21 Mexico

21.1 Summary of Coal Industry

21.1.1 Role of Coal in Mexico

Coal is a relatively small component of Mexico's energy production and consumption, compared to petroleum and natural gas. In 2012, coal accounted for only five percent of total energy consumption while oil and natural gas made up 53 percent and 36 percent, respectively (EIA, 2014). Coal is used primarily for steel production and electric power generation. According to Mexico's Energy Secretariat, while natural gas is still the dominant feedstock for electricity generation, coal consumption by the electricity sector had risen to 320 trillion British thermal units (Btus) in 2013 (EIA, 2014).

Annual coal production in Mexico increased from 10.8 million tonnes (Mmt) in 2005 to 15.2 Mmt in 2012, with estimated proved coal resources of 1,210 Mmt at the end of 2011 (see Table 21-1).

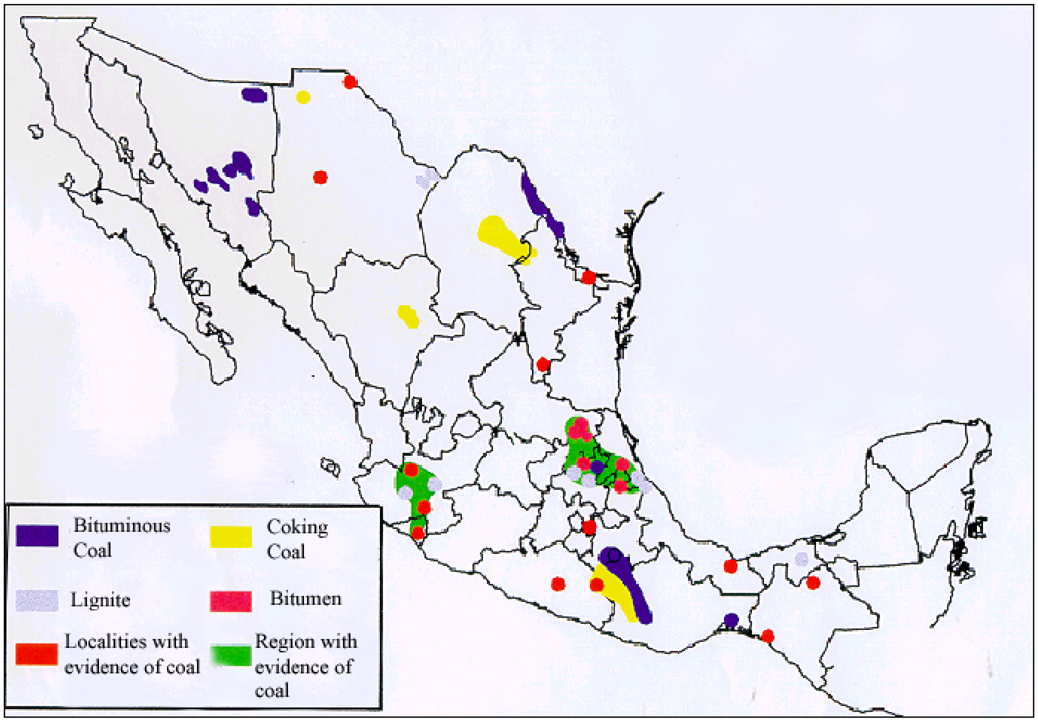
Table 21-1. Mexico's Coal Reserves and Production

Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2011)	859	351	1,210	25 (0.14%)
Annual Coal Production (2012)	15.2	0	15.2	25 (0.19%)

Source: EIA (2013)

Figure 21-1 shows the distribution of coal fields, while Table 21-2 outlines the key characteristics of the major coal basins. As seen, the majority of Mexico's coal reserves are located in Coahuila State in the northeast part of the country. Additional resources are located in Sonora (in northwest Mexico) and Oaxaca (southern Mexico).

