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Coal Mine Methane Country Profiles

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Global Methane Initiative

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UNITS OF CONVERSIONS

Units	
t	tonnes
Mt	thousand tonnes
Mmt	million tonnes
Mmt CO_2e	million tonnes CO_2 equivalent
bt	billion tonnes
kg	kilograms
Mg	megagram
Gg	gigagram
m	meters
m^3	cubic meters
Mm^3 or MMCM	million cubic meters
Bm^3 or BCM	billion cubic meters
km	kilometers
MCM	thousand cubic meters
Mmcf	million cubic feet
TCM	trillion cubic meters
Tcf	trillion cubic feet
kW	kilowatts
MW	megawatts
MW_e	megawatt electrical
kWhr	kilowatt-hours
J	joule
KJ	kilojoule
MJ	megajoule
PJ	petajoule
Btu	British thermal unit
Kpa	kilopascals
psia	pounds per square inch absolute
Conversions	
1 t	1.102 US ton/short ton
1 m	3.28 feet
1 km	0.62 miles
1 m^3	35.32 cubic feet
1 kg	2.21 pounds
1 kg CH_4	1.47 m^3 CH_4
1 t CH_4	21 Mmt CO_2e
1 MJ	0.28 kilowatt-hours
1 Btu	1055 joules

Executive Summary

In 2004, 14 countries came together to launch the Methane to Markets (M2M) Partnership —which was re-launched as the Global Methane Initiative (GMI) in 2010—with the aim of reducing emissions of methane, a potent greenhouse gas (GHG), by promoting the development of projects that recover and use methane as a clean energy source. This international public-private partnership continues to work with government agencies around the world to facilitate project development in five key methane-producing sectors: agriculture (manure management), coal mines, municipal solid waste (MSW), oil and natural gas systems, and wastewater. The efforts of this collaboration are yielding important and diverse benefits across the globe, such as enhanced economic growth and energy security, improved air quality and industrial safety, and reduced GHG emissions.

GMI has grown over the past 10 years to include 42 Partner Countries and the European Commission, representing about 70 percent of the world's anthropogenic methane emissions. GMI also includes a vibrant Project Network of more than 1,300 members from diverse sectors such as international finance, development, the policy arena, and non-profit institutions whose common goal is to promote methane recovery and use projects around the world.

This report was prepared to assist GMI's Coal Subcommittee in its goal of reducing methane emissions in the coal mines sector. The study scopes out opportunities across the world for coal mine methane (CMM) recovery projects, serving as a guide for the Coal Subcommittee to promote the development of future CMM projects. The study profiles 37 countries—GMI Partner Countries and otherwise—most of which are actively producing coal or have significant coal reserves (see Table ES-1).

Countries Profiled in the Report

Argentina*	Finland*	Mexico*	South Africa
Australia*	France	Mongolia*	Spain
Botswana	Georgia*	New Zealand	Turkey*
Brazil*	Germany*	Nigeria*	Ukraine*
Bulgaria*	Hungary	Pakistan*	United Kingdom*
Canada*	India*	Philippines*	United States*
China*	Indonesia*	Poland*	Vietnam*
Colombia*	Italy*	Republic of Korea*	
Czech Republic	Japan*	Romania	
Ecuador*	Kazakhstan*	Russia*	

**GMI Partner Countries*

Each country profile includes an overview of its coal industry, and characterizes and quantifies its CMM emissions. Brief descriptions of individual coal mines also have been provided wherever possible. All information has been sourced from publicly-available literature, or from in-country experts.

Global Overview at a Glance

Table ES-1 summarizes estimated coal reserves in the profiled countries. The United States, Russia, and China are the top three ranking countries together accounting for more than half of the total global coal reserves of 857,937 million tonnes (Mmt) (397,026 Mmt anthracite and bituminous;

460,912 Mmt sub-bituminous and lignite). The United States alone holds roughly 28 percent of the world's total or 234,615 Mmt.

Table ES-1. Estimated Coal Reserves, 2011

Country	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Profiled Country Rank (# and %)
Argentina	a	550	550	23 (0.064%)
Australia	37,100	39,300	76,400	4 (8.905%)
Botswana	40	0	40	34 (0.005%)
Brazil	0	6,630	6,630	13 (0.773%)
Bulgaria	2	2,364	2,366	17 (0.276%)
Canada	3,474	3,108	6,582	14 (0.767%)
China	62,200	52,300	114,500	3 (13.346%)
Colombia	6,746	0	6,746	12 (0.786%)
Czech Republic	181	871	1,052	21 (0.123%)
Ecuador	0	24	24	35 (0.003%)
Finland	0	0	0	36 (tie) (0.0%)
France	0	0	0	36 (tie) (0.0%)
Georgia	201	0	201	29 (0.023%)
Germany	48	40,500	40,548	6 (4.726%)
Hungary	13	1,647	1,660	19 (0.193%)
India	56,100	4,500	60,600	5 (7.063%)
Indonesia	0	28,017	28,017	10 (3.266%)
Italy	0	50	50	33 (0.006%)
Japan	337	10	347	25 (0.040%)
Kazakhstan	21,500	12,100	33,600	8 (3.916%)
Mexico	860	351	1,211	20 (0.141%)
Mongolia	1,170	1,350	2,520	16 (0.294%)
New Zealand	33	538	571	22 (0.067%)
Nigeria	21	169	190	30 (0.022%)
Pakistan	0	2,070	2,070	18 (0.241%)
Philippines	41	275	316	26 (0.037%)
Poland	4,178	1,287	5,465	15 (0.637%)
Republic of Korea, South	0	126	126	32 (0.015%)
Romania	10	281	291	27 (0.034%)
Russia	49,088	107,922	157,010	2 (18.301%)
South Africa	30,156	0	30,156	9 (3.515%)
Spain	200	330	530	24 (0.062%)
Turkey	322	8,380	8,702	11 (1.014%)

Table ES-1. Estimated Coal Reserves, 2011

Country	Anthracite &	Sub-bituminous		Profiled Country
Ukraine	15,351	18,522	33,873	7 (3.948%)
United Kingdom	228	0	228	28 (0.027%)
United States	107,276	127,340	234,615	1 (27.346%)
Vietnam	150	0	150	31 (0.017%)
Profiled Countries Total	**397,026**	**460,912**	**857,937**	

Source: *International Energy Statistics – Coal Reserves,* U.S. Energy Information Administration (EIA), Washington, DC, data as of 31 December 2014. http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=6

Note: EIA calculates U.S. reserves only. It reproduces international reserves data from World Energy Council (WEC) based on WEC's definition of "Proved Recoverable Reserves" as the tonnage within the Proved Amount in Place that can be recovered under present and expected local economic conditions with existing available technology.

Table ES-2. Estimated Coal Production, 2012

Country	Anthracite & Bituminous	Lignite	Total	Profiled Country Rank (# and %)
Argentina	0.08	0.00	0.08	31(tie) (0.001%)
Australia	347.20	73.54	420.74	5 (5.49%)
Botswana	0.74	0.00	0.74	29 (0.01%)
Brazil	3.26	3.04	6.30	24 (0.08%)
Bulgaria	0.01	32.51	32.52	19 (0.42%)
Canada	57.00	9.50	66.50	13 (0.87%)
China	3,510.25	141.52	3,651.76	1 (47.63%)
Colombia	89.45	0.00	89.45	11 (1.17%)
Czech Republic	11.44	43.53	54.97	15 (0.72%)
Ecuador	0.00	0.00	0.00	33 (tie) (0.0000%)
Finland	0.00	0.00	0.00	33 (tie) (0.0000%)
France	0.00	0.00	0.00	33 (tie) (0.0000%)
Georgia	0.25	0.00	0.25	30 (0.003%)
Germany	11.56	185.43	196.99	8 (2.569%)
Hungary	0.00	9.29	9.29	22 (0.12%)
India	545.86	43.49	589.35	3 (7.69%)
Indonesia	442.81	0.00	442.81	4 (5.78%)
Italy	0.08	0.00	0.08	31 (tie) (0.001%)
Japan	0.00	0.00	0.00	33 (tie) (0.0000%)

Table ES-2. Estimated Coal Production, 2012

Country	Anthracite & Bituminous	Lignite	Total	Profiled Country Rank (# and %)
Kazakhstan	120.50	5.52	126.02	10 (1.64%)
Mexico	15.19	0.00	15.19	21 (0.20%)
Mongolia	23.63	9.98	33.61	18 (0.44%)
New Zealand	4.60	0.33	4.93	26 (0.06%)
Nigeria	0.03	0.00	0.03	32 (0.0004%)
Pakistan	1.92	1.17	3.09	27 (0.04%)
Philippines	8.00	0.00	8.00	23 (0.10%)
Poland	79.23	64.28	143.51	9 (1.87%)
Republic of Korea, South	2.09	0.00	2.09	28 (0.03%)
Romania	0.04	33.99	34.03	17 (0.44%)
Russia	276.09	77.85	353.94	6 (4.62%)
South Africa	259.30	0.00	259.30	7 (3.38%)
Spain	6.15	0.00	6.15	25 (0.08%)
Turkey	3.56	65.95	69.51	12 (0.91%)
Ukraine	64.63	0.00	64.63	14 (0.84%)
United Kingdom	16.29	0.00	16.29	20 (0.21%)
United States	850.51	71.60	922.12	2 (12.03%)
Vietnam	42.10	0.00	42.10	16 (0.55%)
Profiled Countries Total	**6,793.84**	**872.52**	**7,666.37**	
WORLD	6,854.2	1,033.5	7,887.7	

Source: *International Energy Statistics – Coal Production*, EIA, Washington, DC, data as of 31 December 2014. http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=1

As seen in Table ES-2 above, China and the United States are by far the world's largest coal producers, together accounting for nearly 65 percent of profiled countries' production. China alone produces more than half of the profiled countries' total production. Of the countries evaluated in this study, Ecuador, Finland, France, and Japan are currently not producing any coal.

Table ES-3. Methane Emissions from Coal Mining (MmtCO$_2$e)

Country	2000	2005	2010	2015*	Profiled Country Rank (as of 2015)
Argentina	0.23	0.04	0.11	0.13	30
Australia	20.84	22.76	27.24	29.57	5
Botswana	0.27	0.27	0.31	0.32	28
Brazil	0.90	1.03	1.15	1.46	20
Bulgaria	1.32	1.23	1.45	1.52	19
Canada	0.97	1.00	0.94	0.98	23

Table ES-3. Methane Emissions from Coal Mining ($MmtCO_2e$)

Country	2000	2005	2010	2015*	Profiled Country Rank (as of 2015)
China	134.74	257.11	295.51	321.16	1
Colombia	3.28	5.08	7.29	9.26	8
Czech Republic	5.02	4.65	4.38	4.20	13
Ecuador	-	-	-	-	34 (tie)
Finland	-	-	-	-	34 (tie)
France	2.37	-	-	-	34 (tie)
Georgia	0.00	0.00	0.00	0.00	33
Germany	9.68	5.69	3.68	3.53	14
Hungary	0.31	0.02	0.02	0.02	32 (tie)
India	14.90	15.95	18.88	20.68	7
Indonesia	1.02	2.26	4.04	4.42	12
Italy	0.03	0.02	0.02	0.02	32 (tie)
Japan	0.77	0.07	0.05	0.05	31
Kazakhstan	18.32	17.51	22.30	23.28	6
Mexico	1.73	2.16	2.35	1.84	17
Mongolia	0.10	0.15	0.20	0.21	29
New Zealand	0.34	0.33	0.39	0.42	26
Nigeria	0.34	0.91	0.96	1.01	22
Pakistan	0.95	1.50	1.13	1.24	21
Philippines	0.20	0.43	0.38	0.41	27
Poland	10.96	9.58	7.90	7.58	10
Republic of Korea	1.16	0.79	0.81	0.88	24
Romania	2.67	2.49	2.73	2.85	15
Russia	41.95	45.39	48.82	50.97	3
South Africa	7.68	8.33	8.17	8.64	9
Spain	1.23	0.92	0.66	0.63	25
Turkey	1.62	1.48	1.90	1.82	18
Ukraine	31.38	29.90	29.71	31.02	4
United Kingdom	6.99	4.08	2.73	2.62	16
United States	60.41	56.91	67.47	69.98	2
Vietnam	1.87	5.23	6.91	7.57	11
Profiled Countries Total	**386.56**	**505.28**	**570.58**	**610.31**	
World Totals	401.41	521.57	588.55	629.74	

*2015 emissions: Extrapolated based on changes in coal production from 2000 to 2010.

Source: *Global Anthropogenic Non-CO_2 Greenhouse Gas Greenhouse Gas Emissions: 1990–2030*, U.S. Environmental Protection Agency (U.S. EPA), Office of Atmospheric Programs, Climate Change Division, December 2012. http://www.epa.gov/climatechange/Downloads/EPAactivities/EPA_Global_NonCO2_Projections_Dec2012.pdf

In Table ES-3 above, total historical and/or projected methane emissions from coal mining are shown for 2000, 2005, 2010, and 2015. China, which has the world's highest coal production, also emits the greatest amount of CMM, estimated at more than 321 $MmtCO_2e$ per year. Other large CMM emitters (i.e., more than 10 $MmtCO_2e$ per year) based on 2015 estimates are the United States, Russia, Ukraine, Australia, Kazakhstan, and India.

GMI's International CMM Project Database (https://www.globalmethane.org/coal-mines/cmm/index.aspx) provides a worldwide snapshot of CMM recovery and utilization activities—both operating and in development—and the amount of CMM emissions avoided. Ongoing CMM projects can be found in nearly half of the 37 countries profiled in this report. China, Australia, Czech Republic, Germany, Poland, United Kingdom, and the United States in particular host numerous projects at active mines, while Germany, Ukraine, United Kingdom, and the United States host many projects at abandoned mines.

According to data found in the International CMM Projects Database, Australia, China, Germany, Poland, Ukraine, and the United States avoid a considerable amount of methane emissions from their coal mines. Australia, Czech Republic, France, Germany, Japan, Mexico, Nigeria, Poland, Ukraine, United Kingdom, and the United States get a portion of their reductions through recovery at abandoned mines.

Introduction

Methane is a potent greenhouse gas (GHG) that is more than 28 to 34 times as powerful as carbon dioxide (CO_2) at trapping heat in the atmosphere, on a mass-basis over a 100-year timeframe.[1] By 2015, it is estimated that methane will account for 14 percent of global GHGs, with more than 60 percent of the total methane emissions coming from human-related activities, such as agriculture, coal mining, municipal solid waste (MSW), oil and natural gas systems, and wastewater.[2] Since methane has a much shorter atmospheric lifetime than CO_2 (about 12 years compared to about 200 years for CO_2), reducing methane emissions can achieve significant climate benefits over the next 25 years.

The Methane to Markets (M2M) Partnership was formed in 2004 as an agreement amongst 14 countries to work toward minimizing methane emissions from major sources. The goal of this international public-private partnership is to reduce emissions of methane by advancing the development of projects that recover and use methane as a clean energy source. M2M was re-launched as the Global Methane Initiative (GMI) in October 2010 and membership has expanded to 42 countries (and the European Commission) as of 2015 (see text box below), representing about 70 percent of the world's anthropogenic methane emissions. Public and private sector organizations around the world are also working together with government agencies to facilitate project development. These collaborative efforts are yielding important benefits across the globe, including enhanced economic growth and energy security, improved air quality and industrial safety, and reduced GHG emissions.

