian Coal according to coal producing zone.

ZONE	AREA	SECTOR	BASE	MOISTURE		Cz	MV	CF	St	PC	PC	PC
					%	%	%	%	%	BTU/Lb	MJ/kg	kcal/kg
La Guajira	Cerrejón norte		ROM	Eq. + 1	11.94	6.94	35.92	45.2	0.43	11,586	27,00	6,440
	Cerrejón Central											
	Cerrejón Sur											
Cesar	La Loma	Sinclinal La Loma El	ROM	Eq. + 1	11.39	10.32	33.37	66.63	0.72	10,867	25.32	6,040
		Boquerón	ROM	Eq. + 11/2	10.29	5.61	36.79	47.31	0.59	11,616	27.07	6,450
		El Descanso Sur										
	La jagua de Ibirico	La Jagua	ROM	Eq. + 1 1/2	7.14	5.32	35.7	51.84	0.62	12,606	29.37	7,000
		Cerro Largo										
Córdoba-Norte de Antioquia	Alto San jorge	San Pedro Sur	BCA	HR	14.49	9.24	37.55	38.73	1.31	9,280	21.62	5,160
		San Pedro Norte	BCA	HR	14.49	9.24	37.55	38.73	1.31	9,280	21.62	5,160
		Alto San Jorge	BCA	HR	14.49	9.24	37.55	38.73	1.31	9,280	21.62	5,160
Antioquia - Antiguo Caldas	Venecia - Fredonia		ROM	Eq. + 1	11.64	8.11	40.06	40.2	0.48	10,426	24.29	5,790
	Amagá - Angelópolis	Amagá -Nechí	ROM	Eq. + 1	13.16	11.96	36.69	38.18	0.55	9,682	22.56	5,380
		Angelópolis										
	Venecia - Bolombo	Rincón Santo	BCA	HR	9.84	11.1	38.45	40.61	1.04	10,090	23.51	5,610
		Bolombo	BCA	HR	8.49	7.9	37.77	45.91	1.09	11,113	25.89	6,170
	Titiribí	Corcovado	ROM	Eq. + 1	7.25	7.92	37.99	46.84	0.72	11,767	27.42	6,540
		El Balsal										
	Río Sucio - Quinchía		BCA	HR	4.08	15.56	31.75	48.61	1.8	10,713	24.96	5,950
	Aranzazu - Santágueda	Aranzazu	BCA	HR	22.22	28.69	30.33	18.76	0.67	5,451	12.70	3,030
		Santágueda	BCA	HR	19.03	25.05	37.32	18.6	0.43	6,230	14.52	3,460
Valle del Cauca - Cauca	Yumbo - Asnazú	Golondrinas - Río Cañaveralejo	ROM	Eq. + 1	2.69	22.38	28.15	46.79	2.85	11,088	25.84	6,160
		Cañaveralejo-Río Pance										
		Río Pance-Río Guachinte										
		Río Guachinte-Río Asnazú										
	Río Dinde - Quebrada honda		ROM	Eq. + 1	2.83	20.63	36.72	40	4.02	11,138	25.95	6,190
	Mosquera - El Hoyo	Pedregosa-Mosquera	ROM	Eq. + 1	8.11	16.3	35.18	40.42	1.42	10,058	23.44	5,590
		Limoncito-Yeguas										
		El Vergel										
		Quilacé-El Hoyo										
Cundina-marca	Jerusalén - Guataquí		BCA	HR	5.19	5.34	39.09	50.38	0.58	13,044	30.39	7,250
	Guaduas - Caparrapí	Caparrapí	BCA	HR	4.12	5.61	22.43	67.83	0.59	12,829	29.89	7,130
		Guaduas										
	Guatavita-Sesquilé-Chocontá	Suesca-Chocontá	BCA	HR	1.98	11.23	34.88	51.91	0.91	12,682	29.55	7,050
		Guatavita										
	Tabio- Río Frío-Carmen de Carupa	Carmen de Carupa	ROM	Eq. + 2	3.42	12.67	20.8	63.1	1.53	13,041	30.39	7,250
		Tabio-Río Frío	ROM	Eq. + 2	4.12	9.76	18.01	68.11	0.93	13,390	31.20	7,440
	Checua - Lenguazaque	Cogua-Sutatausa-Guachetá	ROM	Eq. + 2	13.66	9.46	26.8	60.07	0.8	13,433	31.30	7,460
		Lenguazaque -Cucunubá-Nemocón	ROM	Eq. + 2	4.67	10.6	33.85	50.86	1.06	12,718	29.63	7,070
	Suesca - Albarracín		ROM	Eq. + 1	3.9	10.43	33.53	52.12	0.69	12,738	29.68	7,080
Cundina-marca	Zipaquirá - Neusa	Zipaquirá-Embalse del Neusa	BCA	HR	1.04	14.42	24.33	60.21	1.38	12,993	30.27	7,220
		Embalse del Neusa-Vereda Lagunitas										
	Páramo de la Bolsa-Machetá		BCA	HR	4.42	14.21	35.7	45.67	1.04	11,309	26.35	6,280

Source: Ingeominas (2004)