Figure 21-1. Mexico's Coal Fields



Source: Adapted from Santillan (2006)

Table 21-2. Mexico's Major Coal Basins

State	Basin / Sub-basin	Age	Usage	Resources (million tonnes)	
Coahuila	Coahuila / Sabinas-Saltillo-Monclova	Maestrichtian	Metallurgical	1,180	3,154
	Fuentes-Rio Escondido	Maestrichtian	Steam	1,216	
	Colombia-San Ignacio	Eocene		252	
Oaxaca	Mixteca	Triassic - Jurassic	Bituminous	163	66
Sonora	Barranca	Triassic - Jurassic		143	83
	Cabullona	Maestrichtian		80	
Chihuahua	San Pedro Corrallitos	Maestrichtian		6	17
Total				***3,040**	****3,320**

Sources: *Querol-Sune (2001); ** Cabrera (2009)

21.1.2 STAKEHOLDERS

The key stakeholders involved with the coal industry and the coal mine methane (CMM) and coal bed methane (CBM) industries are listed in Table 21-3.

Table 21-3. Key Stakeholders in Mexico's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	Minera del Norte, SA de CV (MINOSA)	Major mining company in Mexico. MINOSA produces a large percentage of Mexico's coking coal. It is part of Grupo Acerero del Norte (GAN)
	▪ Minera Carbonifera Rio Escondido (MICARE)	MICARE produces steam coal and is also a part of GAN
	Grupo México S.A.B. de C.V. (Sociedad Anónima Bursátil de capital variable - limited liability stock corporation with variable capital)	Largest mining corporation (mainly copper) in Mexico
Developers	See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy and Related Services	REI Drilling Inc. HEL-East Ltd. Advanced Resources International, Inc. Caterpillar Biogas Technology Ltd. See also http://www.epa.gov/cmop/networkcontacts.html	Technical assistance
Government Agencies	Mexican Electricity Commission (CFE) Energy Regulatory Commission (CRE) Petróleos Mexicanos (PEMEX) Secretariat of Economy Secretariat for Environment and Natural Resources Ministry of Energy Comisión Federal de Electricidad	Regulatory

21.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Coal has contributed substantially to the development of industry in Mexico, starting with the development of the railroad industry. Although coal was largely replaced by oil from 1910 to 1954, it remained a major raw material for the steel industry. The mining of iron-ore and coal started formally with the development of the Mexican steel industry in 1930. Coal mining in Mexico increased considerably with the opening of coking facilities in 1954 and in 1959, and a fertilizer plant was opened in Monclova that used gas emitted from the coking facilities.

Starting in 1960, the Energy Regulatory Commission developed a program to generate electricity through two coal-operated thermoelectric power stations, which were installed in Nava, Coahuila, between the late 1970s and the early 1990s. This program led to extensive coal exploration in the Fuentes-Rio Escondido Basin of Northern Coahuila and an increase in coal mining activities (Verdugo, 1991).

In 1992, passage of the Mexican Mining Law allowed 100 percent private ownership of coal mines by both Mexican interests and foreign mining companies. Government-owned Minera Carbonifera Rio Escondido (MICARE) was privatized in 1992 and is now a subsidiary of Altos Hornos de Mexico (AHMSA), a large integrated steel company based in Coahuila state. Minera del Norte (MINOSA), Mexico's principal producer of metallurgical coal is also a subsidiary of AHMSA, which is in turn controlled by Grupo Acerero del Norte (GAN), a corporation focusing on steel production, and the mining of coal and copper.

MINOSA was formerly the name of the subsidiary operating AHMSA's iron ore mines and Minerales Monclova (MIMOSA) operated AHMSA's coal interests. GAN now operates all their mines under MINOSA. The GAN mines together produced about 82 percent of Mexico's coal in 2013. Other important mining companies with coal interests include Grupo Mexico and Carbonifera de San Patricio (Santillan, 2014).

21.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies two active CMM recovery projects and three proposed CMM recovery projects in Mexico. All of the projects, but one, are designed for active underground mines. The operational projects use captured methane for boiler fuel and flaring, while the proposed projects are designed to use captured methane for power generation and flaring (GMI, 2014).