Global Methane Initiative Partners (as of 2015)

Albania	Ethiopia	Kazakhstan	Republic of Serbia
Argentina	European Commission	Mexico	Russia
Australia	Finland	Mongolia	Saudi Arabia
Brazil	Georgia	Nicaragua	Sri Lanka
Bulgaria	Germany	Nigeria	Thailand
Canada	Ghana	Norway	Turkey
Chile	India	Pakistan	Ukraine
China	Indonesia	Peru	United Kingdom
Colombia	Italy	Philippines	United States
Dominican Republic	Japan	Poland	Vietnam
Ecuador	Jordan	Republic of Korea	

Methane released from coal mining activities in underground and surface mines is of particular concern as methane is explosive in nature and poses a safety hazard to coal miners. Constituting 8 percent of the global anthropogenic methane emissions by 2015, coal mine methane (CMM)—if recovered and utilized—not only provides valuable clean fuel and environmental benefits, but also improves mine safety and productivity.

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[1] The fifth report of the Intergovernmental Panel on Climate Change (IPCC), released in the last year, included methane GWP values of 28 to 34. The United States and other developed countries are currently using the fourth report's GWP value of 25 to quantify the climate impact of U.S.-government-supported methane reduction projects.

[2] *Global Anthropogenic Emissions of Non-CO_2 Greenhouse Gases: 1990–2030*, U.S. Environmental Protection Agency (U.S. EPA), Office of Atmospheric Programs, Climate Change Division, December 2012. http://www.epa.gov/climatechange/Downloads/EPAactivities/EPA_Global_NonCO2_Projections_Dec2012.pdf

CMM varies in quality depending on the source of emission. CMM drained from underground mine ventilation systems is very dilute. Referred to as ventilation air methane (VAM), it accounts for the largest source of CMM emissions globally. In some instances, it is necessary to supplement ventilation with a degasification system consisting of a network of boreholes and gas pipelines that may be used to capture methane before, during, and after mining activities to keep the methane concentration within safe limits. Abandoned or closed mines may also continue to emit methane, typically of low to medium quality, from ventilation pipes or boreholes.

A number of technologies are readily available to recover and use methane from active or abandoned coal mines, while technology has been demonstrated to recover the energy content of dilute methane emissions from coal mine ventilation shafts (i.e., VAM). Specific uses for recovered CMM depend on the gas quality, especially the concentration of methane and the presence of other contaminants in the drained gas. CMM is typically used worldwide for power generation, district heating, boiler fuel, or town gas, or it is sold to natural gas pipeline systems. CMM also can be used in many other ways (see text box).

CMM Uses

- Coal drying
- Heat source for mine ventilation or supplemental fuel for boilers
- Vehicle fuel as compressed natural gas (CNG) or liquefied natural gas (LNG)
- Manufacturing feedstock
- Fuel source for fuel cells and internal combustion engines

Although there are significant benefits and scope for CMM recovery and use, developing CMM projects face several challenges. These include accessing appropriate technology to assess resources, effectively installing drainage systems, and selecting appropriate end use technologies. Market barriers include appropriate price signals and adequate infrastructure to transport the gas. Lastly, regulatory and policy issues such as clear establishment of property rights to the gas and access to capital or financing also impede CMM project development.

Purpose of the Report

This report has been prepared under the aegis of the GMI Coal Subcommittee, responsible for guiding GMI efforts to reduce methane emissions from coal mines. The Subcommittee identified the lack of information about project opportunities in different countries as a major barrier to initiating global CMM project development.

Coal Mine Methane Country Profiles was prepared by the Coalbed Methane Outreach Program (CMOP), an initiative of the U.S. Environmental Protection Agency (U.S. EPA) that supports GMI's efforts in promoting CMM project development in coal-producing countries. The information in this report is based on country profiles submitted by GMI Partner Countries, as well as on publicly-available data and consultation with in-country experts.

Organization of the Report

The following sections in the report profile 37 countries in alphabetical order. Each country's overview addresses the following broad topical areas:

- Summary of the Coal Industry
  - Coal production and the importance of coal in the country's economy and energy sector

- Key stakeholders in CMM project development
  - Status of the coal mining industry

- Overview of CMM Emissions, Projects, and Potential
  - CMM from Operating Mines
  - CMM from Abandoned Mines
  - CBM from Virgin Coal Seams

- Opportunities and Challenges to Greater CMM Recovery and Use
- Profiles of Individual Mines

1 Argentina

1.1 Summary of Coal Industry

1.1.1 Role of Coal in Argentina

Although Argentina is a significant energy producer and a net energy exporter, it has limited coal reserves. Its energy resources are dominated by oil and natural gas, with coal playing a minor role in the national energy mix. Only 1.5 percent of Argentina's primary energy supply came from coal and peat combined in 2011 (IEA, 2013). Argentina currently has only one power plant in the country that is partially coal fired; located in the Buenos Aires province, the San Nicolas plant (which also utilizes oil and natural gas to generate electricity) has a total installed capacity of 650 MW (PennEnergy, 2014). By the end of 2014, Argentina's first 100 percent coal-fired power plant—the 240 MW Rio Turbio power plant—was about 90 percent complete and will be the country's first to run entirely on coal.

As shown in Table 1-1, Argentina's coal reserves were 550 million tonnes (Mmt) in 2011 and coal production in Argentina amounted to only about 0.08 Mmt in 2012 (EIA, 2014a).

Table 1-1. Argentina'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)	0	550	550	32 (0.062%)
Annual Coal Production (2012)	0.08	0	0.08	61 (0.001%)

Source: EIA (2014a)

Coal and related organic-rich deposits are widely distributed in Argentina; however, its coal reserves are not extensive (Brooks and Willett, 2004). Rio Turbio has the only operational coal mine in Argentina. Figure 1-1 shows the location of these coal deposits.

Figure 1-1. Argentina's Coal Fields

Source: CIA (2014)

1.1.2 STAKEHOLDERS

Little information on business stakeholders in Argentinean coal mine methane (CMM) development is available. Other potentially interested parties include natural gas transmission and distribution companies and ENARGAS, the gas regulatory agency. Key stakeholders are listed in Table 1-2.

Table 1-2. Key Stakeholders in Argentina's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ Yacimiento de Carbón de Río Turbio (YCRT)	Potential host mine
Natural Gas Transmission & Distribution Companies	▪ Transportadora do Gas del Norte ▪ Transportadora del Gas del Sur (TGS)	CMM pipeline distribution
Regulatory Agencies	▪ National Gas Regulatory Authority or Ente Nacional Regulador Del Gas (ENARGAS) ▪ Department of Environment and Sustainable Development ▪ Department of Energy ▪ Department of Mining	Permitting, gas sale & distribution

Table 1-2. Key Stakeholders in Argentina's CMM Industry

Stakeholder Category	Stakeholder	Role
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Professional Associations	▪ Argentine Petroleum and Gas Institute ▪ Association of Sanitary Engineering and Environmental Sciences	Facilitate government/ industry interaction
Other	▪ Natural gas T&D companies (e.g., MetroGAS)	

1.1.3 Status of Coal and the Coal Mining Industry

Only one underground mine is active in Argentina – the Rio Turbio mine – currently operated by Yacimientos Carboníferos Río Turbio (YCRT), a company owned by the Argentine National State. It was previously run by Yacimientos Carboniferos Fiscales, which privitized in 1994, but at a low production rate. The Rio Turbio mine produces sub-bituminous coal, some of which is consumed onsite in a rail car repair forge and the remainder is sent to Buenos Aires for power generation (Perczyk, 2006).

Annual production statistics reveal a decline in production over the past three decades, from a reported high of slightly over 500,000 tonnes per year in 1982 to less than 100,000 tonnes in 2012 (EIA, 2014a). Although five underground operations were actively exploiting high-volatile sub-bituminous coal at Pico Quemado in the 1950s (M2M, 2005), they are now closed.

Coal production is, however, projected to increase as Argentina is expanding its electric grid to connect the remote Río Turbio mine to Río Gallegos, a big city and potential consumption center for coal-generated power (Perczyk, 2006).

Gas reserves in place at the currently operating Rio Turbio mine are not known.

1.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Argentina, in operation or under development (GMI, 2014). Updates on future CMM projects in Argentina can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

1.2.1 CMM Emissions from Operating Mines

Methane emissions in Argentina totaled 16.1 million cubic meters (m^3) in 2000. Emissions are expected to decrease to 9.1 million m^3 by 2015, and are then anticipated to increase to 13.3 million m^3 by 2030 (see Table 1-3).

Table 1-3. Argentina's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	16.1	2.8	7.7	9.1

Source: USEPA (2012)

Previously, Argentina's Department of Mining estimated the emission factor could be in the range of 0.8 to 1.2 m^3 of methane per tonne of coal (Perczyk, 2006).

1.2.2 CMM Emissions from Abandoned Coal Mines

The five underground operations at Pico Quemado that were active in the 1950s but have ceased to operate could be a potential source of abandoned mine emissions. However, no data on the gassiness of the workings or quantifying methane emissions from these are currently available.

1.2.3 CBM from Virgin Coal Seams

No data is currently available on coal bed methane resources in Argentina.

1.3 Opportunities and Challenges to Greater CMM Recovery and Use

Argentina, a non-Annex I country, has signed and ratified the UNFCCC and the Kyoto Protocol, as indicated in Table 1-4. While Argentina has numerous Clean Development Mechanism projects underway of various types (e.g., biomass energy, landfill gas), none of them involve coal bed/mine methane.

Table 1-4. Argentina's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	March 11, 1994
Kyoto Protocol	March 16, 1998	September 28, 2001

Source: UNFCCC (2014)

Argentina is currently in the process of developing a National Strategy on Climate Change to serve as the framework for mitigation and adaptation measures that reinforce the country's commitment to fight climate change. During the two first stages of development from 2011 to 2012, a set of actions were agreed upon among different public agencies and various competencies (i.e., actions) were assigned to each agency (GMI, 2013).

1.3.1 Market and Infrastructure Factors

Argentina has come a long way from its financial crisis in 2002 when energy prices dipped dangerously low and the country's economy declined. In response, the Argentinean government minimized the devaluation effect in the energy sector by freezing tariffs for gas and electricity and removing taxes from exports. Local producers benefited from frozen tariffs while devaluation improved Argentina's competitiveness in the global market. The government committed to increase the regulated tariffs to industrial customers in an agreement signed with natural gas producers in 2004, allowing for gradual recovery of natural gas prices in the country. These strategies of controlling tariffs helped Argentina emerge as competitive, providing a favorable climate for investments (Perczyk, 2006).

Argentina also experienced an energy crisis in 2004 in which demand outstripped supply, leading to a default on a gas export contract with Chile. In an effort to avoid future such scenarios, the country instituted additional energy sector reforms. It established the Energía Argentina Sociedad Anónima (ENARSA), a state-owned energy company that will be involved in all aspects of the energy sector, while the government made plans to liberalize energy pricing and provide downstream investment incentives (Perczyk, 2006).

The business climate for energy enterprises in Argentina has also improved significantly from the regional integration of Latin American economies. MERCOSUR's (South American Common Market – Argentina, Uruguay, Paraguay, and Brazil) development in 1995 and its subsequent amendments have spurred the investment climate; MERCOSUR members have achieved the greatest degree of energy sector integration to date. Power system integration has occurred between Argentina and Brazil, thereby providing the physical infrastructure necessary to facilitate exchange of electricity between the two countries. Further, Argentina is a member of Organization Latinoamericana de Energia, a Latin American Energy Organization, which provides a framework for developing, integrating, selling, etc. of energy resources in the region.

Argentina has also initiated steps to conserve the environment. In 2011, Argentina was South America's second largest energy consumer and the second largest CO_2 emitter from fossil fuel consumption (EIA, 2014b). With environmental protection growing in importance, the government has entered into cooperative relationships with the industry to facilitate environmental restoration. Requirements to repair a legacy of abandoned drilling wells, production mud pits, and leaking natural gas infrastructure, and to reduce gas-flaring were put in place.

Currently, Argentina has one of the most competitive and deregulated power sectors in South America. Argentinian government has opened up generation, transmission, and distribution to the private sector, and guarantees suppliers access to the grid. In a bid to meet its increasing electricity demands, Argentina sought to expand its thermal generation capacity and released a tender in 2006 for a new 240-MW coal-fired power plant in Santa Cruz province, the Rio Turbio power plant (PennEnergy, 2014). The Rio Turbio plant will be the country's first 100 percent coal-fired power plant, and YCRT hopes to stockpile enough coal from its Rio Turbio mine to run the plant for two years.

These changes in business environment and government requirements are creating a favorable market for CMM development in Argentina. An added incentive is Argentina's substantial gas-in-place resources. With natural gas being Argentina's primary energy source and with the third largest gas reserves in South America, there is an extensive pipeline network not only domestically but to the neighboring countries of Chile, Bolivia, Brazil, and Uruguay that could provide access to both domestic and international markets for gas produced from coalfields (EIA, 2014b). Argentina already has several landfill methane projects on the ground. A starting point for identifying and quantifying CMM/abandoned mine methane development potential in Argentina would be gathering basic information on the methane content of Argentinean coals. Similarly, site-specific data on methane emissions from individual mines, active and abandoned, would be required.

1.3.2 Regulatory Information

While ownership of most minerals in Argentina does not rest with the surface owner, the national government nevertheless is bound to grant a mining license to the discoverer of new deposits. In return, the licensee pays an annual royalty, invests a minimum amount of capital, and can execute reasonable exploitation (MEOSP, nd).

In the natural gas sector, gas distribution is enhanced by open access to the distribution pipeline system for producers and distributors, with transport rates regulated by ENARGAS (Natural Gas Regulatory Authority). Gas users may build a pipeline at their own cost, connect it to the distribution network, and purchase gas directly from producers to avoid distribution costs (MEOSP, nd).

The following federal bodies regulate environmental compliance: Secretaria de Mineria (Department of Mining), Secretaria de Ambiente y Desarrollo Sostenible (Department of Environment and Sustainable Development), and Secretaria de Energía (Department of Energy). Provincial authorities also play a role in ensuring environmental compliance, having established their own policies that largely mirror the federal requirements.

1.4 Profiles of Individual Mines

Rio Turbio Mines

General Overview

Rio Turbio, an active mine located in the Austral Basin in Santa Cruz Province in southern Argentina, is considered to be developed in an extension of the Magallanes Basin to the west (in Chile).

General Information

Total mineable reserves (thousand tonnes)	750,000

General Geologic Information

Number of coal seams above currently mined	None. Five coal-bearing units (mantos) are present: Manto Inferior (lowermost); Manto Superior, Manto B, Manto A, and Manto Doreta (uppermost). At present, only Manto Doreta (1.92 m thick) is being mined.
Aggregate thickness of coal seams above currently mined	None

Geologic and Mining Conditions

Rank of coal	Bituminous
Pitch, degrees	5 – 10 degrees, east dipping
Ash content, % (coal in place, run-of-mine)	12.05%
Moisture, % (coal in place, run-of-mine)	7.65%

Coal Production, Methane Emissions, and Degasification (and Use) Statistics

	1990	1991	1992	1993	1994	1995	1996
Coal Production (million tonnes)	0.28	0.29	0.20	0.16	0.14	0.30	0.31
Methane Emissions (bm³)	0.13	N/A	N/A	N/A	N/A	0.007	N/A
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Coal Production (million tonnes)	0.25	0.29	0.35	0.26	0.19	0.04	0.20
Methane Emissions (bm³)	N/A	N/A	N/A	0.018	N/A	N/A	N/A

Source: Perczyk, 2006

Pico Quemado Mines

General Overview

This mine, located in the south central part of the country, is currently abandoned.