Calculations (MJ/kg y kcal/kg) UPME 2005

. . . Continued

ZONE	AREA	SECTOR		BASE	MOISTURE		Cz	MV	CF	St	PC	PC	PC
						%	%	%	%	%	BTU/Lb	MJ/kg	kcal/kg
Boyacá	Checua - Lenguazaque			ROM	Eq. + 2	3.56	10	25.19	61.25	0.8	13,439	31.31	7,470
	Suesca - Albarracín			ROM	Eq. + 2	4.69	12.18	33.71	49.42	1.07	12,420	28.94	6,900
	Tunja-Paipa-Duitama			ROM	Eq. + 2	9.48	11.4	38.03	41.09	1.53	11,268	26.25	6,260
	Sogamoso-Jericó			ROM	Eq. + 2	4.29	9.57	30.19	55.96	1.23	13,099	30.52	7,280
	Betania			BCA	HR	1.47	8.36	30.94	59.25	1	13,859	32.29	7,700
	Úmbita-Laguna de Tota			ROM	Eq. + 2	5.75	13.1	38.34	42.8	1.21	11,699	27.26	6,500
Santander	San Luis	Flanco Occidental	Térmicos	ROM	Eq. + 1	2.7	25.95	28.11	43.23	1.76	10,913	25.43	6,060
			Coquizables	BCA	HR	1.63	7.65	33.38	57.33	1.37	13,994	32.61	7,770
		Flanco Oriental	Térmicos	BCA	HR	1.18	18.72	30.48	49.62	2.01	12,284	28.62	6,820
			Coquizables	BCA	HR	1.18	10.09	29.05	59.67	2.15	13,893	32.37	7,720
	Cimitarra Sur			BCA	HR	4.61	4.61	29.77	61.01	0.62	13,021	30.34	7,230
	Capitanejo-SanMiguel			BCA	HR	6.33	7.51	19	67.16	0.93	11,782	27.45	6,550
	Miranda			BCA	HR	1.81	14.47	15.13	68.59	3.46	12,803	29.83	7,110
	Molagavita			BCA	HR	0.8	8.58	32.25	58.37	0.7	14,161	33.00	7,870
	Páramo del Almorzadero			BCA	HR	5.18	4.71	14.23	75.88	0.75	12,889	30.03	7,160
Norte de Santander	Chitagá			ROM	Eq. + 1	3.29	12.59	12.9	71.22	1.44	12,804	29.83	7,110
	Pamplona-Pamplonita	Pamplonita		ROM	Eq. + 1	2.96	9.97	36.15	50.92	1.34	13,199	30.75	7,330
		Pamplona											
	Herrán-Toledo	Toledo		ROM	Eq. + 1	2.31	7.46	26.99	63.24	0.83	14,120	32.90	7,840
		Herrán											
	Salazar	Norte		ROM	Eq. + 1	3.76	9.46	36.81	49.96	0.62	12,762	29.74	7,090
		Centro											
		Sur											
	Tasajero	Este	Los Cuervos	ROM	Eq. + 1	2.84	10.17	34.82	52.18	0.85	13,326	31.05	7,400
		Oeste	Los Cuervos	ROM	Eq. + 1	2.56	7.65	33.67	56.12	0.85	13,925	32.45	7,740
		Sur	Carbonera	ROM	Eq. + 1	2.42	17.1	34.59	45.89	0.89	12,291	28.64	6,830
	Zulia-Chinácota	Zulia Sur	Los Cuervos	ROM	Eq. + 1	3.36	11.9	35.29	49.45	1.27	12,967	30.21	7,200
		Santiago	Los Cuervos	ROM	Eq. + 1	2.71	5.95	30.55	60.8	0.71	14,153	32.98	7,860
			Carbonera	ROM	Eq. + 1	8.33	17.06	28.67	47.73	0.62	9,911	23.09	5,510
		San Cayetano	Los Cuervos	ROM	Eq. + 1	2.02	12.12	26.66	59.2	1.43	13,324	31.04	7,400
			Carbonera	ROM	Eq. + 1	2.17	18.05	36.61	43.13	0.78	11,410	26.59	6,340
		SanPedro	Los Cuervos	ROM	Eq. + 1	2.53	11.3	35.63	50.54	0.81	13,290	30.97	7,380
			Carbonera	ROM	Eq. + 1	2.69	14.88	38.49	43.94	0.83	12,436	28.98	6,910
		Villa del Rosario	Los Cuervos	ROM	Eq. + 1	2.74	7.5	36.7	53.06	0.7	13,588	31.66	7,550
	Catatumbo	Zulia Norte-Sardinata		ROM	Eq. + 1	3.67	9.18	37.57	49.59	0.95	12,602	29.36	7,000
		El Carmen		BCA	HR	4.31	8.64	39.17	47.88	0.95	12,316	28.70	6,840
Amazonas	Leticia			BCA	HR	10.39	30.89	36.09	22.63	3.67	6,664	15.53	3,700

Source: Ingeominas (2004)

Cálculos (MJ/kg y kcal/kg) UPME 2005

On average, with low moisture, ash and sulfur contents which make them competitive on the international market to be used in industries and to generate heat, steam and electric power.

Mining in this zone is fairly technified, and the mines in most cases are surface mines; although in the department of Cesar there are some underground mines.

a) Department of La Guajira

The coalfield called El Cerrejón is in the central – southern sector in the Cesar and Ranchería river basins of this department, which is located in the northernmost part of Colombia. For exploitation purposes it has been divided into three sectors:

North Cerrejón: a coalfield which comprises an area of 380 km2 (38,000 ha) and measured reserves of 3,000 Mt; the infrastructure of this sector has a railway of 194 km between the mine and Puerto Bolívar, an exportation port which has two docks to harbor ships with payloads from 35,000 t and 150,000 t.

Central Cerrejón: this sector comprises an area of 100 km2 (10,000 ha) and its measured reserves are 670 Mt.

South Cerrejón: this sector corresponds to a continuation of El Cerrejón formation; it has been determined that this sector has coal reserves of 263 Mt.

TABLE 3. Resources plus coal reserves in La Guajira (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
La Guajira	**North Cerrejón**	3,000.00				3,000.00	T
	Central Cerrejón	670.00				670.00	T
	South Cerrejón	263.30	448.86	127.50	27.16	866.82	T
	Totals	3,933.30	448.86	127.50	27.16	4,536.82	T

Source: Ingeominas (2004)

b) Department of Cesar

The coal mining area of this region is located in the central part of the department, about 100 Km away from the city of Valledupar, with measured reserves of 2,035.40 Mt, which are distributed in two zones: La Loma, with measured reserves of 1,777.1 Mt, and which is subdivided as follows:

a) La Loma - Boquerón - El Descanso: in the municipalities of Chiriguaná, El Paso y La Jagua de Ibirico, it is being exploited and it is estimated that the exploitable reserves are 687.5 Mt. The infrastructure has railway transportation, and a port of embarkation in Ciénaga (Magdalena).

b) La Loma-Calenturitas: located 15 km northeast of the municipality of La Loma, measured reserves of 102 Mt have been determined. The infrastructure of the region has railway transportation, and a port of embarkation in Santa Marta.

c) El Hatillo: it comprises La Siminera which is located to the north of La Loma mountain range with measured reserves of 150 Mt and El Hatillo with measured reserves of 57 Mt.

And la Jagua de Ibirico where the measured reserves are as much as 258.3 Mt and it is estimated that of these reserves 197 Mt are exploitable.