21.2.1 CMM Emissions from Operating Mines

In November 2006, Mexico submitted its third National Communication reporting 1.39 $MTCO_2e$ of fugitive methane emissions from solid fuels for 2002 (IPCC Source Category 1B1) and another 36.69 $MTCO_2e$ from petroleum and natural gas and a total of 389.50 $MTCO_2e$ from all energy consumption (Category 1B2) (UNFCCC, 2006). In the fifth communication in December 2012, Mexico reported that total emissions amounted to 748.252 $MTCO_2e$ in 2010. The energy sector accounted for 67.3 percent (503.817 $MTCO_2e$), of which, 48.8 percent was from the energy industry and fugitive emissions (SEMARNAT, 2012).

Estimates for emissions specific to coal mining activities have varied. The National Greenhouse Gas Inventory 1990-2002 reported 1.56 $MTCO_2e$ from coal mining activities in 2002 (Category 1B1a) (UNFCCC, 2007). According to the Mexican environment ministry's undersecretary for environmental norms, approximately 2.14 $MTCO_2e$ of methane had been liberated from coal mines into the air each year (Bremer, 2006). These numbers differ slightly from U.S.EPA estimates for emissions related to coal mining activities of 1.729, 2.157, and 2.353 $MTCO_2e$ for the years 2002, 2005, and 2010, respectively. An emissions estimate of 1.836 $MTCO_2e$ is predicted for 2015 (USEPA, 2012).

Table 21-4 shows CMM emissions in Mexico. The data in this table may vary from U.S. EPA data presented in the Executive Summary due to differences in inventory methodology and rounding.

Table 21-4. Mexico's CMM Emissions (million cubic meters)

Emissions	2000	2005*	2010*	2015* (projected)
Underground mining	109.54			
Surface mining	4.70			
Underground Post-mining	6.76			
Total CH_4 Emitted	121.01	145.71	158.95	124.06

Sources: Flores (2007), *USEPA (2012)

MINOSA (formerly MIMOSA) operates five underground mines in the gassy coals of the Upper Cretaceous Los Olmos Formation in the state of Coahuila in northern Mexico and has been draining the coal beds prior to mining through in-seam horizontal boreholes since 1992, with efficiency above 30 percent (Brunner, 1999). MINOSA has several active CMM gas drainage projects and has been very progressive in their pursuit of reducing methane emissions from their mining operations. In addition to a boiler operation at the Esmeralda mine, MINOSA began operating the first CMM flare at an active coal mine in September 2011 (CDM, 2014).

The MINOSA flaring project destroys mine methane from gas drainage systems at three of its mines in northern Mexico (CDM, 2014):

- 1 flare at the Esmeralda Mine (Mine 5) in the Saltillo Basin commissioned in October 2012
- 1 flare at Mine 6 (Sabinas Basin) commissioned in April 2014
- 1 flare at Mine 7 (Sabinas Basin) commissioned in September 2011

The mines have been in operation for 15 years, with annual coal production totaling 3.9 million tonnes per year. According to MINOSA, the mines have a remaining life of more than 20 years.

Although the coal industry of Mexico is relatively small with 15 million tonnes of coal mined per year, the coal mines of northern Mexico are notoriously gassy and these three mines are among the gassiest.

Recent estimates by Mexican experts suggest that combined emissions from the mines total 208 million cubic meters (m^3) of methane, which is significantly greater than emissions projected by EPA in Table 21-4 (Santillan, 2013). This equates to an average specific emission rate of about 50 m^3 per tonne of coal mined with a range of 30 m^3 to 60 m^3 at current production rates (CDM, 2014). Internationally, the often accepted standard for a "gassy" mine is 10 m^3 per tonne, which gives an indication of the challenges facing MINOSA and other coal producers in Mexico.

The high gas content of the coal has resulted in a sustained effort by MINOSA to address methane issues through employment of a holistic approach targeting gas drainage systems and mine ventilation air. The mine ventilation systems at the mines account for 70 percent of the methane liberated at the three mines, with the remainder of emissions coming from methane drainage systems (CDM, 2014). MINOSA's gas drainage program entails a range of degasification methods including surface vertical pre-drainage wells, surface to inseam directional drilling, surface gob wells, and in-mine long hole directional boreholes that is proving very effective. Methane concentrations in the drainage system average 95 percent according to Santillan (Santillan, 2013).