General Information

Total mineable reserves (thousand tones)	75,000 (estimated as regional total less Rio Turbio reserves)

General Geologic Information

Number of coal seams above currently mined	N/A; volcanic intrusions overlay the coal seams
Faults?	Yes, minor

Geologic and Mining Conditions

Ash content, % (coal in place, run of mine)	47.03%
Moisture, % (coal in place, run of mine)	17.61%

Coal Production, Methane Emissions, and Degasification (and Use) Statistics

	1990	1991	1992	1993	1994	1995	1996
Coal Production (million tonnes)	None	None	None	None	None	None	None
Degasification	None	None	None	None	None	None	None
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Coal Production (million tonnes)	None	None	None	None	None	None	None
Degasification	None	None	None	None	None	None	None

Source: Perczyk (2006)

1.5 References

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2 Australia

2.1 Summary of Coal Industry

2.1.1 Role of Coal in Australia

Australia is the fifth largest producer of coal in the world, behind China, the United States, India, and Indonesia. Although rich in energy resources with significant petroleum, natural gas, and coal reserves, its energy consumption is dominated by coal, which fuels most of the country's power generation. In 2011, coal accounted for 69 percent of the country's electricity generation (IEA, 2013). This is a decrease from previous years where coal has consistently accounted for 75 percent of power generation.

Australia ranks fifth in black coal (all non-lignite coal) production, with its current economic reserves estimated to sustain production for the next 200 years. About 97 percent of Australia's black coal production comes from Queensland and New South Wales (NSW) with very small production in Tasmania and Western Australia, and it ranks second in metallurgical coal production. Australia also produces about 8 percent of the world's brown coal and ranks third after Germany and Russia. All of its brown coal (lignite) production comes from Victoria, with more than 98 percent sourced from the La Trobe Valley (ACA, 2009; M2M – Australia, 2005; WCA, 2013; UNFCCC, 2014a).

Australia is the world's second largest coal exporter. It exported 301 million tonnes (Mmt) in 2012, comprising 24 percent of total world coal exports. As of 2012, Australia exported about 70 percent of its annual coal production, with the largest share going to Japan. Other markets included Taiwan, South Korea, China, and India (WCA, 2013; UNFCCC, 2014a).

Table 2-1 quantifies Australian coal reserves and recent production.

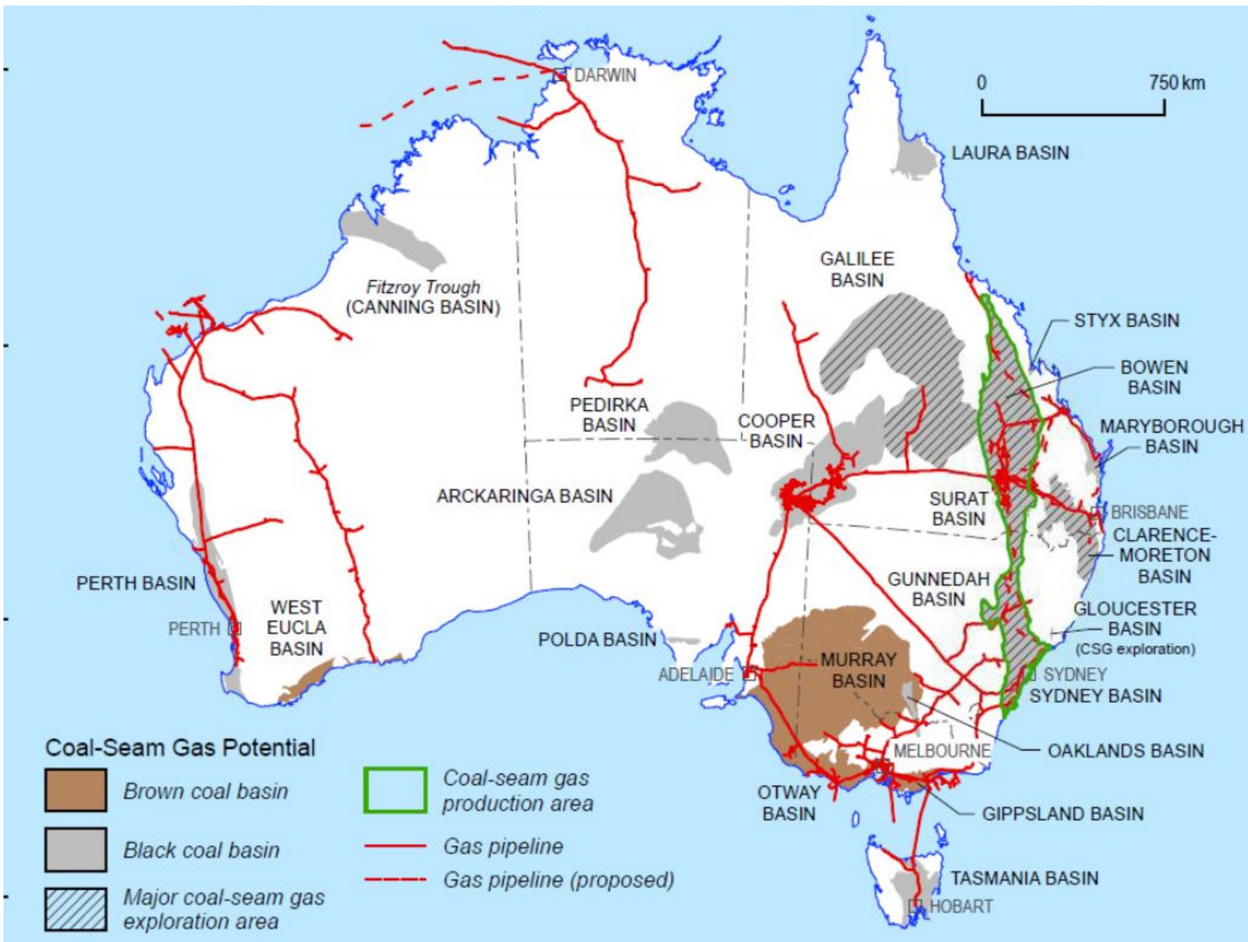
Table 2-1. Australia's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2012)	37,100	39,300	76,400	4 (8.9%)
Annual Coal Production (2012)	317,3*	113.4*	430.7*	5 (5.4%)

Sources: BP (2013); *IEA (2013)

Australia has large deposits of both brown and black coals, located on the east coast in the states of Queensland, NSW, and Victoria (see Figure 2-1). In NSW, the principal coal fields are the Southern, Newcastle, Hunter, and the Western NSW. In Queensland, the main coal fields are the Northern Bowen Basin, the Central Bowen Basin, and the Southern Basin. Since 1990, there has been strong growth in production from the Hunter and Bowen Basins and declines from the Southern and Newcastle Basins (UNFCCC, 2014a). Hard coal reserves are located primarily in NSW (37 percent) and Queensland (59 percent) (EIA, 2009). The Bowen Basin in Queensland contains the largest reserves at 37.8 billion tonnes (Bt). Reserves in the Sydney-Gunnedah Basin and surrounding areas of northern NSW contain about 32.1 Bt (EIA, 2009). Minor reserves are also located in Southern and Western Australia, as well as Tasmania (USGS, 2002).

Figure 2-1. Australia's Coal Fields



Source: Australian Gas Resource Assessment (2012)

2.1.2 STAKEHOLDERS

Table 2-2 identifies potential key stakeholders in Australian coal mine methane (CMM) development.

Table 2-2. Key Stakeholders in Australia's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ BHP-Billiton ▪ Rio Tinto (Coal & Allied Industries Limited; Pacific Coal) ▪ GlencoreXstrata ▪ Anglo Coal ▪ Peabody Energy ▪ Vale ▪ Ensham Resources ▪ Anglo Coal Australia Pty Ltd ▪ Illawarra Coal Holdings Pty Ltd ▪ Planet Gas Ltd. ▪ Centennial Coal	Project hosts / potential project hosts
Developers	▪ Arrow Energy ▪ BG Group ▪ Santos ▪ Queensland Gas Company (QGC) – a BG subsidiary ▪ Petronas ▪ Energy Developments Ltd. ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Equipment Manufacturers	▪ BCCK ▪ BOC Gases ▪ Caterpillar ▪ ComEnergy ▪ Cummins Engine ▪ Engelhard ▪ Ingersoll-Rand ▪ MEGTEC Systems ▪ Northwest Fuels Development ▪ Solar Turbines ▪ Waukesha Engines	Methane treatment and utilization equipment
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Natural Gas Transmission & Distribution Companies; Power Companies	▪ Stanwell Corporation ▪ CS Energy ▪ Tarong Energy Corporation ▪ AGL Energy ▪ Epic ▪ Ergon ▪ Energex	
Universities, Research Establishments	▪ Australian Coal Association Research Program ▪ Commonwealth Scientific and Industrial Research Organization (CSIRO) ▪ Energy Development Limited	Technical assistance
Regulatory Agencies	▪ Queensland Department of Natural Resources and Mines ▪ NSW Department of Primary Industries Minerals	Project identification and assessment support
Government Groups	▪ Department of Industry, Tourism, and Resources ▪ Australian Greenhouse Gas Office ▪ Department of Environment, Water, Heritage, and the Arts	Licensing and permitting

Table 2-2. Key Stakeholders in Australia's CMM Industry

Stakeholder Category	Stakeholder	Role
Other	▪ Large-scale industrial applications ▪ Fertilizer plants (Incitec) ▪ Retail consumers	

2.1.3 Status of Coal and the Coal Mining Industry

Australia's coal production has increased by 88 percent over the last two decades, with more operations coming online every year (BP, 2013). There were 137 coal mines operating in 2012, located across Australia: 89 open pit and 48 underground operations (UNFCCC, 2014a). Underground mines account for 59 percent of coal production in NSW and 10 percent of coal production in Queensland. Table 2-3 breaks up Australia's coal production by mining method and region (ACA, 2009).

In addition to Australian private mining companies, international companies also play a large role in Australian coal production. Major coal companies operating in Australia include: BHP-Billiton, Rio Tinto Coal, GlencoreXstrata, Peabody, Vale, and Anglo Coal. Australia mostly produces high-quality coking and steaming coals that are high in energy content and low in sulfur, ash, and other contaminants.

Table 2-3. Australia's Coal Production by Mining Method and Region (Mmt)

	Black Coal (Raw Production)						
	2006/07	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**	**2012/13**
NSW	130.9	135.0	137.8	147.3	157.0	167.2	185.6
Queensland	184.1	180.5	190.5	208.9	179.8	188.2	202.7
South Australia	3.9	3.9	3.6	3.8	3.7	2.6	2.2
Western Australia	6.0	6.2	7.0	6.7	7.2	7.0	7.5
Tasmania	0.4	0.4	0.4	0.4	0.4	0.3	0.4
Total Production	**325.2**	**326.0**	**339.3**	**367.1**	**348.1**	**365.3**	**398.4**

Source: BREE (2014)

2.2 Overview of CMM Emissions and Development Potential

Globally, Australia ranks fifth in annual CMM emissions behind China, the United States, Russia and Ukraine. By 2020, however, Australia's emissions are expected to surpass Ukraine's (USEPA, 2012).

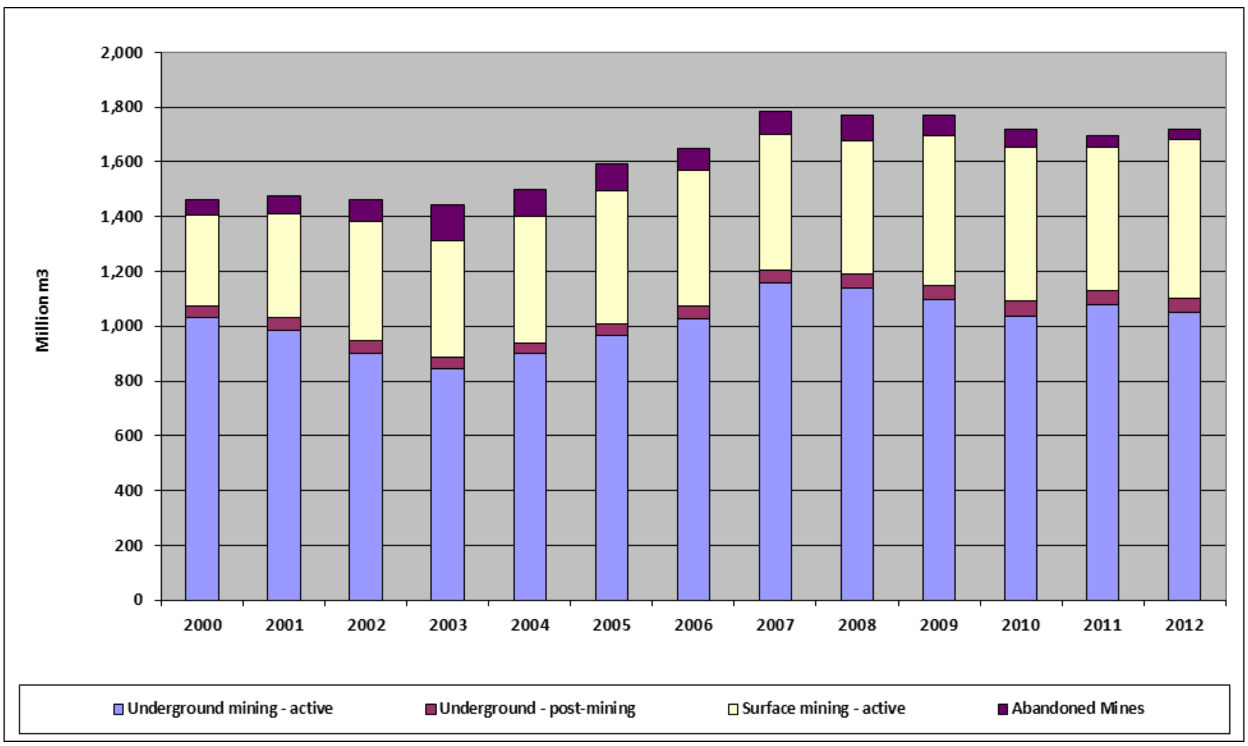
Although Australia's coal production has doubled since 1990, CH_4 emissions have not grown as fast. Production from surface mines is increasing at a faster rate than coal production at underground mines, and there is a decreasing share of underground production from the gassiest southern NSW coalfield according to the Australian National Inventory (UNFCCC, 2014a).

2.2.1 CMM Emissions from Operating Mines

In 2012, net emissions associated with coal mining and handling, and decommissioned mines were 24.9 metric tons of carbon dioxide equivalent ($MTCO_2e$) and accounted for 4.6 percent of Australia's total net greenhouse gas (GHG) emissions of 543.6 $MTCO_2e$ (UNFCCC, 2014a). Coal sector methane emissions increased 44 percent between 1990 and 2012, while coal mine production doubled. Emissions per 1000 tonnes of coal produced decreased by 29 percent from 82 $MTCO_2e$ to 58 $MTCO_2e$ over the same time period and this reduction is primarily attributed to the mining of less gassy coal reserves and the expanding implementation of methane recovery, use, and flaring technologies (BP, 2013; UNFCCC, 2014a).