TABLE 4. Resources plus coal reserves in the department of Cesar (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
Cesar	La Loma	1,777.10	1,563.98	1,963.18	993.50	6,297.76	T
	La Jagua de Ibirico	258.30				258.30	T
	Totals	2,035.40	1,563.98	1,963.18	993.50	6,556.06	T

Source: Ingeominas (2004)

c) Department of Córdoba

The coal reserve area of Córdoba corresponds to the San Jorge zone which is located between the municipalities of Ciénaga de Oro and Cerrito. There are three outstanding coal blocks with measured reserves of 381 Mt: Las Palmeras, la Escondía and la Guacamaya.

TABLE 5. Resources plus coal reserves in the department of Córdoba (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
Córdoba - Norte de Antioquia	Alto San Jorge	381.00	341.00			722.00	T
	Totals	381.00	341.00			722.00	T

Source: Ingeominas (2004)

[1] In this type the reserves the information points are between 500 and 1500 m away from each other; this is equal to an area between 250 m and 750 m counted from the information point.
[2] To determine this to the reserves, the information points are 500 m away from each other; this is equal to an area of influence of up to 250 m counted from the information point.

Inland Colombia

Inland measured coal reserves account for 713.8 Mt and they occur mainly in seven departments: Antioquia, Valle del Cauca, Cauca, Boyacá, Cundinamarca, Santander and Norte de Santander.

The coals that occur in Norte de Santander are bituminous and anthracitic, and they are known for having a high volatile matter content, being commonly binding, and of good quality for thermal use and iron and steel industries. The zones of Cundinamarca and Boyacá have a smaller amount of bituminous and anthracitic coals. The former ones have varied percentages of volatile content and are of excellent quality for thermal use and iron and steel industries.

The type of mining that is developed in this region is low technology subsistence mining. The following are the main mining areas in this zone.

a) Department of Antioquia

The coal reserve areas of this department are located in the municipalities of Amagá, Ángelopolis; Venecia, Fredonia and Titiribí; the coal in this zone is of the thermal type.

The area of Amagá - Ángelopolis, is located in the southwest of the department. It has measured reserves of 11.84 Mt, while the area of Venecia - Bolombolo which is located in the same region, has measured reserves of 57.95 Mt and the area of Titiribí has 11.33 Mt. Most of the mining activity in Antioquia is subsistence mining.

TABLE 6. Resources plus basic coal reserves in Antioquia (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
Antioquia-Antiguo Caldas	Venecia-Fredonia	8.94	40.14	16.87		65.95	T
	Amagá-Angelópolis	11.84	63.64	92.33	25.38	193.19	T
	Venecia-Bolombolo	57.95	84.80	18.75		161.50	T
	Titiribí	11.33	37.25	4.45	1.07	54.10	T
	Totals	90.06	225.83	132.40	26.45	474.74	

Source: Ingeominas (2004)

b) Department of Boyacá

The coal reserve areas of Boyacá go from the municipality of Jericó, to the north, to the border with the department of Cundinamarca; the main mining area is located between the municipalities of Sogamoso and Jericó which has bituminous type coals and measured reserves of 102.84 Mt, other important areas are: Tunja - Paipa - Duitama with 24.03 Mt, Suesca - Albarracín with 7.81 Mt and Chequa - Lenguazaque with 35.69 Mt, shared with Cundinamarca. Mining in this region is low technology subsistence mining.

TABLE 7. Resources plus basic coal reserves in Boyacá (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
Boyacá	Checua-Lenguazaque	35.69	129.87	115.84		281.40	M,T
	Suesca-Albarracín	7.81	43.29	106.26		157.36	T
	Tunja-Paipa-Duitama	24.03	97.21	171.41		292.65	T,M
	Sogamoso-Jericó	102.84	412.25	473.71		988.80	M,T
	Totals	170.37	682.62	867.22		1,720.21	

Source: Ingeominas (2004)

c) Department of Cundinamarca

This area is located in the center of the country. The coal formation in the region goes from municipality of Zipaquirá to the border with the department of Boyacá. The coal is of the bituminous type and it has the following mining zones: Chequa - Lenguazaque, San Francisco - Subachoque - La Pradera con 11.35 Mt, Tabio - Río Frío – Carmen de Carupa with 19.43 Mt, Zipaquirá - Neusa with 1.64 Mt, Guatavita - Sesquilé - Chocontá with 21.90 Mt, Suesca - Albarracín with 32.92 Mt and Chequa - Lenguazaque with 140.42 Mt, in total it is calculated that there are measured reserves of 236.23 Mt. the kind of exploitation is associated with low technology subsistence mining.

TABLE 8. Resources plus basic coal reserves in Cundinamarca (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
Cundinamarca	Jerusalén-Guataquí	1.81	5.73	5.28	3.23	16.05	T
	Guaduas-Caparrapí	6.76	32.68	21.36	0.91	61.71	M
	San Francisco-Subachoque-La Pradera	11.35	48.20	60.89	6.46	126.90	M,T
	Guatavita-Sesquilé-Chocontá	21.90	64.31	106.88	10.14	203.23	M,T
	Tabio-Río Frío-Carmen de Carupa	19.43	55.82	54.84	24.78	154.87	M,T
	Checua-Lenguazaque	140.42	345.44	210.66	16.25	712.77	M,T
	Suesca-Albarracín	32.92	87.71	68.90		189.53	T
	Zipaquirá-Neusa	1.64	4.96	10.41		17.01	M,T,E
	Totales	**236.23**	**644.85**	**539.22**	**61.77**	**1,482.07**	

Source: Ingeominas (2004)

d) Department of Norte de Santander

The department of Norte de Santander is located next to the border with Venezuela and its main mining zones are in Catatumbo and Tasajero, other coal mining zones with a lower potential are Zulia -Chinácota, Pamplona - La Don Juana, Salazar and Toledo. It has measured reserves of 119.69 Mt and it is known for its low technology mining. In addition, due to its geographical location, most of the production is exported through the port of Maracaibo, in Venezuela.

TABLE 9. Resources plus basic coal reserves in Norte de Santander (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
Norte de Santander	Chitagá	0.66	1.98	7.40		10.04	A, M
	Mutiscua-Cácota	1.56	0.66	0.16		2.38	T, M
	Pamplona-Pamplonita	2.79	6.25	4.83		13.87	T, M
	Herrán-Toledo	4.78	14.63	9.17		28.58	T, M
	Salazar	7.71	15.50	5.80		29.01	T, M
	Tasajero	14.18	29.51	50.23		93.92	T, M
	Zulia-Chinácota	40.05	124.15	103.20		267.40	M

	Catatumbo	47.96	121.66	179.98		349.59	T
	Totals	**119.69**	**314.34**	**360.77**		**794.79**	

Source: Ingeominas (2004)

f) Departments of Valle del Cauca and Cauca

The coal mining region of Valle del Cauca, is known for coals with a high ash and sulfur content. They go from the municipality of Yumbo to the Timba river on the border with the department of Cauca. The main mining area is located in Yumbo - Asnazú with estimated measured reserves of 30.70 Mt.