As a first step in a comprehensive program designed to manage its CMM emissions, MINOSA constructed the flares at Mine 7 and Mine 5, and finally, Mine 6. The projects are sited at fixed locations and are enclosed flares (also known as ground flares) where the flame is contained within the stack and is not visible. The projects include 9 meter stacks and have a total combined throughput capacity of 6,000 Nm^3/hour (1 flare per mine x 2,000 Nm^3/hour/flare).

The equipment contains important safety features such as flame arrestors. The flares are also designed to stop operating when the oxygen concentration reaches 6 percent, the combustion temperature reaches 1200 °C, or the pressure reaches 200 mbar. Currently MINOSA anticipates a project life of seven years.

Thus far the three projects have performed at 7 percent (Mine 5), 24 percent (Mine 6) and 90 percent (Mine 7) availability, respectively (CDM, 2014), and with nearly 100 percent destruction efficiency and no reported operational problems (Santillan, 2013). CMM emission reductions totaled 13,660 tCO_2e in 2012 (Santillan, 2013) and 87,865 tCO_2e from October 2013 through October 2014 (CDM, 2014).

With the implementation of a comprehensive mine gas drainage program and the deployment of flares at three of its mines, MINOSA has taken the initial steps in what is expected to be one of the most comprehensive and ambitious CMM projects worldwide. Ultimately the company expects to operate CMM flares at other MINOSA mines, generate power from CMM and employ VAM oxidation to minimize its carbon footprint. Expected emission reductions from the integrated project are expected to be around 3.1 million tCO_2e once the project is fully implemented. The project was approved by the United Nations CDM Executive Board and the company is now monetizing the carbon credits generated by the project.

MINOSA also has developed several previous CMM projects involving their No.5 (Esmeralda), No.6 and No.7 mines. A total of almost 10 kilometers (km) of in-seam drainage holes were drilled at the three mines, along with 52 gob wells in Mine 5 and 23 gob wells in Mine 6 (Santillan, 2010). In 1991, more than 3,000 meters of in-seam horizontal drainage boreholes were drilled in advance of mining development at the Pasta de Conchos mine in the Coahuila coal region. The project was successful in reducing the methane concentration in return ventilation air from 1 percent to 0.8 percent and had a peak methane production rate of 45,000 m^3 per day (WME, 1994). An expanded CMM/CBM development program was under consideration by the mine owners, Grupo Mexico, including analysis of various end-use options. However, in February 2006, the mine experienced a lethal methane explosion that killed 65 miners and the mine was closed (El Universal, 2007). This mine disaster led to increased awareness of CMM drainage issues and a revision of Mexican mining law (see section 21.3.2).

MINOSA is currently planning on developing a new mine area, “Conchas Sur,” which is projected to be as gassy as their current mines. U.S. EPA recently funded a pre-feasibility study to look at the technical and economic aspects of pre-mine drainage for this new mine complex.

21.2.2 CMM EMISSIONS FROM ABANDONED COAL MINES

MINOSA has closed several gassy mines in Northern Mexico, and these mines are believed to present excellent opportunities for abandoned mine methane (AMM) projects. In addition, mines controlled by other companies that were gassy during operation also exist in the Sabinas Basin and likely present good AMM opportunities. However, it is important to note that there is no definitive data on AMM emissions and potential at this time and project development would require substantial due diligence. In addition, recovery of AMM would be probably be independent of active mining operations and would likely fall under traditional oil and gas regulation.

A 2010 presentation by MINOSA indicates that the company has considered an AMM project at their No.2 mine in the Sabinas basin. MINOSA estimated emissions from the mine to be 4.1 million m^3 per year (100 percent methane). The project envisions utilizing the methane for power generation and selling the produced electricity to the grid or using it to power maintenance depots at the mine site (Santillan, 2010). MINOSA, though, has prioritized developing flaring and power generation at its active mines, and thus far has not pursued AMM project development at the No. 2 mine or any other of its closed mines (Santillan, 2014).