The Australian government estimates that ventilation air methane (VAM) is responsible for 60 percent of Australia's underground coal mine emissions, with a typical gassy mine producing VAM at a rate of 150 to 300 cubic meters/second(m^3/s) (M2M – Australia, 2005). Figure 2-2 shows Australia's CMM emissions (including emissions from abandoned mines) from 1990-2012.

Figure 2-2. Australia's Fugitive Emissions from Coal Mining, 2000-2012



Source: Australian Government Department of the Environment (2012)

Table 2-4 shows Australia's historic and projected CMM emissions.

Table 2-4. Australia's CMM Emissions 2000-2012 (million cubic meters)

Emission Category	2000	2005	2010	2015 (projected)
Underground mining - active	1,030	966	1,035	
Underground - post-mining	46.01	43.36	58.87	
Surface mining - active	329.18	486.59	559.46	
Surface - post-mining	N/A	N/A	N/A	
Abandoned Mines	54.99	99.02	66.28	
TOTAL	**1,460.18**	**1,594.97**	**1,719.61**	**2,069.97***

Sources: UNFCCC (2014a); *USEPA (2012)

There are currently 25 CMM projects registered in Australia at 19 mines, 14 of which are active underground mines and 5 are abandoned mines. Nine of the projects involve flaring recovered gas; 10 projects generate electricity using reciprocating engines; three projects destroy VAM, two projects involve injection of high quality CMM into a sales pipeline, and there is one boiler fuel project (GMI, 2014a).

Nine projects use CMM to generate 215 MW of electricity sold into the national grid, and the Clean Energy Future Plan has a goal of a five percent reduction on 2000 levels GHG emissions by 2020 (GMI –Australia, 2013). The largest CMM power station is located at BHP Billiton's Appin and Tower mines near Sydney. Commissioned in 1996, this project consists of 94 1-MW reciprocating engines and consumes 600,000 m^3 of CMM a day. Other large power plants, built and operated by Energy Developments Ltd., include a 32MW project at the German Creek coal mine (uses 16 2MW engines and came on-line in November 2006) and the $60 million 45MW plant at Anglo's Moranbah North coal mine (uses 15 3MW engines and started operation in late 2008). Both of these plants are located in the Bowen Basin in central Queensland (Energy Developments, 2010).

In one landmark CMM project, BHP Billiton was awarded up to $6 million from the Australian Greenhouse Office (AGO) to construct a CMM power station at the West Cliff Colliery, near Wollongong, NSW, to allow the combustion of very dilute methane contained in coal mine ventilation air (also known as VAM) (BHP, 2010). The West Cliff VAM Project (WestVAMP) officially opened on 14 September 2007 and was the first to generate commercial power solely from VAM. The project burns 0.9 percent VAM concentration to produce 6 MW of electricity via a conventional steam turbine. Along with displacing coal-fired electricity generation, WestVAMP is estimated to reduce emissions by up to 0.250 million $MTCO_{2e}$ each year (MEGTEC, 2008; 2010).

2.2.2 CMM Emissions from Abandoned Coal Mines

The latest report on Australia's GHG emission trends, released by the Department of Climate Change, notes that emissions from decommissioned mines are small (relative to total emissions), at 0.53 $MTCO_2e$ in 2012 (UNFCCC, 2014a). Emission levels vary with mine closures, but are projected to be 1.3 $MTCO_2e$ in 2020 (DCC, 2009).

2.2.3 CBM FROM VIRGIN COAL SEAMS

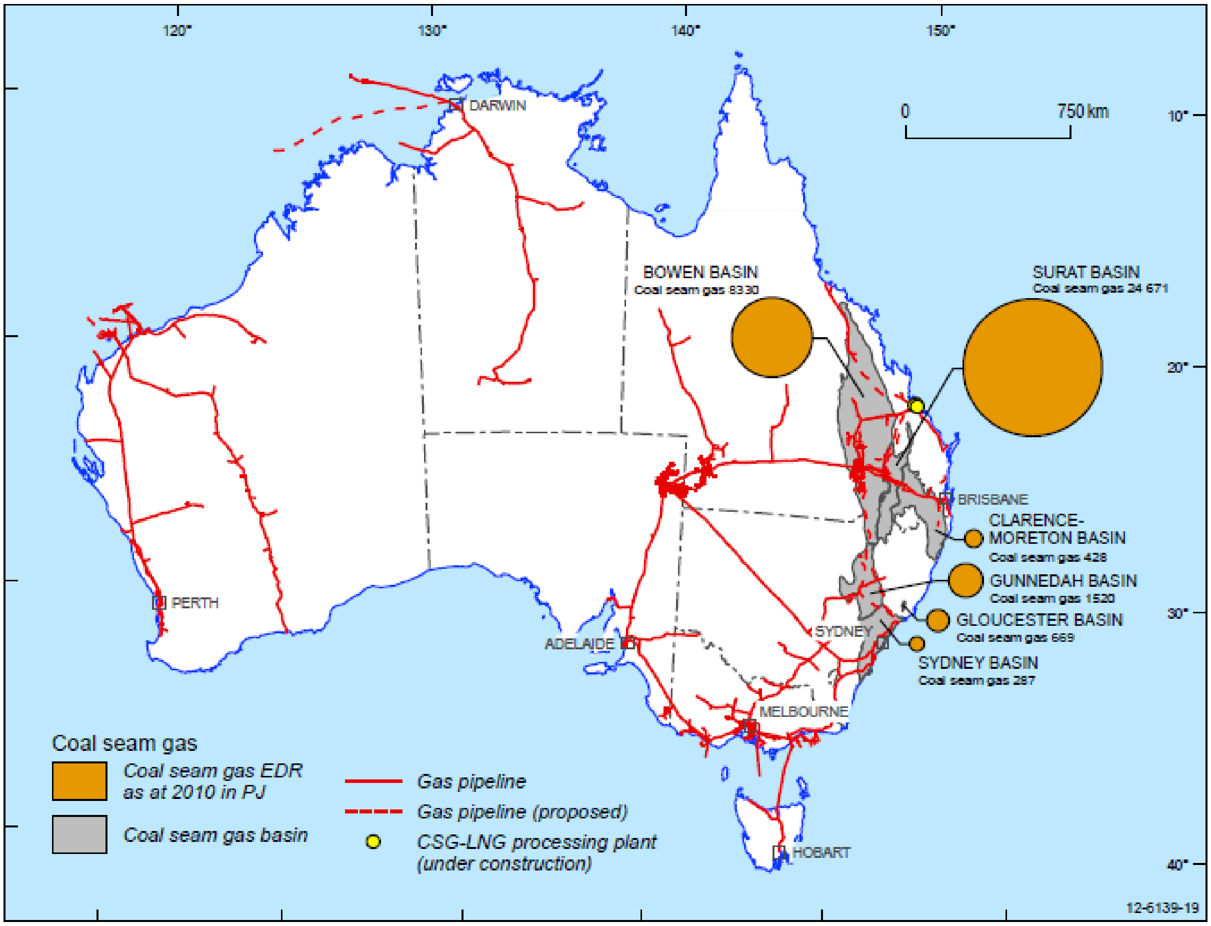
Australia has the most active development of unconventional gas outside of North America. Coal bed methane (CBM) recovery activity has been focused predominately in NSW and Queensland, Australia's two largest coal-producing states, with 97 percent of CBM production occurring in Queensland and 3 percent in the Sydney Basin of NSW (IEA, 2012). Exploration for CBM is also occurring in Victoria (M2M – Australia, 2005). Drained CBM has been used to generate electricity in NSW since the 1980s, while commercial CBM production began in Queensland in 1996, providing pipeline-quality gas to three coastal cities (Schwochow, 1997).

Annual CBM production in Australia more than doubled between 2003 and 2006, from 538 million m^3 to 1.6 billion m^3 (Bcm). The rapid rate of increase in production has continued with 2.9 Bcm produced in 2007, 3.7 Bcm in 2008, and 5.2 Bcm in 2011 (AIMR, 2014). In 2003, CBM accounted for 3 percent of Australia's total gas production. By 2010, CBM's share had increased to 10 percent (AIMR, 2014). At the same time, proved and probable reserve estimates have risen rapidly to 934 Bcm (33 Tcf) in 2011 with 92 percent of reserves located in Queensland and the rest in NSW (AIMR, 2014). At current production this is a 150 year reserve life. Total CBM resources including Economic, Subeconomic, and Inferred Resources (JORC Code) was 5.75 Tcm (203 Tcf) in 2012 (Australian Gas Resource Assessment, 2012).

In 2011, 97 percent of Australia's CBM production came from the Bowen and Surat Basins in Queensland representing 88 percent of Queensland's gas production for that year (Queensland, 2014). Analysts believe CBM could provide up to 50 percent of the Australian east coast natural gas supply by 2020 (AIMR, 2009).

During 2012-2013, CBM exploration in Queensland continued at record levels with about 1315 CBM wells drilled (Queensland, 2014). The Bowen, Galilee and Surat Basin continue to be the main areas of focus, while the Sydney, Gunnedah, Gloucester and Clarence-Morton Basin are being targeted in NSW.

Figure 2-3. Location of Australia's Coal Seam Reserves



Source: Australia Gas Resource Assessment (2012)

Driving much of the recent CBM activity, several major international companies have acquired stakes in Australia's CBM industry with plans to convert CBM into liquid natural gas (LNG) for export to the energy hungry markets of Southeast Asia. The BG Group, Santos Ltd. (with Petronas), ConocoPhilips (with Origin Energy), and Royal Dutch Shell are planning four separate CBM-to-LNG projects in Queensland (Dow Jones Newswires, 2010).

For details on all ongoing CBM operations and the vested companies, visit the Australian Mines Atlas at http://www.australianminesatlas.gov.au/aimr/commodity/coal_bed_methane_09.jsp.

2.3 Opportunities and Challenges to Greater CMM Recovery and Use

Australia is a signatory to the UNFCCC and ratified the Kyoto Protocol in 2007 (see Table 2-5). Australia is committed to meeting its Kyoto target to reduce GHG emissions by 5 percent below 2000 levels by 2020 as well as a very ambitious internal target of 80 percent reduction of 2000 levels by 2050 (Calder, 2011).

Table 2-5. Australia's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 4, 1992	December 30, 1992
Kyoto Protocol	April 29, 1998	December 3, 2007

Source: UNFCCC (2014b)

Having ratified the Kyoto Protocol, Australia is now able to take advantage of the revenues generated by its carbon emission reductions. Other opportunities for project financing include the Greenhouse Gas Abatement Program (GGAP), providing up to $43.47 million to support the development of power stations using CMM. GGAP aims to reduce Australia's net GHG emissions by limiting emissions to 108 percent of 1990 levels between 2008 and 2012. The country is on track to meet this target. The Australian government is funding four CMM projects (for seven individual power stations) in Queensland and NSW under the GGAP (IEA, 2009).

Australia's Carbon Pricing Mechanism (CPM) came into effect on 1 July 2012. Regulated entities were required to pay a fixed price for their emissions until 1 July 2015, when the carbon price will change to a market-determined floating price. The carbon pricing mechanism covered a range of large business and industrial facilities. The carbon price was fixed for the first three years of the CPM. In 2013-14, it was AUS$24.15 a tonne.

In April 2014, the Liberal Government, elected in 2013, released a white paper offering an alternative to the CPM, and in July 2014, Australia's Senate repealed the CPM.

The white paper proposes to replace the CPM with an Emissions Reduction Fund of AUS$2.55 billion, part of the Government's Direction Action Plan. Under the proposed incentive-based plan, emission reduction projects would be voluntary and the project sponsors would offer emission reductions to be generated by the project in an auction. Actual emission reductions would be purchased by the Government as they are generated using the Emissions Reduction Fund (ERF). The proposed scheme is similar to approaches being considered in other markets, collectively referred to as Results Based Financing.[3] However, international offsets will not be accepted into the ERF.

Technical working groups have been established to develop methodologies for certain source categories including CMM. Sources with straightforward methods that can be developed quickly are being prioritized so that those methodologies are being developed first. CMM, in particular, is noted in the White Paper as an example because emissions are already covered under the National Greenhouse and Energy Reporting Scheme. The CMM methodology will reportedly cover the capture and flaring and/or electricity generation at underground and open cut mines and, in time, VAM oxidation at active underground mines. It will use existing factors used under the National Greenhouse and Energy Reporting (NGER) Scheme to directly measure the amount of methane captured and destroyed (Australia Ministry of Environment, 2014).

On 31 October 2014, the Australian Senate passed the Carbon Farming Initiative Amendment Bill 2014. The Bill will take effect once passed by the House as amended. This will establish the

[3] See World Bank: http://siteresources.worldbank.org/EXTCARBONFINANCE/Resources/Methane_Finance_Study_Group_Report.pdf

Emissions Reduction Fund. The Clean Energy Regulator will begin administering the scheme once legislative amendments start and the necessary legislative rules are made (Department of Environment, 2014).

Australia has included coal seam methane in its Renewable Energy Target definition for a transitional period to greater renewable production (Renewable Energy, 2010). Aside from the federal level support for CMM/CBM development, the governments of NSW and Queensland provide further incentives for their development. Queensland is promoting a transition to gas supplies via its Smart Energy Policy. Starting in 2010, 15 percent of all electricity sold in Queensland has to be from gas-fired generation, which may be increased to 18 percent by 2020 (Smart Energy, 2010). NSW has had a Greenhouse Gas Reduction Scheme since 2003 that encourages a switch from coal-based energy production to natural gas-based production, including CBM/CMM (GHG Reduction, 2010).

2.3.1 Market and Infrastructure Factors

Although Australia's CMM development has been primarily driven by mine safety concerns, the industry has received a boost from the country's GHG emissions reduction obligations and accompanying incentives from the national government (see GGAP discussion in section 2.1). State-based schemes have also provided additional incentives to encourage a shift in energy use towards natural gas, including CBM and CMM.

Electricity generation has provided the main market for drained CMM and based on expected growth in the industry, there is potential to double generating capacity over the next decade (GMI, 2014a). Growth in the coal mining industry is robust with six new coal mine projects, valued at more than $1.5 billion, completed in 2008-2009, and a further twenty-one projects scheduled for completion in the near to medium term (ACA, 2009).

While Queensland produces more than 90 percent of CBM volumes, NSW coal basins hold greater potential for CMM development with greater coal production from underground mines in NSW than in Queensland (51.6 Mt versus 30.8 Mt, respectively) (NSWMC, 2009; GSQ, 2010) and generally gassier mines. With natural gas infrastructure in place and serving the Sydney-Newcastle corridor, local major energy markets are conveniently accessible.