The extension of the Valle del Cauca coal field which is located in Cauca has two important areas: the first is Suárez - El Tambo and the other is Tambo - Patía, also known as “El Hoyo de Mosquera” which is still under exploration. This zone has measured reserves of 6.38 Mt.

It is estimated that these two departments have measured reserves of 41.45 Mt.

TABLE 11. Resources plus basic coal reserves in Valle del Cauca and Cauca (Mt)

Zone	Area	Resources plus basic reserves			Resources	Potential	Type
		Measured[1]	Indicated[2]	Inferred[3]	Hypothetical[4]		
Antioquia Antiguo Caldas	Yumbo-Asnazú	30.70	56.42	47.49	10.98	145.59	T,M
	Río Dinde-Quebrada Honda	4.37	16.66	19.69		40.72	T
	Mosquera-El Hoyo	6.38	19.06	30.72		56.16	T
	Totales	**41.45**	**92.14**	**97.90**	**10.98**	**242.47**	

Source: Ingeominas (2004)

3.2 Exploitation and production

After the exploration stage with feasible economical results, the exploitation stage begins. This stage is divided into: development – set up (access roads, infrastructure projects, mine services), preparation (marking the boundaries of the areas within the reservoir, banks, levels, sublevels, drums, among others) and it finishes with the go-live, extraction or mine production, by means of different exploitation methods and systems, according to the conditions of the coal seam.

Figure 16. Types of exploitation

Source: UPME

a) Surface mining

Source: Saminas

b) Underground mining

On the Atlantic Coast high technology and large scale surface mining is predominant while low technology subsistence underground mining prevails inland. The following are the most relevant characteristics of each type of mining:

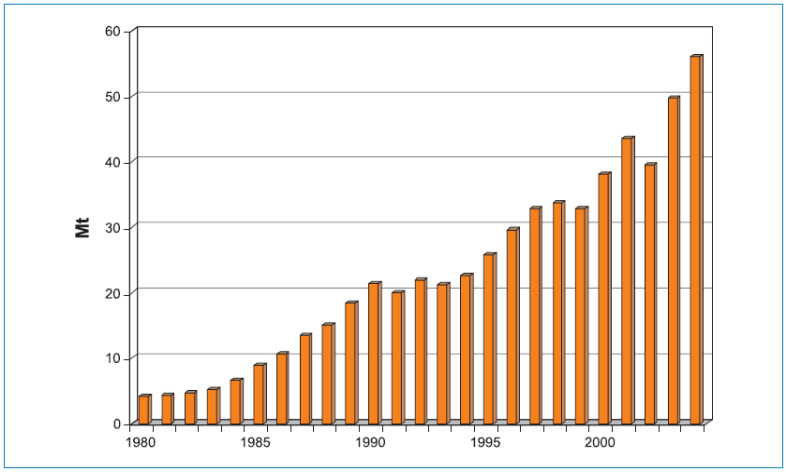
- High technology or large-scale mining: it has high levels of investment, which guarantees an adequate technological infrastructure to develop the exploration, exploitation, transportation and loading work efficiently, in addition to control and monitoring activities. The projects of el Cerrejón and el Cesar are examples of this type of mining.

- Medium technology mining: although there is technology and knowledge of exploration and exploitation of the material and there is a certain degree of environmental control, the investments are smaller than in high technology mining.

- Small-scale subsistence mining: extraction activity developed manually, where the coal is removed manually and without technology. In general, it is associated with pollution, deterioration, erosion and destabilization of the terrain due to the absence of mining exploitation designs.

Production

As it is shown on Graph 17, coal production in the last 25 years has had a constant growth, especially after the year 2000. Until the 80s, when the Cerrejón Zona Norte exportations started, the greatest percentage of national production came from inland Colombia. Now the projects of the Atlantic coast account for 90% of the total and inland production has tended to decline since 1980, especially between 1992 and 1999. In 2003 there was an increase in production of 26% compared to 2002 and it reached 49.6 Mt.



Sources: UPME (2004), Ministry of Mines and Energy (2004)

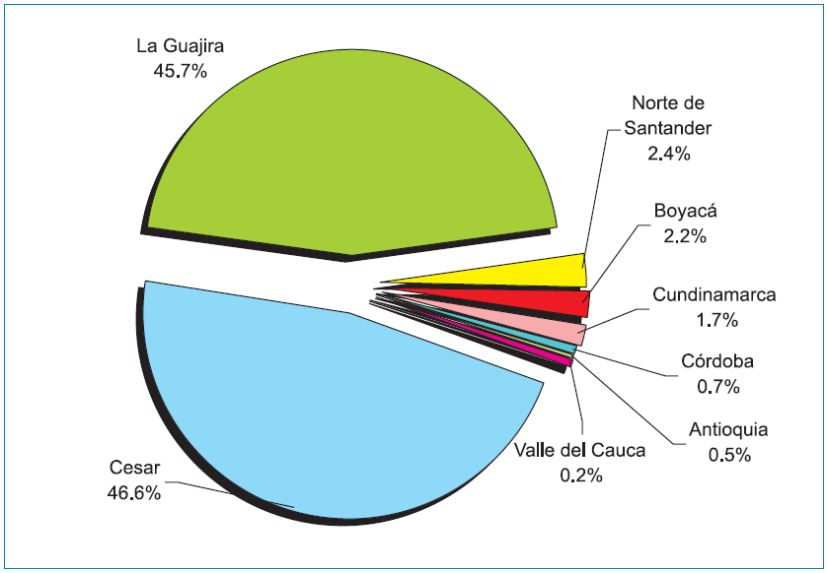
Figure 17. Colombian production of coal between 1980 and 2004

According to the levels of coal production recorded during 2004, the departments that accounted for the greatest part were La Guajira (45.72%) and Cesar (46.61%), while the remaining 7.67% was distributed among the departments of Norte de Santander, Boyacá, Cundinamarca, Córdoba, Antioquia and Valle del Cauca.

In 2004, the greatest production in history was reached with 53.6 Mt, of which 50.2 Mt correspond to thermal coal and the rest to metallurgic coal and anthracites. This volume was the result of the evolution of the exportation projects located on the Atlantic Coast and of the evolution of global prices.