21.2.3 CBM FROM VIRGIN COAL SEAMS

The coal in Mexico can be quite gassy. MINOSA reports an average *in situ* content of gas in the coals of the Sabinas Sub-basin at 10 to 14 m^3 per tonne and 12 to 18 m^3per tonne in the coals of the Saltillo Sub-basin (Santillan, 2004). Methane content in the gas is usually above 97 percent. Total gas resources in the Maestrichtian coals of Coahuila are estimated between 122 and 220 billion m^3 (Santillan, 2004).

Very little published data are available for CBM in Mexico. It is apparent from the quality of coal that the basins of Coahuila are the most promising sources of CBM because of their relatively high gas contents, moderate permeability, and relatively shallow depth. Mexico's CBM reserves are estimated at between 4.2 and 7.5 trillion cubic feet and are concentrated in the northern states of Coahuila and Sonora, according to the Economic Ministry's mining division.

Until the change in the mining law in 2006, only the state owned oil and gas monopoly, Petróleos Mexicanos (PEMEX) had the right to exploit Mexico's natural gas resources, including CBM. PEMEX has done several studies on the potential of CBM in the Sabinas Basin region, but their data are not publically available. They have invested little in CBM extraction, focusing on their core business of oil and conventional gas extraction (Barclay, 2006). The major coal companies had little incentive to research CBM drilling prior to 2006 focusing instead on CMM emissions. MINOSA has done significant research regarding the potential of CMM in the Sabinas Basin and appears, at this time, to be following up on potential CMM projects rather than ones involving CBM extraction.

The Mexican government has recently proposed new regulations for the oil and gas industry which are intended to further liberalize the sector and promote private investment and development. The passage of this new legislation should provide added incentives for CMM and CBM development.

21.3 Opportunities and Challenges to Greater CMM Recovery and Use

Mexico is a signatory to both the UNFCCC and the Kyoto Protocol (see Table 21-5). As a Non-Annex I Party to the Kyoto Protocol, Mexico has no national emissions targets but is eligible to host mitigation projects under the Clean Development Mechanism (CDM). The MINOSA CMM flaring project is currently the only CMM/CBM project in Mexico registered under the CDM (UNEP, 2010).

Table 21-5. Mexico's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	March 11, 1993
Kyoto Protocol	June 9, 1998	September 7, 2000

Source: UNFCCC (2014)

21.3.1 Market and Infrastructure Factors

PEMEX's natural gas network currently exceeds 93,032 km (PEMEX, 2011) and has 12 compression stations. There were 13 natural gas interconnection stations between Mexico and the United States at the end of 2013, with at least two new pipeline interconnections planned (EIA, 2014). Natural gas import capacity was increased when two new pipelines came on-stream during 2003 and in 2012 Mexico imported 620 billion cubic feet (Bcf) of natural gas from the United States (EIA, 2014). Currently, all proposed CMM utilization projects are limited to coal mine operations and local power generation and not to pipeline sales.

If it were on the market, CMM would compete directly with other supplies of natural gas in Mexico, which come from various natural gas basins and as associated gas from increasing onshore and offshore oil production. Rising natural gas prices and increasing gas demand for expanding power generation capacity are expected to make CMM and CBM prices competitive with natural gas and other resources, including coal. Market access for CMM is currently limited by legal requirements that hydrocarbon resources be handled through contracts with PEMEX.

21.3.2 Regulatory Information

Mineral exploration and mining in Mexico are regulated by the Mining Law of 1992 (as amended in 2006), which establishes that all minerals found in Mexican territory are owned by the Mexican nation, and that private parties may exploit such minerals (except oil and nuclear fuel minerals) through mining licenses, or concessions, granted by the Federal Government.

Before 2006, Mexico's Constitution (Article 27), enacted through the Ruling Law on the Subject of Hydrocarbons required that all exploration, recovery, processing, and sales of methane were to be managed by PEMEX. Therefore, coal mines did not have the right to sell CMM or to use CMM to generate heat or electricity on site.