In contrast with eastern NSW, gas transport infrastructure is more limited in Queensland, and CBM projects have historically been sited near existing gas pipelines, such as the 750 km Wallumbilla-Ballera pipeline which connects the gas fields of the Cooper Basin to eastern Queensland. But major pipeline projects are in development, driven by planned CBM to LNG projects. The BG Group is planning a 380 km underground pipeline from the Surat Basin to the port of Gladstone to deliver CBM to its proposed LNG plant. Additional pipeline capacity will be built to link BG's CBM resources to the new transmission pipeline. In 2009, BG Group signed an LNG Project Development Agreement with China National Offshore Oil Corporation (CNOOC) who is the intended customer for the produced LNG (BG Group, 2010). Santos Ltd reports that it plans to upgrade field infrastructure at the Fairview CBM field and also build a pipeline to Gladstone as part of its proposed CBM to LNG project (OGJ, 2010).

Major pipeline operators such as Epic Energy and the APA Group have been active in expanding the capacity of existing pipelines in Queensland and NSW, adding compression facilities, building links between the major pipelines and adding new inlet stations to receive CBM from new production areas (AGL, 2009; APA, 2010).

Australia has been a world leader in work on the development and trial of technologies to capture and use CMM, VAM, and CBM. Commonwealth Scientific and Industrial Research Organization (CSIRO), Energy Development Limited, and BHP Billiton, are some of the Australian organizations who have conducted research, development, and demonstration work related to the recovery and utilization of CMM and VAM.

BHP Billiton's WestVAMP project (see section 2.2.1) was the first commercial demonstration using a thermal flow-reversal oxidizer for VAM-fueled power generation, while CSIRO has funded the development of new lean-fuel catalytic gas turbines designed to capture 1 to 2 percent of methane from ventilation air (VAMCAT). The first trial of the technology, sponsored by AGO, took place at the Huainan mine in China. Other VAM mitigation technologies being researched include catalytic flow reverse reactors; catalytic monolith combustors; and recuperative gas turbines.

CSIRO is also investigating enhanced CBM techniques to increase methane drainage from coal seams before opencast mining takes place. Other research topics include gas drainage systems improvement and cogeneration of electricity using CMM in coal fired power plants (M2M – Australia, 2010; M2M – Australia, 2005).

Other important projects in which the Australian Government has invested include (GMI, 2014b):

- The University of Newcastle VAM Abatement Safety Project demonstrating large-scale VAM capture duct complete with safety control measures and supporting design and testing information and understanding the underlying scientific and engineering principals behind methane ignition, deflagration, and detonation. Australian Government funding is AUS $12.5 million and total project value is AUS $27 million.
- The University of Newcastle Chemical Looping VAM Abatement Project investigating mitigation of VAM flows at concentrations ranging from 0.005 percent to 2.0 percent using a 1-m^3/s VAMCO prototype and then a 10 m^3/s pilot scale demonstration unit. Australian Government funding is AUS $2.7 million and total project value is AUS $8.5 million.
- Glencore Coal Australia Methane Capture and Abatement Optimization to increase the longwall gas capture efficiency from 60 percent to 80 percent. Site characterization, monitoring and measurement, a fundamental modeling study and development are mostly completed.

2.3.2 Regulatory Information

The legal framework governing resource ownership and licensing in Australia is complex because there is currently no national legislative framework in place for CMM. Each state has its own legislation and licensing arrangements.

In Queensland, a Mining Lease for coal does not provide rights to the contained coal seam gas. CMM production comes under the *Petroleum and Gas (Production and Safety) Act of 2004* and requires a Production License which can co-exist with a Mining Lease covering the same area. The Queensland government had released a new regimen in November 2002 to address issues that arise where CBM and coal exploration and production activities may occur under different tenures granted over the same area. To implement the regimen, a new *Petroleum and Gas (Production and Safety) Act* was passed in 2004 to replace the *Petroleum Act of 1923*. Recent amendments to legislation in Queensland have established a clear distinction between resources administered under the *Mineral Resources Act of 1989* and those coming under the *Petroleum and Gas (Production and Safety) Act of 2004.*

In NSW, a Mining Lease or Exploration License is required before mining operations commence. If the holder of the lease wants to extract coal seam gas, an application must be made for the inclusion of petroleum in the Mining Lease. Although CMM extraction and utilization currently falls under a coal extraction or Mining Lease, more specific regulation is being drafted. The *Mining Act of 1992* is the principal legislation governing mineral exploration in NSW. Under the *Mineral Resources Act 1989 (NSW)*, where CMM is produced as a by-product of coal mining, there is no provision for payment of royalties on VAM, or on pre- or post-drainage methane that is flared. Waste methane flaring in NSW has been standard, but further legislative changes to the *Mineral Resources Act* now require that pre- and post-drainage methane is used or flared rather than simply being vented. CBM is however considered a petroleum product in NSW and hence, falls under the *Petroleum (Onshore) Act of 1991*.

In Queensland, where an oil and gas exploration tenement co-exists with a coal mining lease, and production testing within that exploration tenement yields in excess of 3 million m^3 of gas, the tenement holder is liable for royalty payments. However, in order to facilitate the development of deep coal seams in and around Sydney, the NSW state government has not been imposing royalties on the capture and utilization of waste gases from coal mining and is providing a 5-year exemption for stand-alone coal seam gas operations.

In Victoria, CBM resources are administered under the legislation for mineral resources development.

2.4 Profiles of Individual Mines

Some of Australia's most productive underground coal mines are listed in Table 2-6.

Table 2-6. Major Australian Underground Coal Mines

Mine	Location	Operator	Annual Coal Production (million tonnes)
Broadmeadow	Bowen Basin, Queensland	BMA (BHP Billiton Mitsubishi Alliance)	4
Moranbah North	Bowen Basin, Queensland	Anglo Coal	4.5
German Creek mines	Bowen Basin, Queensland	Anglo Coal	6
Kestrel	Bowen Basin, Queensland	Rio Tinton Coal Australia	4
North Goonyella	Bowen Basin, Queensland	Peabody Energy	2-3
Oaky Creek	Bowen Basin, Queensland	Xstrata	11 (rom)
Beltana	Hunter Valley, NSW	Xstrata	7.6
Clarence	Western Coalfield, NSW	Centennial Coal	2.5
Springvale	Western Coalfield, NSW	Centennial Coal	7

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3 Botswana

3.1 Summary of Coal Industry

3.1.1 Role of Coal in Botswana

Botswana possesses huge coal resources estimated at greater than 200 billion tonnes. However, only three to five billion tonnes can be economically mined (Mmegi, 2009). The quality of coal is suitable for power generation and is the feedstock for 99.4 percent of electricity generated in the country (eStandards Forum, 2009). Table 3-1 quantifies total recoverable reserves and recent coal production in Botswana.

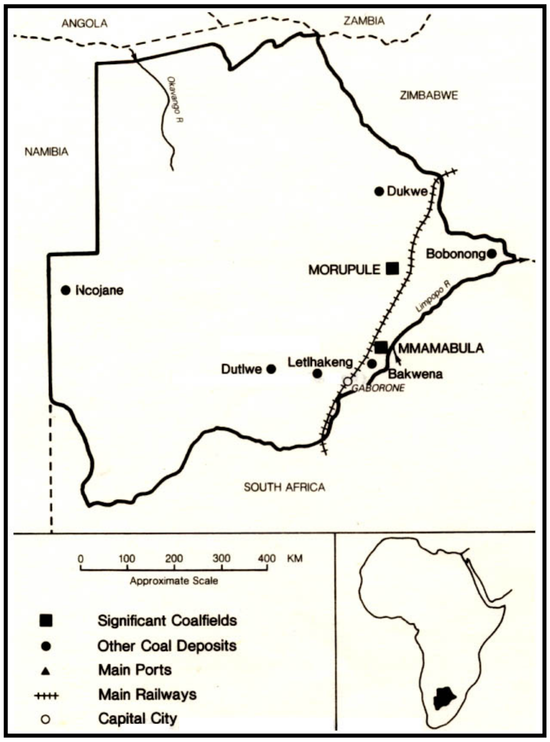
Table 3-1. Botswana's Coal Reserves and Production

Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2011)	39.99	0	40	67 (0.0045 %)
Annual Coal Production (2012)	0.740	0	0.740	47 (0.02%)

Source: EIA (2013)

In 2012, coal represented 21.6 percent of Botswana's total primary energy supply (IEA, 2014). At present, all coal mined is used domestically for power production, but studies are under way to explore the possible exportation of coal mined at the Morupule mine, the country's only operating mine (Mining Journal, 2005). The Morupule mine has completed Phase I of its expansion and is investigating reserves in the northern boundary of its mining lease to establish an open pit mine to meet additional demand as a part of Phase II (BCM, 2014). The Morupule Mine is located in the Morupule coalfield near the town of Serowe (Figure 3-1) and is the most thoroughly explored of Botswana's coal fields. The only other major coal field to be explored in some detail is Mmamabula, situated about 81 miles south of Morupule (IEA, 2010).

Figure 3-1. Botswana Coalfields Map



Source: IEA Coal Research (1983)

3.1.2 STAKEHOLDERS

Table 3-2 identifies potential key stakeholders in Botswana's coal mine methane (CMM) and coal bed methane (CBM) development.

Table 3-2. Key Stakeholders in Botswana's CMM Industry

Stakeholder Category	Stakeholder	Role
Developers	Kalahari Energy Tlou Energy Limited (TLOU) Anglo Thermal Coal (formerly Anglo Coal Botswana) Jindal Power & Steel Many other small developers See http://www.epa.gov/coalbed/networkcontacts.html	Project developer
Engineering, Consultancy and Related Services	Scales & Associates Advanced Resources International See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
	Botswana Development Corporation	Research

3.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

The Morupule Mine is 93 percent owned by Debswana (a joint venture of DeBeers and the Government of Botswana) and supplies coal to Botswana's only coal-fired power station.

Production from the mine is relatively stable (0.7-1 Mt per year) as it is essentially a captive mine for the Morupule Power Station. The mine also supplies coal to hard rock mining operations at Selebi-Phikwe and to the Sua Pan soda ash plant, and coal is exported to Zimbabwe, Zambia and the Democratic Republic of the Congo.

Debswana has completed Phase I of its coal production expansion at the Morupule Mine and raised production capacity to 3.4 million tonnes per year (Mmt/yr) to accommodate Botswana Power Corporation's (BPC) plans to add four 150 MW coal-fired power stations alongside the existing four 33 MW units currently at Morupule (eStandards Forum, 2009).

CIC Energy Corporation, which for several years had been trying to develop the Mmamabula coal mining and energy project, was acquired in 2012 by Jindal Steel & Power, one of India's major steel producers with a significant presence in the mining, power generation, and infrastructure sectors. The initial Mmamabula efforts included a proposed export coal project, one or more power projects, and a potential coal-to-hydrocarbons project. The acquisition makes Jindal Africa the frontrunner for building a 1,200-MW power plant in Botswana to supply power to South Africa (ESI-Africa, 2012).

3.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no CMM recovery projects for Botswana, in operation or development (GMI, 2014). Updates on future CMM projects in Botswana can be found at: https://www.globalmethane.org/coal-mines/cmm/index.aspx.

3.2.1 CMM Emissions from Operating Mines

Methane emissions in Botswana were estimated at 18.9 million cubic meters (m^3) in 2000, and are projected to increase to 22.4 million m^3 by 2015, and then to 26.6 million m^3 by 2030 (see Table 3-3).

Table 3-3. Botswana's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	18.9	18.9	21.7	22.4

Source: USEPA (2012)

3.2.2 CMM Emissions from Abandoned Coal Mines

There are no reported emissions from abandoned mines in Botswana.

3.2.3 CBM from Virgin Coal Seams

A CBM feasibility study conducted for the Botswana Department of Geological Study estimated that Botswana contains about 5.6 trillion cubic meters (Tcm) of CBM reserves in the Central Kalahari Karoo Basin (ARI, 2003). However, these estimates are tenuous as they were derived from only a few core holes drilled into the coals of the basin. Helping Botswana meet growing domestic and regional demand for low-cost, clean and efficient fuel for power plants was the goal of a USTDA grant awarded to the Botswana Development Corporation (BDC). The grant funded a feasibility study on a CBM project that was estimated to have 1.7 Tcm in CBM reserves with some of the most prospective areas being found in the eastern portions of the basin (ARI, 2008). Following the completion of the study, the project was successfully implemented and yielded more than $52 million in U.S. exports for power generation units, drilling equipment, compressors, and hydraulic fracturing equipment (USTDA, nd).

In recent years, there has been a tremendous increase in interest in developing CBM projects in Botswana. The Department of Geological Survey (DGS) reported a 50 percent increase in the number of exploration licenses issued between January and December 2009 for various energy minerals, which includes coal and CBM (UGC, 2010). This interest is being driven by the favorable investment climate in Botswana, coupled with an increasingly dire power situation in the region. However, out of more than 50 companies that have taken out CBM leases in the country, very few carried out any substantial resource assessment work to date.

The main companies that have carried out significant CBM exploration activity in Botswana are Kalahari Energy (now Karoo Sustainable Energy), Anglo Thermal Coal (formerly Anglo Coal Botswana) and Tlou Energy (TLOU). Kalahari Energy (KE) has been actively pursuing CBM development since 2000, and in 2008 drilled a five-well pilot program that is currently in the production testing phase. This was financed with a U.S. Overseas Private Investment Corp (OPIC) $8.5 million investment guarantee for the purchase of equipment and the drilling of wells. In 2009, KE formed a joint venture with Exxaro Resources to perform ongoing exploration work and completed a five-well production test in late 2010 (KE, 2010). KE, which continues to pioneer energy growth in Botswana through coal-based methane exploitation, currently operates the small 90-MW Orapa power plant and is in the process of developing a new 180-MW power project in the country (EN, 2012).

Anglo Thermal Coal embarked on a major CBM exploration drive, which started in late 2008, with the aim of delineating gas reserves totaling at least 110 billion m^3 (Bcm), sufficient to justify construction of a dedicated synfuels plant. In March 2013, Anglo Thermal Coal emerged the winner of some 23 applicants for the coal blocks – the Mmamabula South and Central blocks – which are adjacent to the Mmamabula East property owned by Jindal Steel & Power, the company that recently bought CIC Energy (MiningMx, 2013). The former Saber Energy drilled over 80 exploratory holes on their lease areas from 2008 to 2010 to test coal gas content and permeability. Saber Energy was acquired by TLOU, which merged with Talon Metals Corporation in 2010. Following acquisition, TLOU performed pilot horizontal well drilling and in the coming years will prepare updated reserve/resource statements, complete marketing and commercialization arrangements (i.e., contracts), and continue to consolidate/upgrade the resource classification through additional exploration drilling (TLOU, 2013).

3.3 Opportunities and Challenges to Greater CMM Recovery and Use

Botswana, a non-Annex I country, has signed and ratified the UNFCCC and Kyoto Protocol as shown in Table 3-4.

Table 3-4. Botswana's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	April 27, 1994
Kyoto Protocol		August 8, 2003

Source: UNFCCC (2014)

In 2013, the Government of Botswana—with support from the Common Market for Eastern and Southern Africa (COMESA) and the United Nations Development Programme (UNDP)—commissioned a team of consultants to develop a National Climate Change Policy, Strategy and Action Plan. Botswana's national climate change policy was expected to be ready in 2014, while the strategy and action plan will follow (UNDP, 2013).