92.3% of the total volume produced was contributed by the great projects, Cerrejón Norte (La Guajira) and La Loma (César), which have the participation of important international operators. These are projects which have a great exportation potential due to their location and the properties of their coal which is in high demand on the global market.

On the other hand, the coal that was produced inland contributed close to 3.8 Mt which represents 7.02% of the national total and it is mostly destined to supply the internal market.



Source: Ingeominas (2004)

Figure 18. Colombian production of coal (2004)

Metallurgic coal is produced mainly in the Cundiboyacense region and in the department of Norte de Santander which account for 68% and 31% respectively.

During 2004, 3.4 Mt were produced, of which close to 70% was consumed internally in the production of coke and the remaining 30% was exported.

Based on the information about consumption and exportation, it is estimated that the production of anthracite in 2004 was 0.1 Mt, coming from the municipalities of Zipaquirá (Cundinamarca) and Socotá (Boyacá), of which 30% was exported.

3.3 Benefits

It is the set of necessary activities and operations for the improvement of the physical conditions of coal that make it suitable for certain uses and for more convenient transportation. In general it includes the following stages:

- Separation: division of coals of different qualities which are arranged in adjacent strata or veins; this is generally done inside the mine.

- Manual selection or classification: manual removal of rocks which are adjacent or interpolated between the strata or impurities which may come with the coal when it is extracted from the mine.

- Crushing and breaking: reduction of the size of the fragments of extracted coal as part of a classification by size which is also useful for its transportation or to fulfill the requirements of the market. Jaw and hammer crushers are used in this process. They use mechanical systems such as: compression, rolling, impact, friction and attrition.

- Screening or classification by size: classification of the material by means of screens which separate the material according to its size.

- Washing: reduction of the ash content and removal of impurities to minimize negative environmental impact associated with coal combustion. This process may involve wetting the coal to separate it according to the size and shape, or with dry coal separating it according to differences in density and friction.

- Drying: reduction of moisture by means of mechanical heating of the coal.

- Coal mixing: blending and homogenizing coals with different properties for the mixture to meet the market requirements.

Source: UPME

Figure 19. Benefits - classification

3.4 Transformation

Set of physicochemical or metallurgic operations used to obtain a commercial product which is not identifiable with the material in its natural state, such as distilling of coal to produce coke, gas, ammonia and tar, among others.

Source: Ciro Serrano

Figure 20. Transformation - Coking

3.5 Internal transportation

Source: UPME

Figure 21. Coal transportation and unloading

Coal is generally transported from the mine on 10t-dump trucks, 20t-tandem axle trucks and 40t-semis, otherwise by barges, conveyor belts, cable cars and railroads. It is taken to the bulk storage areas, the beneficiation plants, internal consumers and to ports of embarkation prior to its exportation.

The main Colombian exportation ports are shown in the following table:

TABLE 12. Ports and terminals for the exportation of Colombian coal

Port - Terminals	Location	
Puerto Bolívar	Bahía Portete - La Guajira	Atlantic Coast
Prodeco	Puerto Zúñiga - Magdalena	
Drummond Terminal	Cienaga - Magdalena	
Carbosan Terminal	Santa Marta - Magdalena	
Colclinker Terminal	Bahía de Cartagena - Bolívar	
Cementos de Caribe Terminal	Barranquilla - Atlántico	
Port of Buenaventura (Sociedad Portuaria Regional)	Buenaventura - Valle del Cauca	Pacific Coast
Port of Buenaventura - Muelle 13 (Sociedad Grupo Portuario)	Buenaventura - Valle del Cauca	

Puerto Santander	Puerto de Santander - Norte de Santander	Venezuela
Puerto seco de Cúcuta	Cúcuta - Norte de Santander	

Source: UPME (2004)

Some of the coal produced inland is exported through the port of Buenaventura; the coal from Norte de Santander is exported through Puerto Santander and Barranquilla.

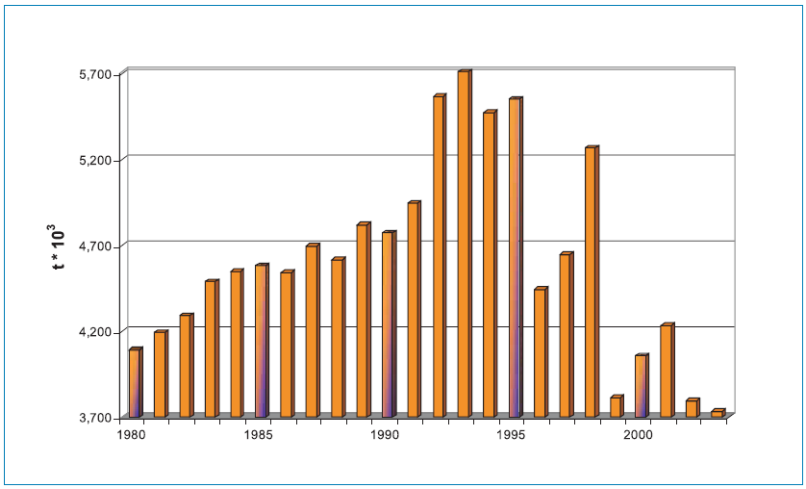
TABLE 13. Transportation costs of Colombian coal (US$/t)

Section	Mode	Road	Railroad	Fluvial	Transshipment	Total
La Loma - Santa Marta	Road	6.23		0.0	0.0	6.23
La Jagua - Santa Marta	Road	7.56		0.0	0.0	7.56
La Jagua - La Loma	Road	3.36		0.0	0.0	3.36
La Jagua - Barranquilla	Road	8.08		0.0	0.0	8.08
La Jagua- Tamalameque - Barranquilla	Road		1.95	4.55	2.08	8.58
La Jagua - Tamalameque - Barranquilla	Road	5.67		4.55	2.08	12.31
La Jagua - Tamalameque (El Burro - Tamalameque Paved)	Road	5.67				5.67
Cerrejón - Ebanal - Santa Marta (unpaved)	Road	5.73		0.0	0.0	5.73
Cerrejón - Ebanal - Santa Marta (paved)	Road	5.72		0.0	0.0	5.72
Lenguazaque - Santa Marta	Road		29.70			29.70
Lenguazaque - Puerto Salgar - Barranquilla	Road	29.95		0.0	0.0	29.95
Lenguazaque - Landazuri - Barranquilla	Road	23.82		0.0	0.0	23.82
Lenguazaque - Bucaramanga - Barranquilla	Road	24.36		0.0	0.0	24.36
Lenguazaque - P. Salgar - Barranquilla	Road-Fluvial	8.93		16.61	2.08	27.62
Lenguazaque - Bogotá - Buenaventura	Road	17.78		0.0	0.0	17.78
Troncal del Carbón Unpaved	Road	4.06				4.06
Cúcuta - La Fría - La Ceiba	Road	10.01		0.0	0.0	10.01
Cúcuta - La Fría - Maracaibo	Road	10.96		0.0	0.0	10.96
Cúcuta - P. Santander	Road	5.67		0.0	0.0	5.67
Cúcuta - Barranquilla	Road	18.68		0.0	0.0	18.68
Cúcuta - Gamarra - Barranquilla	Road-Fluvial	8.55		5.47	2.08	16.10