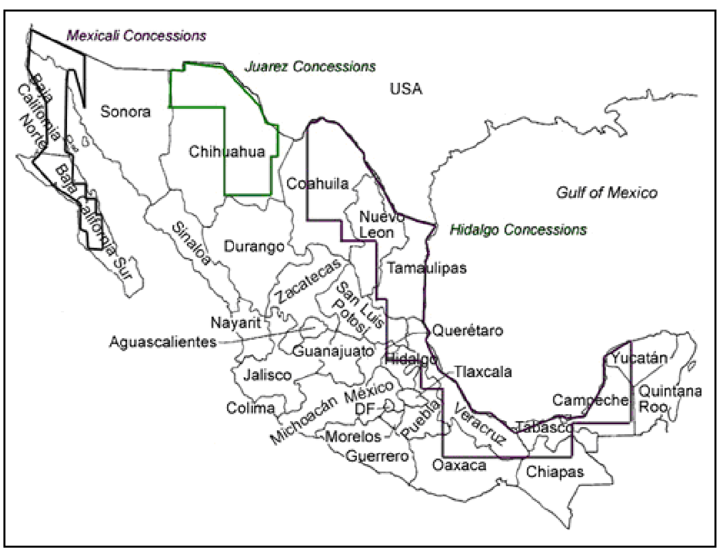
However, changes to this regulatory barrier have been made. Media attention to the dangers posed by CMM was triggered by an explosion at Pasta de Conchos coal mine in Coahuila in February 2006 that killed 65 miners. Following this disaster, the Congress and the Senate quickly passed an amendment to the Mining Law (April 2006), allowing coal mines to recover and use CBM, CMM, AMM, and ventilation air methane from their coal mining operations for any purpose. The amendment also allowed the concessionaires to sell the gas to PEMEX through a contract (Flores, 2007).

The regulations were further adjusted by an amendment to the Mining Law on June 26, 2006 which allows holders of coal mineral concessions to recover and use methane in order to stop methane venting. Methane can be used on-site and/or delivered to PEMEX, which is required to pay justifiable market rates for recovery, transportation, operation and maintenance plus a reasonable profit. Holders of CMM concessions are contracted to report on the start and suspension of any activities, collect geological data, report on discovery of non-associated gas, and deliver captured, non-self-consumed CMM to PEMEX (Flores, 2007; LatinPetroleum, 2006).

A new law, "Safety for Underground Mines" (NOM-STPS-032-2008), was passed in 2008 and contained rules for obtaining permits and authorizations that grant the use and recovery of coal mine gas (Cabrera, 2009; Briseno, 2009). The Secretaria de Energía (SENER) is the agency in charge of authorizing and monitoring CBM/CMM activity, and issues permission for the recovery and utilization of CBM. SENER will also issue contracts for the delivery of gas to PEMEX; establish terms for payment for the delivery of gas, and is charged with developing policies for recovery and utilization of CBM (Roldan, 2009).

The Mexican government recently staked out three large regions and designated them for CBM development. The staking is a response to the changes to the Mining Law passed in 2006, and seeks to assert the primacy of CBM resources in these areas. Until the concessions are put up for auction, the reservation of these areas will be an impediment to other mining development (Wood, 2007). Figure 21-2 shows an estimate of the outlines of the staked regions.

Figure 21-2: Estimated Boundaries of Recent CBM Staking by the Mexican Government



Source: Wood (2007)

21.4 Profiles of Individual Mines

Mexico has seven significant coal basins spread across the country. Two-thirds of the country's resources are located in Coahuila where most of the active mining is taking place. Table 21-6 shows the coal characteristics of the different coal basins in Mexico and Table 21-7 gives a joint profile of three MINOSA mines in the Sabinas basin.