3.3.1 Market and Infrastructure Factors

It is doubtful whether Botswana will have significant CMM emissions in the foreseeable future. This is because there are abundant reserves of coal at relatively shallow depths and the overall demand for coal in the country is limited. Currently, the prospects for exporting coal are not good, given the distances to available ports in South Africa and limited rail infrastructure. However, in cooperation with the government of Namibia, Botswana is considering the construction of a $6 billion, 1500-mile rail link between the Mmamabula Coalfields of southeastern Botswana to either the ports of Walvis Bay or Luderitz in Namibia (Mmegi, 2009).

Since there is negligible domestic demand and support infrastructure for natural gas, the market for methane in Botswana is fairly limited (EIA, 2013).

However, CBM projects may see increased attention thanks to a report titled, *Botswana Technology Needs Assessment on Climate Change*, jointly produced by several Ministries and the UNDP. The report acknowledges Botswana's CBM reserve potential, and advises that Botswana determine such resource potential. CBM, it concludes, may be used to provide fuel for cars and power generation, and alleviate potential power crises. CBM may also be exported to Mozambique through the Maputo pipeline and to the Secunda Sasol Plant in South Africa (TNA, 2004), although this option is probably not viable now given the large offshore gas reserves recently discovered by Anadarko, ENI, and others.

To support more domestically driven power production, Kalahari Sustainable Energy (KSE) has been active in converting the 90-MW diesel turbines at the Orapa power plant over to natural gas and negotiating the development of the 180-MW Mmashoro power station. Both projects would be supplied from domestic CBM resources (CR, 2013).

3.3.2 Regulatory Information

As there are no operating CMM projects, a legal framework regulating them does not exist.

3.4 Profiles of Individual Mines

Morupule

Morupule is located along the eastern margin of the Kalahari Basin. Production began in 1973, and the mine has a production capacity of 1 Mmt/yr.

General Information

Total mineable reserves (thousand tones)	44,000

General Geologic Information

Coal seams (thickness)	Morupule Main (6.5-9.5 m) Lotsane (0.6-4.5 m) Serowe Bright (average 1.8 m)
Faults?	Yes, minor. Some dolerite dyke intrusives.

Geologic and Mining Conditions

Ash content, % (coal in place, run of mine)	40 – 50%
Moisture, % (coal in place, run of mine)	5 – 10%

Coal Production, Methane Emissions, and Degasification (and Use) Statistics

	2006	2007	2008	2009	2010	2011	2012
Coal Production (million tonnes)*	0.962	0.828	0.910	0.737	0.987	0.787	0.740
Degasification	None	None	None	None	None	None	None

Source: *EIA (2013)

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4 Brazil

4.1 Summary of Coal Industry

4.1.1 Role of Coal in Brazil

Brazil is the world's eighth largest energy consumer and the third largest in the Western Hemisphere, trailing the United States and Canada (EIA, 2013). Total primary energy consumption in the country has been increasing in recent years, but coal only accounted for approximately 5 percent in 2011 compared to 35 percent from hydroelectricity and 47 percent from oil and other liquid fuels. The country's domestic annual coal production is approximately 6.3 million tonnes (Mmt) (EIA, 2014). Brazil's annual coal consumption, however, was estimated at 24.8 Mmt in 2012, relying on 18.0 Mmt of coal imports for its energy requirements (EIA, 2014).

Brazil has recoverable coal reserves of approximately 6.6 billion tonnes, the third largest reserves in the Western Hemisphere, after the United States and Colombia (EIA, 2014). Table 4-1 presents most recent statistics for coal mining in Brazil.

Table 4-1. Brazil'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)	0	6,630.0	6,630.0	14 (0.75%)
Annual Coal Production (2012)	3.26	3.04	6.3	31 (0.08%)

Source: EIA (2014)

Demand for metallurgical coal in Brazil, the world's ninth-largest steel producer in 2011, accounts for 84 percent of the region's coal consumption from 2010 to 2040, with demand for steel in both domestic and international markets expected to increase throughout that period (EIA, 2013).

Brazil's coal mining operations are concentrated in the southern states of Santa Catarina (46 percent), Rio Grande do Sul (53 percent), and Paraná (1 percent) as shown in Figure 4-1.

Figure 4-1. Brazil's Coal Fields

Source: Maps of World (2010)

4.1.2 STAKEHOLDERS

Table 4-2 lists potential stakeholders in Brazilian coal mine methane (CMM) development.

Table 4-2. Key Stakeholders in Brazil's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Companhia Riograndense de Mineracao (CRM) ▪ Copelmi Mineracao Ltda. ▪ Carbonifera Palermo Ltda. ▪ Nova Prospera Mineracao S.A. ▪ Carbonifera Metropolitana S.A. ▪ Carbonifera Criciuma S.A. ▪ Companhia Carbonifera de Urussanga ▪ Carbonifera Treviso S.A. ▪ Carbonifera Barro Branco S.A. ▪ Ibracoque Mineracao Ltda. ▪ Companhia Brasileira Carbonifera Ararangua ▪ Industria Carbonifera Rio Deserto Ltda.	Project hosts

Table 4-2. Key Stakeholders in Brazil's CMM Industry

Stakeholder Category	Stakeholder	Role
Government Groups	▪ Carbonifera Belluno Ltda. ▪ Companhia Carbonifera Catarinese (CCC) ▪ Campanhia Carbonifera do Cambui ▪ Klabin S.A. ▪ Ministry of Environment ▪ Ministry of Mines and Energy (MME) ▪ National Department of Mineral Production ▪ Coal Mining Industry Union of the State of Catarina ▪ Sindicato da Industria da Extracao de Carvao do Estado de Santa Catarina (SIECESC)	Licensing and permitting
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities	▪ Federal University of the State of Rio Grande do Sul ▪ Associação Beneficente da Indústria Carbonífera de Santa Catarina (SATC)	Technical assistance

4.1.3 Status of Coal and the Coal Mining Industry

As previously stated, the Brazilian coal industry's mining operations are concentrated in three southernmost states. It has 15 coal mining companies, all owned by Brazilian investors. The main producers that have underground mines are the following:

Companhia Riograndense de Mineraçao (CRM) (State of Rio Grande do Sul) – CRM, a state-owned company, is the largest Brazilian coal producer with a current output of nearly 2.4 Mmt per year (CRM, 2014). Most of CRM's output comes from surface mines, but it has two underground mines. Mina do Leão I is 125 meters deep, has two shafts, and is highly mechanized, but underground production halted in 2002 due to high costs. The mine remains open as an opencast mine. Mina do Leão II is six km from Mina do Leão I and has a projected capacity of 2.4 Mmt/year of run-of mine (ROM) coal, using the longwall method at an average depth of 200 meters.

Carbonifera Criciuma S.A. (State of Santa Catarina) – The Verdinho Mining Unit II—the company's underground mine—began operations in 1982, is approximately 170 m deep, and has a capacity of 2.8 Mmt/yr ROM (CC, 2014).

Industria Carbonifera Rio Deserto Ltda. (State of Santa Catarina) – This company has two underground mines: Mina do Trevo in the municipality of Siderópolis producing 1.6 Mmt ROM annually; and Mina Barro Branco in the municipality of Lauro Muller producing 0.85 Mmt of ROM annually. Both are room and pillar mines. The company is also responsible for providing coal to Tractebel, the largest private energy generator in Brazil (RD, 2014).

Carbonífera Metropolitana S.A. (State of Santa Catarina) – This company has an annual output of nearly 1.2 Mmt ROM and 0.6 Mmt of processed coal. It has two underground room and pillar mines, Esperança and Fontanella, both in the municipality of Treviso. The Esperança mine was opened in

1984 with a nominal annual capacity of 3.0 Mmt ROM, and the Fontanella mine was opened in 1985 with a nominal annual capacity of 2.4 Mmt ROM.

Carbonífera Belluno Ltda. (State of Santa Catarina) – This company has three coal mines, only one of which is underground (Meia Encosta Fiorita), located in the municipality of Siderópolis. The company's total output is nearly 0.24 Mmt of processed coal. Its underground mine has a nominal capacity for 0.36 Mmt ROM annually.

Companhia Carbonifera Catarinense (CCC) (State of Santa Catarina) – It has two underground mines, named Bonito I and Novo Horizonte. Both are room and pillar mines (Vasconcelos, 2006).

In the near term, coal consumption in Brazil's electricity sector is set to increase with the completion of the Pecem I, Pecem II, and Itaqui power plants (EIA, 2013). Since 2011, Brazil has expanded its coal-fired power generation by 1,440 MW as shown in Table 4-3 (GEO, 2014). The number of coal-fired plants had remained unchanged for many decades, until these new projects were commissioned.

Table 4-3. Brazil's Coal-Fired Power Plants

Name of Plant	Year Commissioned/Last Unit Installed	Generating Capacity (MW)	Location (State)
Porto do Itaqui	2012	360	Maranhao
Porto do Pecem	2011/2012	1080	Ceara
President Medici (Candiota)	1974/2010	796	Rio Grande do Sul
Jorge Lacerda Thermal	1965/1997	857	Santa Catarina
Figueira	1963/1974	20	Parana
Charqueadas	1962/1969	72	Rio Grande do Sul
St. Jerome (UTSJ) Thermal	1953/1955	20	Rio Grande do Sul

Source: GEO (2014)

4.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Brazil, in operation or development. Updates on future CMM projects in Brazil can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

4.2.1 CMM Emissions from Operating Mines

Methane emissions in Brazil totaled 63.0 million cubic meters (m^3) in 2000, are expected to increase to 102.2 million m^3 by 2015, and then further increase to 146.4 million m^3 by 2030 (see Table 4-4).

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

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	63.0	72.1	80.5	102.2

Source: USEPA (2012)

4.2.2 CMM Emissions from Abandoned Coal Mines

No data were found quantifying methane emissions from abandoned mines.

4.2.3 CBM from Virgin Coal Seams

No data were found quantifying production from virgin coal seams.

4.3 Opportunities and Challenges to Greater CMM Recovery and Use

Brazil has signed and ratified both the UNFCCC and the Kyoto Protocol (see Table 4-5). As a party to the Kyoto Protocol, CMM projects in Brazil can be expected to benefit from revenues deriving from the sale of carbon emission reduction credits.

Table 4-5. Brazil's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 4, 1992	February 28, 1994
Kyoto Protocol	April 29, 1998	August 23, 2002

Source: UNFCCC (2014)

Brazil's National Plan on Climate Change (Plano Nacional sobre Mudança do Clima or PNMC, in Portuguese), finalized in December 2008 and last amended in 2010, established a voluntary national greenhouse gas (GHG) reduction target of between 36.1 percent and 38.9 percent of projected emissions by 2020 (CPW, 2014). Unlike other top GHG-emitting countries, however, more than 75 percent of Brazil's emissions are attributed to deforestation, agriculture, and land use change rather than with energy consumption (Yale, nd). In international climate negotiations (e.g., COPs), Brazil typically coordinates with the other BASIC nations (i.e., Brazil, South Africa, India, China) and hosted the Rio+20 United Nations Conference on Sustainable Development in 2012.

4.3.1 Market and Infrastructure Factors

Brazil's coal mining industry has become increasingly important in recent years attributable to periods of economic uncertainty, instability in the energy sector, and a resulting shift in energy policy. Santa Catarina, the largest coal-producing state, has been the primary beneficiary of the industry's increase in status and importance. However, it also faces increased scrutiny from environmental groups concerned about the negative socioeconomic and environmental impacts caused by the growing industry.

On the technology front, groups are working in Brazil's mining regions to implement Integrated Resource Management techniques. These technical improvements are intended to reduce transportation costs, reduce waste and harmful emissions, and increase the scale of production to increase domestic coal supplies and reduce reliance on imports. Thus far, efforts have resulted in the 1989 establishment of an association of coal mining companies in the State of Santa Catarina, the Sindicato da Industria da Extracao de Carvao do Estado de Santa Catarina (SIECESC). SIECESC actively works with the Brazilian Ministry of Environment, the Ministry of Mines and Energy, the National Mineral Production Department (NMPD), and several international organizations to devise strategies to implement regional and global sustainable mining and industry development. In Santa Catarina, for example, SIECESC is coordinating a recovery project (i.e., Project for Environmental Recovery Carboniferous Basin Southern Santa Catarina) to restore lands previously degraded through mining activities and whose results are already being noted (CPRM, 2002).

4.3.2 Regulatory Information

Aiming to adjust the current mining regulation and simplify mining procedures, the creation of a new agency—the National Mining Agency—has been proposed, similar to those already in place for petroleum and electricity regulation (the National Petroleum Agency and the National Electric Energy Agency, respectively). The new agency will regulate, supervise, encourage, and increase the development of mineral policy, including the penalties applied to irregular mining activities. These roles have been performed to date by DNPM, which is the entity in charge of authorizing research, permits, and mineral mining concessions, and for other relevant aspects of the industry. Under the new proposal, DNPM is expected to be disbanded, with its functions encompassed by the new agency (ILO, 2011). Despite the new mining agency, no information on regulations pertaining to CMM development in Brazil was found.

4.4 Profiles of Individual Mines

No information profiling individual Brazilian mines was found.

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5 Bulgaria

5.1 Summary of Coal Industry

5.1.1 Role of Coal in Bulgaria

Most of the coal consumed in Bulgaria is used for power production. A substantial portion of its thermal electric power plants, which produce more than one-half of the country's total production of about 45 billion kilowatts, operate on domestic coal (Steblez, 2000). A reliable supply of higher-quality hard coal is, however, necessary for Bulgaria's metallurgical industries, and such coal is obtained from as near as Ukraine and as far away as Australia (USDOE, 2004). Bulgaria's annual coal production and consumption both remained relatively constant from 1990 through 2010, peaking in 2011, and the country is expected to remain a net coal importer (EIA, 2014).