Source: UPME (2004)

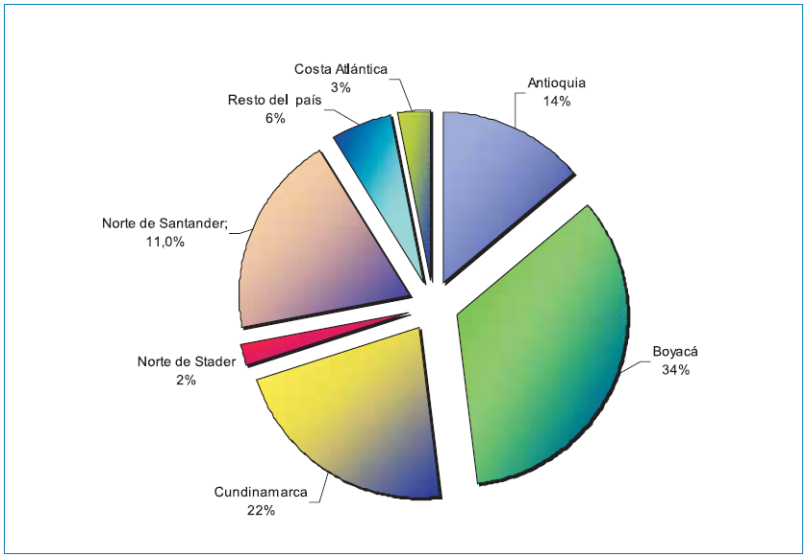
3.6 Loading, Transportation, Marketing, Distribution and Uses

The coal produced inland supplies the domestic market and it is destined for the generation of electric power and as a primary and secondary source of energy in industrial projects. This internal consumption increased by 39.59% between 1980 and 1993, when it reached its historical peak and started a decrease that reached 32.08% between 1993 and 2004, as shown in Graph 21.
On the other hand, the departmental share of the national consumption of coal for 2003 (Graph 22), shows Boyacá as the biggest consumer (34%), followed by Cundinamarca (22%), Valle del Cauca (19%), and Antioquia (14%).



Source: Ministry of Mines and Energy, (1980 - 1997), UPME (1997- 2004).

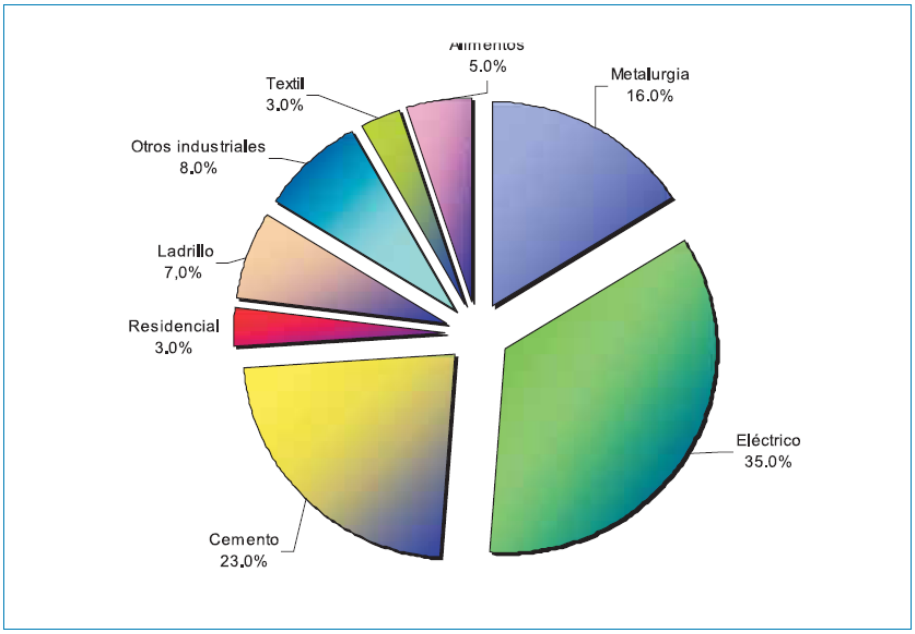
Figure 22. Colombian consumption of coal between 1980 and 2003.



Source: UPME (2004)

Figure 23. Departmental consumption of coal (2003)

The dynamics of consumption per economic activity has been stable. Thermal coal has the biggest share with 88% of the domestic total, especially in the electric and cement sub-sectors, followed by the food, brick and textile sub-sectors, and finally the residential sector (see Figure 23). As it was described above, metallurgic coal is destined for industrial foundry processes and the iron and steel industry, where it accounts for 12% of the total.



Source: UPME (2004)

Figure 24. Departmental consumption of coal (2003)

The coal used for coke

Colombian coke is produced in the departments of Boyacá, Cundinamarca and Norte de Santander, where there is a continuous growth in the construction of furnaces.

3.6.1 Exportations

There was an average annual increase in production of 35.4% starting in 2000 until it reached a maximum of 1.4 Mt in 2004. It is estimated that 30% of the total production is consumed internally for the manufacture of steel and other industrial uses while 70% is exported through the ports of Buenaventura, Santa Marta, Barranquilla, and destined for Venezuela, by way of the dry port of Cúcuta.