Table 21-6. Coal Characteristics of Mexican Coal Basins

Site	Carbon %	Volatile Matter %	Ash %	Sulfur Total %	Moisture %	Calorific Value Btu/ kg	Resources On Site (million tonnes)
Sabinas-Saltillito-Monclova Sub-Basins, Coahuila	45.61	16.97	40.43	1.0	1.26	5,897	1,180
Fuentes-Rio Escondido Basin, Coahuila	32.07	30.50	33.27		4.16	3,740	1,216
Colombia-San Ignacio Basin, Coahuila	32.4	42.6	44.0	3.5	4.10	5,053	252
Mixteca Basin, Oaxaca. Areas:							
- Plaza de Lobos							
-Plancha-el Consuelo	31.11	6.92	60.30	0.26	1.05		163
- San Juan Viejo	29.75	6.02	63.11	0.25	0.82		
	40.14	10.07	49.13	0.28	0.47		
Barranca Basin, Sonora	77.3	4.8	10.6	0.37	8.0	5,216	143
Cabullona Basin, Sonora	67.45	9.92	18.86	0.00	3.76	4,107	80
San Pedro Corralitos Basin, Chihuahua	27.37	26.75	45.86	0.34	18.2		6
Total							**3,040**

Source: Flores-Galicia (2001)

Table 21-7. Profile of MINOSA Mines V, VI & VII

MINOSA Mines - 5, 6, and 7			
Mine Status	Active	**Mine Owner**	MINOSA Mines
Mining Method	Longwall	**Parent Company**	Altos Hornos de Mexico
Depth of Seams	120-150 m	**Location**	Sabinas Coal Basin, Coahuila
No. of Seams	2 – Olmos Fmtn	**2008 VAM Volume**	128. Mm^3
Seam Thickness	1.2-3.5 m (total)	**2008 Drained CH_4 Volume**	6.41
2008 Coal Production	3.5 million tonnes	**2008 Utilized CH_4 Volume**	0

	2000	2001	2002	2003	2004	2005
Coal Production (thousand tonnes/yr)	1714.6	2093.7	1910.9	1319.7	1814.2	1641.9
Methane (million m^3/yr)						
Emitted from ventilation systems	42.40	81.13	107.73	101.18	107.7	128.2
Liberated from drainage systems	3.90	4.82	13.44	20.11	4.82	13.4
Total Methane Emissions	46.3	85.95	121.17	121.29	112.52	141.6

Table 21-7. Profile of MINOSA Mines V, VI & VII

MINOSA Mines - 5, 6, and 7						
	2006	2007	2008	2009*	2010*	2011*
Coal Production (thousand tonnes/yr)	2676.9	1897.2	2586.9	3,992	3,641	4,008
Methane (million m³/yr)						
Emitted from ventilation systems	118.1	102.3	128.4	111.3	111.3	111.3
Liberated from drainage systems	20.1	14.18	6.41	22.1	22.1	22.1
Total Methane Emissions	138.2	116.4	134.8	133.4	133.4	133.4
	2012*	2013*	2014*			
Coal Production (thousand tonnes/yr)	5,654	4,603	5,444			
Methane (million m³/yr)	0	0	0			
Emitted from ventilation systems	111.3	111.3	111.3			
Liberated from drainage systems	22.1	22.1	22.1			
Total Methane Emissions	133.4	133.4	133.4			

*Projected from Mina La Esmeralda, Mina VI, and Mina VII (GMI, 2010)
Profiles of five potential CMM projects in Mexico have been presented as project posters at GMI Expos can be found at:
MIMOSA power and flaring project (Beijing Expo 2007)
https://www.globalmethane.org/activities/actDetails.aspx?ID=269

CMM Recovery and Use at MIMOSA mines (New Delhi Expo 2010)
https://www.globalmethane.org/activities/actDetails.aspx?ID=1080

Advanced Gob Gas Drainage at MIMOSA Mines (New Delhi Expo 2010)
https://www.globalmethane.org/activities/actDetails.aspx?ID=1081

MIMOSA CMM Project (Sabinas Basin, Coahuila, Mexico) (Vancouver Expo 2013)
https://www.globalmethane.org/expo-docs/posters/CoalMines/CM_MX_Project_Mimosa_FINAL.pdf

MIMOSA VAM Destruction Project (Sabinas Basin, Coahuila, Mexico) (Vancouver Expo 2013)
https://www.globalmethane.org/expo-docs/posters/CoalMines/CM_MX_Success_Mimosa_FINAL.pdf

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