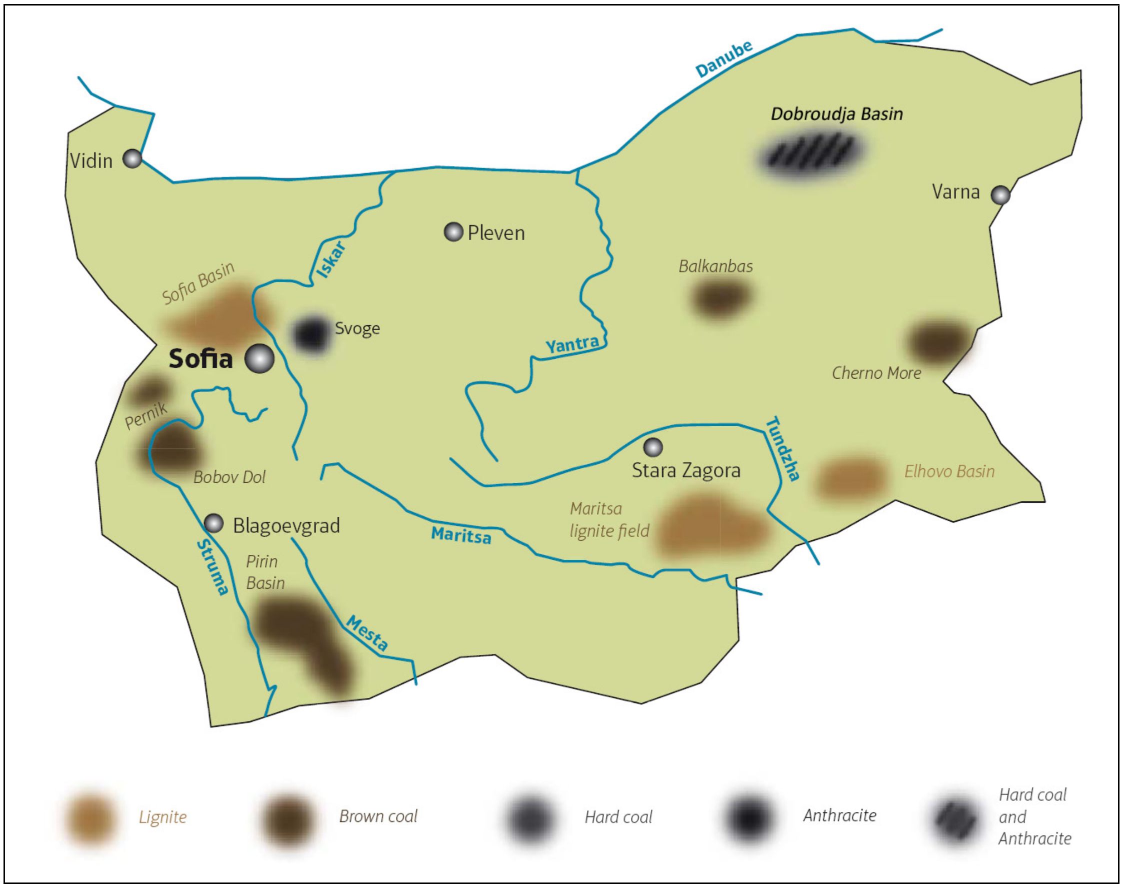
Bulgaria's coal reserves include about 88.7 percent lignite, 10.9 percent brown coal, and 0.4 percent hard coal (Euracoal, 2014). Much of the household coal heating is with briquettes, especially in the vicinity of the state-owned briquette factory, Stara Zagora (see Figure 5-1). About 9 percent of Bulgaria's coal production is used for making briquettes (USDOE, 2004).

Table 5-1. Bulgaria'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)	2.0	2,364	2,366	20 (0.266%)
Annual Coal Production (2012)	0.01	32.51	32.52	22 (0.41 %)

Source: EIA (2014)

Figure 5-1. Bulgaria's Coal Fields



Source: Euracoal (2014)

5.1.2 STAKEHOLDERS

Table 5-2 summarizes key stakeholders in Bulgaria's coal mine methane (CMM) industry.

Table 5-2. Key Stakeholders in Bulgaria's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Mining companies (see Section xx.1.4)	Project host
Universities, Research Establishments	▪ University of Mining and Geology "St. Ivan Rilski" - Bulgaria ▪ Geological Institute "St. Dimitrov"	Consulting assistance
Government Groups	▪ Ministry of Energy and Economy	Permitting and licensing
Other	▪ Bulgaria's Energy Efficiency Center in the Industry Efficiency Agency (executive agency to the Minister of Energy and Energy Resources)	Transfer of technologies, knowledge , and experience in the field of energy efficiency and use of renewable energy sources

5.1.3 Status of Coal and the Coal Mining Industry

Bulgaria produced 32.52 million tonnes (Mmt) of coal in 2012 (EIA, 2014b), with most of the lignite reserves found in the central (Maritsa East) and western part of the country (Sofia and Bobov dol) (Euracoal, 2014). There are three opencast mines operated in the Maritsa East coalfield—Troyanovo-1 mine, Troyanovo-North mine and Troyanovo-3 mine—which have the potential to produce more than 30 Mmt of lignite per year (Euracoal, 2014). Their supplies feed 2,240 MWe of three mine-mouth power plants (USDOE, 2004).

Other mines in Bulgaria have much lower production rates. The brown coal from the one open cast and two underground Bobov Dol Mines, in southwestern Bulgaria, and the lignite from the Stanyantsi, Bely Brag, and Choukourovo Mines are used mostly at the 630-MWe Bobov Dol power plant. The two open cast Pernik Mines, west of Sofia, have been supplying mainly for the Republica power plant (USDOE, 2004; Euracoal, 2008). Table 5-3 summarizes coal production by type of mine and from individual mines in Bulgaria.

Table 5-3. 2012 Statistics for Bulgaria's Coal Mining

Company/Mine Name	Coalfield	Mine Type	Coal Type	Annual Production (million tonnes)
Mini Maritsa Iztok EAD	▪ Maritsa East	▪ 3 Opencast	▪ Lignite	32.1
Bely Brag Mine AD	▪ Sofia	▪ 1 Opencast	▪ Lignite	0..6
Choukourovo Mine AD	▪ Sofia	▪ 1 Opencast	▪ Lignite	0.2
Stanyantsi Mine AD	▪ Sofia	▪ 1 Opencast	▪ Lignite	0.6
Vagledobiv Bobov Dol EOOD	▪ Bobov Dol	▪ 1 Opencast, ▪ 2 Underground	▪ Brown	0.97
Otkrit Vagledobiv Mines EAD	▪ Pernik	▪ 2 Opencast	▪ Brown	1.1
Balkan 2000 Mines EAD	▪ Sliven	▪ Underground	▪ Black	0.007

Source: MEET (2013)

Currently, there are 17 coal licensees and as of 2005, there were 19 companies operating mines (Ilkova, 2005). The Bulgarian coal industry has been restructured and certain mines have closed down, mainly underground, that have proven to be inefficient. The closing of mines is consistent with government rules and regulations. These mines namely are Zdravets, Antra, Marbas, Pirin, Bistritsa, Balkanbas, Balkan mine, Ivan Roussev mine, and Kolosh mine (Ilkova, 2005).

There are five mines considered potentially gassy – Bobov dol (two underground mines), Minior, and Balkan-2000 (two deposits are operated there – Tvarditsa and Paisii). The gas emissions are measured regularly (Ilkova, 2005).

5.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Bulgaria, in operation or under development (GMI, 2014). Updates on future CMM projects in Bulgaria can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

5.2.1 CMM Emissions from Operating Mines

Methane emissions in Bulgaria were estimated at 92.4 million cubic meters (m^3) in 2000, are projected to increase to 106.4 million m^3 by 2015, and then anticipated to remain relatively steady with only a slight increase to 107.1 million m^3 by 2030 (see Table 5-4).

Table 5-4. Bulgaria's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	92.4	86.1	101.5	106.4

Source: USEPA (2012)

5.2.2 CMM Emissions from Abandoned Coal Mines

No data quantifying CMM emissions from abandoned mines were found.

5.2.3 CBM from Virgin Coal Seams

In April 2014, Park Place Energy Corp. (headquartered in Texas) announced an agreement with the Bulgarian Ministry of Economy and Energy to explore the Vranino coal block in the country's northeast region as a source for natural gas. The company will drill five wells and utilize seismic data to get a better understanding of the potential to exploit coal resources for natural gas development (Park Place Energy Corp, 2014).

Table 5-5 summarizes coal bed methane (CBM) resources in Bulgaria's Dobroudja Basin.

Table 5-5. CBM and Coal Resources of Bulgaria's Dobroudja Basin

CBM Resource	Proven	Probable	Possible	Total
Billion m^3	3.2	81.6	80.8	195.6

Coal Resource	Measured	Indicated	Inferred	Total
Billion tonnes	2.8	6.8	11.8	21.4

Source: Marshall (2001)

5.3 Opportunities and Challenges to Greater CMM Recovery and Use

Bulgaria signed and ratified the United Nations Framework Convention on Climate Change and Kyoto Protocol (see Table 5-6) as an Annex 1 country. As such, it is eligible to host Joint Implementation projects that generate revenue by creating emission reduction credits. Bulgaria's greenhouse gas (GHG) emission reduction target under the Kyoto Protocol was 8 percent of base year 1988 emissions during the first commitment period from 2008-2012 (UNFCCC, 2000; UNFCCC, 2002).

Table 5-6. Bulgaria's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 5, 1992	May 12, 1995
Kyoto Protocol	September 18, 1998	August 15, 2002

Source: UNFCCC (2014)

An evaluation of 2011 GHG data revealed Bulgaria's emissions had decreased by approximately 50 percent against the Kyoto base year, and the country was likely to meet its Kyoto target through domestic emissions reductions directly (Ecologic Institute/eclareon, 2014). In May 2012, Bulgaria's Ministry of Environment and Water (MoEW) issued its Third National Action Plan on Climate Change (NAPCC). Bulgaria's climate change policy is based on two essential aspects: 1) the country's international commitments under UNFCCC/Kyoto Protocol (described above) and 2) the newly-adopted European climate legislation that seek to reduce emissions from member countries by 2020. The Third NAPCC outlines a framework to combat climate change for the period from 2013 to 2020, and focuses Bulgaria's efforts on actions leading to commitment(s) implementation and climate impacts reduction (MoEW, 2012).

5.3.1 Market and Infrastructure Factors

The Bulgarian coal industry has been restructured, shifting the focus to privatization and compliance with environmental standards. Certain mines, mainly underground, that have proven to be inefficient per government rules and regulations, have closed, and a gradual shift toward the privatization of Bulgaria's mines has encouraged foreign investment. AES Corporation, of the United States, took over operations of the Maritsa Unit 1 power plant, part of the Maritsa East mining and power generation complex, in late 2008. As part of the transaction, AES financed the construction of a newer 2 x 300-MW lignite-fired power plant, which became operational in 2011 (PowerEng, 2011). The new plant replaced an older, inefficient, 500-MW plant. An earlier analysis revealed the effort as one of Bulgaria's largest foreign investment projects, and construction of the adjacent state-of-the-art ash disposal facility would help the coal industry comply with European Union environmental standards (EBRD, 2005). Also, the Kanina Mine, Oranovo Mine, and Otkrit Vagedobiv Mines were privatized in 2004. The Stanyantsi Mines, Bely Brag Mines, Choukourovo Mines, and Pernik Mines have also been privatized (Euracoal, 2008).

The Maritsa East Mines and the Bobov Dol Mines are state-owned and sell coal at state-regulated prices to consumers. Similarly, the briquette factory at Maritsa East sells briquettes to consumers at state-regulated prices (USDOE, 2004).

Besides these state-owned mines, there are some coal mines that sell their products at contracted prices. The largest of these are the Pirin Mine, the Maritsa Basin Mine, the Balkan Mine, the Cherno More Mine, the Vitren Mine, and the Anthra Mine (USDOE, 2004).

5.3.2 Regulatory Information

No regulatory information was found specifically applicable to CMM development in Bulgaria.

5.4 Profiles of Individual Mines

See Table 5-3 above for information on individual mines in Bulgaria.

5.5 References

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6 Canada

6.1 Summary of Coal Industry

6.1.1 ROLE OF COAL IN CANADA

Coal is the most abundant fossil fuel in Canada, comprising 61 percent of all its fossil fuel reserves (CCPC, 2010). Coal accounted for 10 percent of Canada's total energy consumption in 2010 (EIA, 2012). Canada exports more than 40 percent of its tonnage as coking coal for steelmaking to Asian countries and some to Europe and Latin America. Conversely, Canada imports coal for electricity generation—estimated at about 11.2 million tonnes (Mmt) in 2012 (EIA, 2014)—largely from the United States, with smaller volumes from Colombia, Venezuela, and Russia (NRC, 2014). About 89 percent of the coal consumed in Canada is for thermal power generation and the remainder is used in the steel (7 percent), cement, and other industries.

The recoverable coal reserves in the country are estimated at 6.6 billion tonnes and Canada's coal production has been declining, dropping from 78.7 Mmt in 1997 to 66.5 Mmt by 2012 (EIA, 2014).

Table 6-1 quantifies recoverable reserves and recent coal production in Canada.

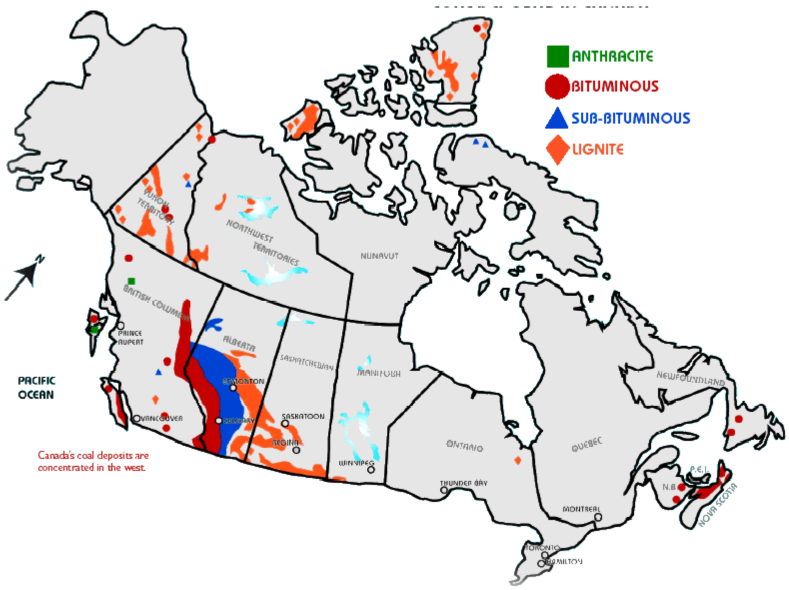
Table 6-1. Canada's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	3,474	3,108	6,582	15 (0.74%)
Annual Coal Production (2012)	57.0	9.5	66.5	13 (0.84%)

Source: EIA (2014)

Production occurs mainly in Alberta (43 percent), British Columbia (BC) (35 percent), and Saskatchewan (11 percent), as shown in Figure 6-1. Coal mines in eastern Canada, New Brunswick, and Nova Scotia are small operations.

Figure 6-1. Canada's Coal Fields



Source: CAC (2006)

6.1.2 STAKEHOLDERS

Table 6-2 identifies potential key stakeholders in coal mine methane (CMM) development in Canada.

Table 6-2. Key Stakeholders in Canada's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ The three giants in the coal industry (Luscar Ltd., Teck Cominco Ltd., and Fording Inc.) have merged to form the Elk Valley Coal Corp., with Teck Cominco as the managing partner. ▪ Western Canadian Coal Corp. ▪ Grande Cache Coal Corp. ▪ Encana ▪ MGV Energy Inc. ▪ Apache Canada Ltd. ▪ Trident Exploration Co. ▪ Burlington ▪ Nexen ▪ Anadarko ▪ Talisman ▪ CDX ▪ Thunder ▪ Dominion ▪ APF ▪ Vectren ▪ Walter Energy Inc.'s Canadian Operations ▪ Winsway Coking Coal Holdings Ltd ▪ Marubeni Corporation ▪ Anglo American Plc's Peace River Coal Inc.	Project hosts

Table 6-2. Key Stakeholders in Canada's CMM Industry

Stakeholder Category	Stakeholder	Role
	▪ Sherritt International Corporation	
Mining Companies (con't)	▪ Vitol Group's Hillsboruough Resourced Ltd. ▪ NB Power (power-producing company that also mines coal) ▪ TransAlta Corporation (power-producing company that also mines coal)	Project hosts
Developers	▪ VWVulcan Energy of Canada, Ltd. ▪ Trident Exploration ▪ Husky Energy ▪ Nexen ▪ Red Willow ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities, Research Establishments	▪ University of Montana (Water Quality Management) ▪ Alberta Research Council ▪ Natural Resources Canada ▪ Canadian Mineral and Energy Technologies (CANMET)	Technical assistance
Government Groups	▪ Natural Resources Canada ▪ Alberta Ministry of Energy ▪ British Columbia Ministry of Energy, Mines, and Petroleum Resources	Permitting and licensing
Professional Associations	▪ Canadian Association of Petroleum Producers (CAPP) ▪ The Mining Association of Canada ▪ Coal Association of Canada ▪ Saskatchewan Mining Association	Technical assistance

Sources: AAPL (2005); NRC (2014)

6.1.3 Status of Coal and the Coal Mining Industry

Canada has 24 coal mines. Practically all coal mined in Canada (97 percent) is extracted by surface mining methods, specifically open-pit mining in the mountainous regions of Alberta and BC and strip mining in BC and the Prairies of central and southern Alberta and southern Saskatchewan. Nova Scotia also hosts two surface pits. There are only two operating underground mines in Canada, the Quinsam mine on Vancouver Island in BC and the Grande Cache mine in Alberta, which has both surface and underground operations (NRC, 2012). However, several underground mines are in various stages of planning, and it is likely that the number of underground mines and their contribution to total coal production will grow in the future. Table 6-3 provides statistics on Canadian coal mining as of 2012.