Source: UPME (2004)

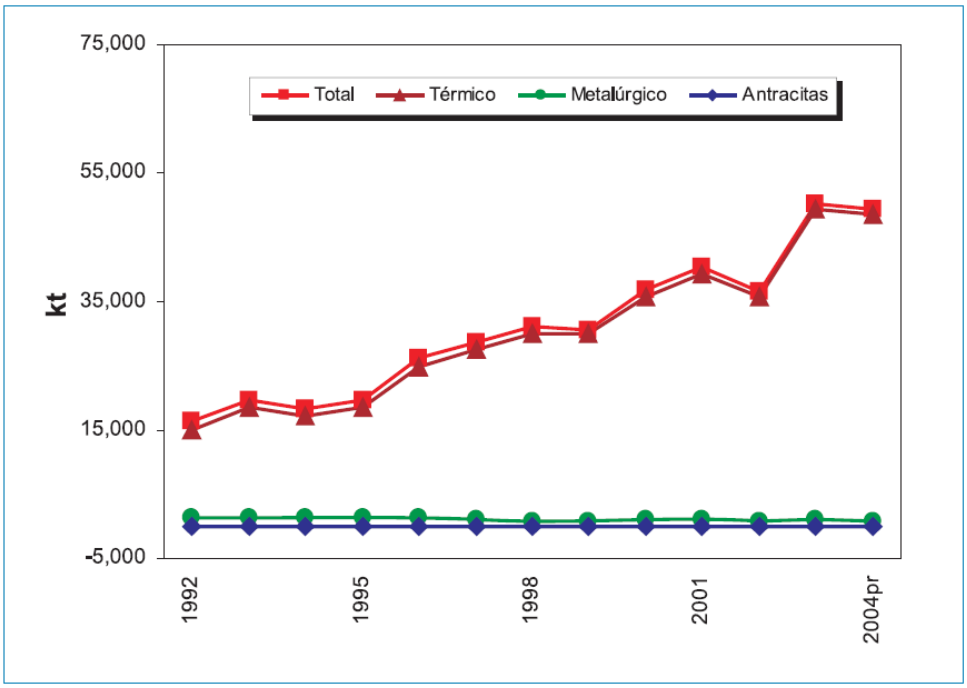
Figure 25. Shipping and Transportation

Coal exportations in 2004, the second largest Colombian exportation after oil with 10.67% of the national total, were US$1.765 billion (50.3 Mt) while coke and semi-coke exportations accounted for US$88.6 million.

Colombia supplies mainly the markets of the United States and Europe with the coals from the large projects of the Atlantic Coast, and it has been positioning itself in countries like Dominican Republic, Puerto Rico, Guatemala and Jamaica and increasing exportations through the Pacific Coast to Chile, Perú and Ecuador.

The exportable offer of the Colombian Atlantic Coast in 2004 was approximately 49.9 Mt. El Cerrejón shipped close to 52% of the total exported through Puerto Bolívar. La Loma (Cesar) exported 38% of the total through the port of Ciénaga, and La Jagua de Ibirico (Cesar) accounted for 10%, which was exported through the ports of Santa Marta.

On the other hand, 1.0 Mt of the thermal coal which was produced inland was exported by way of the ports of Buenaventura on the Pacific and some in Santa Marta.



Source: Minercol (2003), UPME (2004)

Figure 26. Colombian coal exportations (1992 – 2004)

3.6.2 Prices

In 2003 the average price per ton reported by the thermoelectric industries ranged between $36,000 and $38,000; in the first semester of 2004, the price was between $38,000 and $43,000 in Cundinamarca and Boyacá, and $75,000 in Norte de Santander, while the national average for the second semester reached $85,000. For industrial use it went from $38,000 in the first semester of 2004 to $100,000 at the beginning of 2005.

Historical records show that the FOB price for thermal coal tended to rise towards the late 80s when the process of fuel oil substitution for coal was reaffirmed, reaching US$40/t in 1990. After that it started to descend and reached US$33/t in 1993 and US$27.6/t in 2003, which reflects the surplus to be marketed facing a moderate growth in the demand.

For the case of Colombian coke, prices had a rising dynamics in the late 90s, reaching a maximum of US$91.6/t in 1999 due to the decline in the global exportable supply. As of that year, prices descended and remained stable in the order of US$77/t until the end of 2003 when a significant rise began and an FOB price close to US$105/t was recorded.

According to the surveys carried out, the International demand for metallurgic coal and coke, which allowed the use of thermal coal in blending processes, especially of coals with a low volatile matter content, generated a scarcity that forced coal power plants and other industrial sub-sectors to assume the high prices in view of the growing threat of being left without their coal supply.

The prices of metallurgic coal and coke had a rising dynamics between 2003 and 2004 as shown on Table 14.

TABLE 14. Prices per type of coal

Year	Metallurgic Coal	Coke	
	Average Price ($/t)	Internal Consumption ($/t)	For Exportation ($/t)
2003	45,342	135,000	145,000
2004	74,485	240,000	280,000

Source: UPME (2004)

4. INSTITUCIONALS ASPECTS AND CURRENT SITUATION

Since 1968 the State has participated in the country´s coal mining policy, reaching notable attention since the end of the 60s and early 70s with the creation of the Mining Statutes of 1970, when coal exploration and exploitation policies were established.

After the Political Constitution of 1991, the State´s ownership of the subsoil and non renewable resources was ratified. Carbones de Colombia S.A. (Carbocol) was created in order to plan, promote and administrate the resource which was later divided as follows: planning was assigned to the Mining and Energy Planning Unit (Unidad de Planeación Minero Energética), administration was assigned to the Colombian Coal Company (Empresa Colombiana de Carbones) (Ecocarbón), and the administration of the association contract with Intercor and the marketing of the coal coming from the exploitation of El Cerrejón Zona Norte was assigned to Carbocol.

Ecocarbón and Mineralco fused originating the National Mining Company (Empresa Minera Nacional) (Minercol Ltda.) as part of the public expenditure rationalization process and by means of decree 1679 of 1997.

With the division of Carbocol by means of decree 1139 of 1999, rights on unowned lands and mining contributions[3] were transtered to Minercol along with other functions.

When Minercol was liquidated, Ingeominas and the governments of Antioquia, Bolívar, Boyacá, Caldas, Cesar and Cundinamarca were delegated by the Ministry of Mines and Energy to carry out the following functions: 1) to administrate the mining resources of the country; 2) to contract for the exploration and exploitation of the mining and coal resources of the country; 3) to promote the development of self-sustainable, technical and competitive mining, and; 4) to incentivize the strengthening of the transportation infrastructure for mining products.

For the State´s ownership of the subsoil and non renewable natural resources, their exploitation brings about an economic consideration as royalties in the territory where they are exploited and in the maritime and fluvial ports through which they are transported. A certain percentage of the royalties which are paid is destined to the National Royalties Fund (Fondo Nacional de Regalías) which designates them, among others, for mining promotion and to finance development plans of territorial entities (National Constitution, articles 360 and 361, and Law 141 of 1994).

[3] Act by which the Ministry grants entities (registered or referenced entities) which have mining activites as one of their purposes the temporary and exclusive faculty to explore and exploit the deposits and fields of one or several mineral that may exist in a particular area.

5. PRODUCTIVE EFFICIENCY OF COAL

Colombian mining diversity is represented in numerous productive units with different geological environments and extraction methods which make each case particular as to its productive efficiency as follows:

Scale economy. It is associated with technified mining which diminishes the competitiveness of small scale mining, which should face the challenge by means of producer´s partnerships and with transportation activities, whose increase has made the exploitation and marketing of the resource more costly.

Illegal extractions. This activity has been difficult to erradicate due to the social impact it has, and because of local authorities´ unawareness of their obligations regarding this activity and their support of legal producers and marketers who occasionally resort to these extractions to meet their clients´demand.

Materials used. There is overhead in exploitation work, especially in regions where illegal extractions prevail, and they are associated with excessive exploitation of timber resources and the difficulty to find explosives.

Negotiation power. Until the Mining Code established business freedom for mining activities, the obligation of mining producers to supply the national demand caused an imbalance in the negotiation power and favored consumers who in many cases paid for coal at prices which were lower than production costs. As of 2003, the new condition of business freedom in addition to high international prices tipped the scale in favor of producers which led to a fear of leaving thermoelectric industries without their supply of coal due to the prices required by producers. In order to avoid abuses of a dominant position like those described here, it is necessary to create long term bonds between producers and consumers which may guarantee an adequate income for producers and a supply for consumers.

Seasonal Weather. With El Niño/Southern Oscilation (ENSO) phenomenon, which occurs every four years on average, coal consumption for generation of electricity is increased; however, under normal conditions or La Niña, internal demand is significantly reduced and those productive structures which are not very solid cause mining interference and high production costs, especially due to the costs of shutting down and opening said mines.

Rational Use of Energy Program. Rational use of energy programs are aimed at reducing consumption by means of efficient processes. Industrial use of gas is among these programs since it allows reductions in costs and energy. Such is the case of the cement industry where the change in one of the phases of the wet process for a dry process has achieved reductions, in terms of efficiency, of 25%

and according to international estimates a reduction in the thermal load of 1680 MJ/kg to 2100 MJ/kg (720 BTU/lb – 900 BTU/lb) of clinker[4], and savings in the order of 450 kt of coal per year could be achieved in an industry operating a full capacity.

Gas-fired thermal plants compete with coal-fired plants for their low relative costs; however, coal reserves show that there is a better prospect for the future for coal than for natural gas and therefore it can be foreseen that there will be a need to construct al coal-fired plant in addition to the four existing plants before 2010 (UPME, 2005).

AVERAGE PRICE OF COAL USED IN THERMAL PLANTS
YEARS 2003 AND 2004

Plant	Fuel	Price $/Ton	Period
Termozipa	Coal(6,802 kcal/kg)	36,412	Semester II-2003
		43,000	Semester 1-2004
Termopaipa	Coal (6,300 kcal/kg)	36,183	Semester II-2003
		42,381	Semester 1-2004
Termotasajero	Coal (6,950 kcal/kg)	38,015	Semester II-2003
		72,000	Semester 1-2004
Termoguajira	Coal (6,112 kcal/kg)	75,694	Semester II-2003
		75,694	Semester 1-2004
		52,422	

Note : Information on the year 2003 gathered in October of 2003. Information on the year 2004 gathered in July of 2004

Environmental Aspects. Modern technologies allow reducing or mitigating emissions of pollutants associated with the use of coal; nevertheless, the generalized image of coal combustion is still negative and this makes its use difficult. The environmental challenges of the coal producing sector can be focused as follows:

- In production, environmental responsibility is faced according to the type of mining. In large scale mining, prevention, mitigation and control are taken care of, and in small scale mining, low profitability and poor marketing have led producers not to consider and evaluate the environmental impact.

[4] The process of cement production takes place in kilns where calcining of the raw materials takes place at a temperature of 1550 °C; nodules of cement called clinkers are produced and later ground into a fine powder.

- In consumption, pollution is due to the low efficiency of the technology used for the production of energy and the lack of mitigation plans. In the case of the generation of electric power, clean coal technologies have been developed which minimize the emission of nitrogen oxides (NO_x), which are the gases that cause the greenhouse effect. This is achieved by means of reburning processes.

It is necessary to consider alternatives to take advantage of clean development mechanisms like the Rio de Janeiro agreement and the Kyoto protocol, which are related to the effect of greenhouse gases.

The reduction of the negative impacts associated to the production and use of coal may be achieved by improving efficiency in the sectors that require it or in reforestation programs such as the case of the so called “green coal”[5].

[5] It consists of exporting coal with an emissions reduction certificate for hectares of planted forests.

BIBLIOGRAPHY

BRITISH PETROLEUM, 2004. Statistical Review of World Energy, www.bp.com/worldenergy

COAL PROCESSING CONSULTANTS LTD. 1980. The effect of physical and chemical properties of coals on their acceptability for steam generation. The Netherlands

INGEOMINAS. 2004. El carbón colombiano: recursos, reservas y calidad. 470 p. Bogotá.

MINERCOL. 2003. Estadisticas.

MINISTERIO DE MINAS Y ENERGÍA. Estadisticas Mineras 1980-1997

UPME. 2005. Plan de expansión de referencia generación – transmisión 2005 – 2019 (Versión preliminar). 148 p. www.upme.gov.co

____. 2005. Evaluación de la demanda potencial del carbón colombiano en el mercado nacional e internacional. Informe Final. 280 p.

____. 2004. Boletín estadístico de minas y energía; 1994 – 2003. 120 p. Bogotá. D.C.

____. 2004. Boletín estadísticas internacionales minero energéticas; 1998 – 2003. 80 p. Bogotá. D.C.

____. 2004. Plan de infraestructura de transporte y portuaria para el desarrollo de la minería en Colombia. Informe Final. 787 p. Bogotá. D.C.

____. 2004.

U.S. International Energy Agency (IEA). 2004. Coal Information CD Rom -2004.

This book is published by the UPME;
the printing and binding process was finished
in the month of November of 2005
at the Digitos y Diseños workshop,
in Bogota, D.C., Colombia