Table 6-3. Canada's Most Recent Statistics for Coal Mining

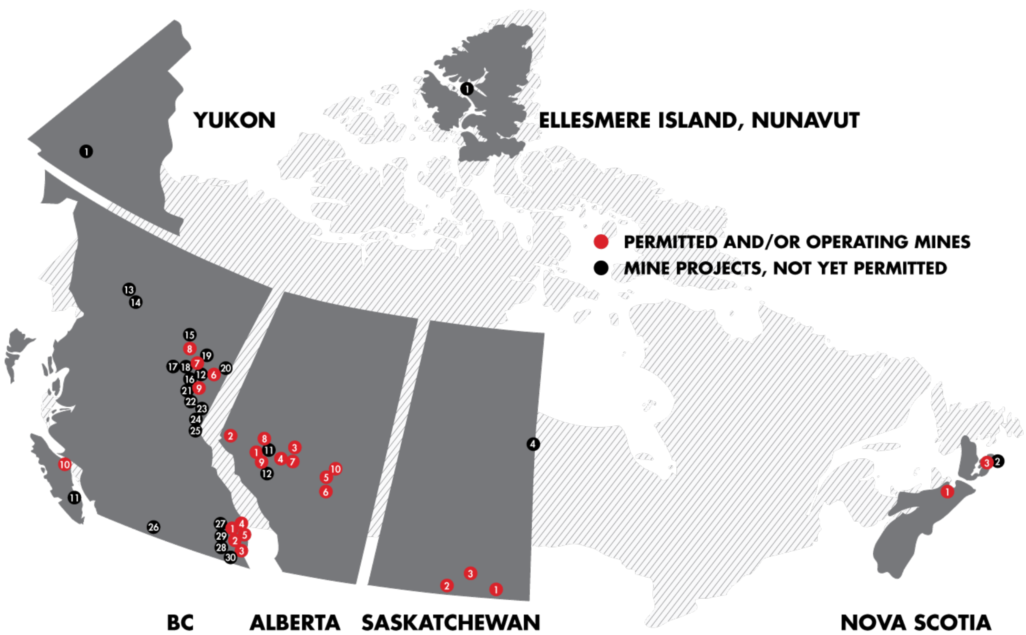
Type of Mine	Production (million tonnes)	Number of Mines
Underground (active) mines – total	*0.5 (2012)	1 (2012)
Surface (active) mines – total	66 (2012)	20 (2012)

Source: *NRC (2012)

The country largely produces bituminous coal, which accounted for 48 percent of its entire coal production in 2001. Sub-bituminous coal, mined in Alberta, forms the next largest component in Canada's coal production at 35 percent. No anthracite currently is mined in Canada, although some has been discovered in BC. Lignite occurs in Saskatchewan and Alberta and is used to produce 65 percent of Saskatchewan's electricity.

The operational status of Canadian coal mines is illustrated in Figure 6-2, while Table 6-4 lists mine status by region.

Figure 6-2. Status of Canada's Coal Mines



Source: CAC (2014)

Table 6-4. Status of Canada's Coal Mines

Region	Permitted and/or Operating Mines (operated by)	Mine Projects, Not Yet Permitted (owned*/operated by)
Alberta	1. Gregg River (Sherritt International) 2. Grande Cache (Grande Cache Coal) 3. Highvale Mine (TransAlta and SunHills Mining Partnership) 4. Coal Valley (Sherritt) 5. Paintearth Mine (Sherritt) 6. Sheerness Mine (Sherritt) 7. Genesee Mine (Sherritt) 8. Obed Mountain (Sherritt) 9. Cheviot (Teck) 10. Ryley (Dodds Coal)	11. Vista (Coalspur) 12. Palisades (Altitudes Resources Ltd.)
Nova Scotia	1. Stellarton Mine (Pioneer Coal Limited) 3. Point Aconi *(currently in reclamation phase)*	2. Donkin Mine Project (Morien Resource Corporation)
Saskatchewan	1. Boundary Dam (Sherritt) 2. Poplar River Mine (Sherritt) 3. Bienfait Mine (Sherritt)	4. Border Mine (GoldSource Mines)
Yukon		1. Division Mountain coal deposit (Pitchblack Resources)
Ellesmere Island, Nunavut		1. Fosheim Property (Canada Coal Inc.)
British Columbia	1. Fording River Mine (Teck) 2. Greenhills Mine (Teck) 3. Line Creek Mine (Teck) 4. Coal Mountain Mine (Teck) 5. Elkview Mine (Teck) 6. Wolverine Mine (Walter Energy Inc.) 7. Brule Mine (Walter Energy Inc.) 8. Willow Creek Mine (Walter Energy Inc.) 9. Trend Mine (Anglo American) 10. Quinsam Mine (Hillsborough Resources)	11. Raven (Compliance Energy Corporation 12. Quintette (Teck) 13. Arctos (Arctos Anthracite Joint Venture)* 14. Groundhog (Atrum Coal) 15. Carbon Creek (Cardero Resource Corp.) 16. Sukunka (Xstrata Coal Canada) 17. Suska (Xstrata Coal Canada) 18. Mt. Hudette/Brazion (Walter Energy's Canadian Operations 19. Gething (CKD Mines Co. Ltd.) 20. Echo Hill (Hillsborough Resources Limited) 21. Murray River (HD Mining Ltd.) 22. Roman Mountain (Anglo American) 23. Belcourt (Walter Energy's Canadian Operations) 24. Huguenot (Colonial Coal International Corporation) 25. Saxon (Walter Energy's Canadian Operations) 26. Basin (Coalmont Energy Corp) 27. Bingay (Centermount Coal Limited) 28. Marten-Wheeler (Teck) 29. Crown Mountain (Jameson Resources) 30. Coal Creek (Crows Nest Pass Coal Mining)

Note: *Number by mine name indicates location on Figure 6-2*
Source: CAC (2014)

The coal deposits in central and southern parts of Alberta and Saskatchewan lie in blankets of uniform thickness close to the surface, while the coal around the BC/Alberta border run into mountainous terrain and the seams can be as thick as 15 meters, deeply buried and inclined, making mining a challenge. In eastern Canada, Nova Scotia contains the largest coal deposits. The largest one, Sydney coalfield, has 11 seams that are 1.0 to 4.5 meters thick and is located under the ocean. Economics posed challenges to extracting that coal, however, and the mines were closed. Furthermore, the mining conditions are quite difficult and dangerous in the region as evidenced by an explosion and fatalities at the Westray mine. The coal in Ontario has a low-heat value and is not exploited. Finally, the potential of coal deposits in the northern half of the country have yet to be explored (CAC, 2003).

The Canadian coal industry has undergone major restructuring recently with the consolidation of mining companies starting in 2003. The three giants in the coal industry—Luscar Ltd., Teck Cominco Ltd., and Fording Inc. —merged to form the Elk Valley Coal Corp. (EVCC), with Teck Cominco as the managing partner of EVCC. As part of the deal, Luscar Energy Partnership bought the thermal coal assets of Fording to become the largest producer of thermal coal in Canada. Luscar's assets include the undeveloped coalfields, royalty interests, mining service contracts, and an interest in a joint mining venture. With these mergers, Luscar Coal Ltd. and EVCC are in charge of 99.5 percent of the entire Canadian coal production, operating all 15 large-scale mining operations (>1 Mmt/yr) (NRC, 2005). In 2008, Teck bought out the Fording Canadian Coal Trust (Mining Exploration News, 2008). In 2011, Anglo American acquired an additional 25.17 percent interest of Peace River Coal Limited Partnership thus making Anglo American the 100 percent owner of PRC. PRC operates the Trend mine in the Rumbler rage of BC and is conducting future exploration studies. Also in 2011, Xstrata plc took over First Coal Corporation through its subsidiary, Xstrata Coal Canada Ltd, while Walter Energy acquired Western Coal Corporation and GCC entered an acquisition agreement with Winsway and Marubeni through the partnership "1629835 Alberta Ltd." (NRC, 2011).

Although domestic consumption of coal has declined recently, coking coal exports are on the rise with an increasing demand for metallurgical coal worldwide, especially as China turns into an importer of coking coal. Canada was the world's third largest exporter of coking coal in 2012 when coking coal exports reached 30.7 Mt, an 11-percent increase from 2011 to 2012. EVCC has increased metallurgical coal production and opened the Cheviot Creek Pit near Hinton, Alberta, which has a production capacity of 1.7Mt/y. Walter Energy, Winsway Coking Coal Holdings Ltd., and Marubeni Corp also produce coking coal for export. In recent years, six more mining projects have been or are under development by individual companies, five of which are in BC (i.e., Carbon Creek, Murray River, Echo Hill, Bingay, and Sukunka). Four of the mines plan to produce coking coal while the other mine plans to produce bituminous thermal coal for export (NRC, 2012). In eastern Canada, Nova Scotia is taking steps to restart coal mining, although a contract has not yet been assigned.

6.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Canada, in operation or under development (GMI, 2014). Updates on future CMM projects in Canada can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

6.2.1 CMM Emissions from Operating Mines

There are no CMM utilization projects in Canada. Methane emissions in Canada were estimated at 67.9 million cubic meters (m^3) in 2000, are expected to increase slightly to 68.6 million m^3 by 2015, and then anticipated to further increase to 76.3 million m^3 by 2030. Table 6-5 summarizes the country's CMM emissions.

Table 6-5. Canada's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	67.9	70.0	65.8	68.6

Source: USEPA (2012)

6.2.2 CMM Emissions from Abandoned Coal Mines

Closed coal mines on Cape Breton Island in Nova Scotia may hold the greatest promise for abandoned mine methane (AMM) recovery in Canada. Four closed mines on Cape Breton Island near New Waterford (the Phalen and Lingan collieries), Glace Bay (No. 26 mine) and at the northeastern tip of Boularderie Island (Prince colliery) were large, high production longwall operations when operating. The No. 26 colliery opened in 1944, and the other three mines began operations between 1972 to1975. At their peak, the No. 26 produced 900,000 tonnes, the Lingan mine produced nearly 2 Mmt of raw coal and the Prince colliery produced nearly 1 million tonnes of coal (Nova Scotia Department of Mines, 1985). The No. 26 colliery operated until 1984 when it closed due to a fire. The Lingan colliery closed in 1992, the Phalen closed in 1999 and the Prince colliery closed in 2001. A fifth mine, the Donkin mine on Cape Breton Island began development in 1987 and operated for several years in the 1990s, but also closed in the 1990s. However, a significant effort is underway to reopen the Donkin mine, with several permitting steps already accomplished. Although information on methane emissions is limited, the Phalen mine was considered a gassy mine. However, a significant challenge with AMM recovery from any of these mines is that they are submarine mines extending underneath the surface of Atlantic Ocean requiring an offshore production system or use of horizontal drilling from the surface. Flooding of the mine workings is also a potential problem.

In addition to these mines, several other smaller mines have operated in Nova Scotia (Nova Scotia Department of Mines, 1985).

6.2.3 CBM from Virgin Coal Seams

Assessing the extent of coal bed methane (CBM) prospects in Canada started within the last decade. The results are illustrated in Figures 6-3, 6-4, and 6-5 on following pages. According to the Canadian Gas Potential Committee, however, they could be anywhere between 5.3 and 13 trillion m^3. These estimates are from exploration mainly in the Western Canada Sedimentary Basin. Table 6-6 lists the major Canadian CBM exploration sites.

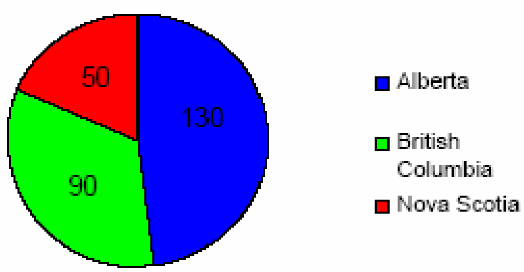
Table 6-6. Canada's Major CBM Reserves

Location	Reserves (trillion cubic meters)
Horseshoe Canyon	1.04
Pembina (including Ardley)	0.84
Mannville	4.76
Alberta/BC Foothills (Gates/Mist Mtn)	3.7

Source: AAPL (2005)

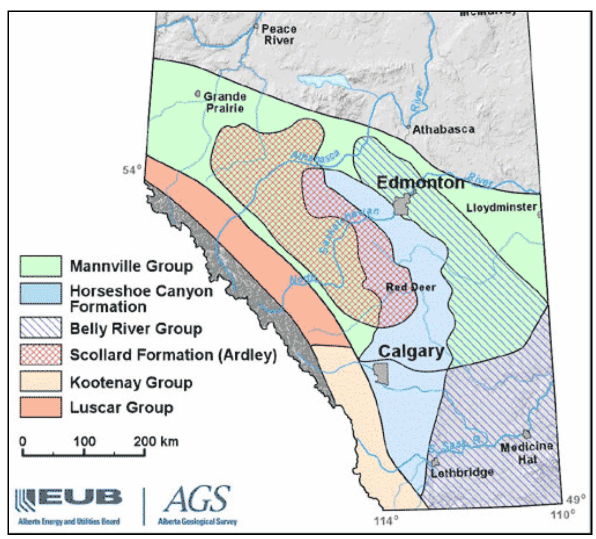
Canadian coal seams with CBM potential are found beneath much of Alberta, especially in the southern and central regions, in which the Alberta Geological Survey (AGS) have estimated there could be as much as 14 trillion m³ (about 500 trillion cubic feet or Tcf) of CBM held in Alberta coal (AGS, 2013). The primary CBM potential areas in Alberta are the Ardley, Horseshoe Canyon, and the Mannville coal zones, with the Upper Manville being the gassiest zone. Alberta offers particularly favorable conditions for CBM development as the geology of CBM deposits are relatively simple and uniform over a wide area (Amazouz, 2006). Within BC, the major concentration is in the northeast and to a much lesser extent in the southeast of the province, amounting to a total of 2.5 trillion m³ (BC, 2002). Nova Scotia forms the third largest portion of the Canadian CBM reserve.

Figure 6-3. Location of Probable Economically Recoverable CBM Reserves in Canada (trillion cubic feet)



Source: AEUB (2004)

Figure 6-4. Primary CBM Potential Areas in Alberta

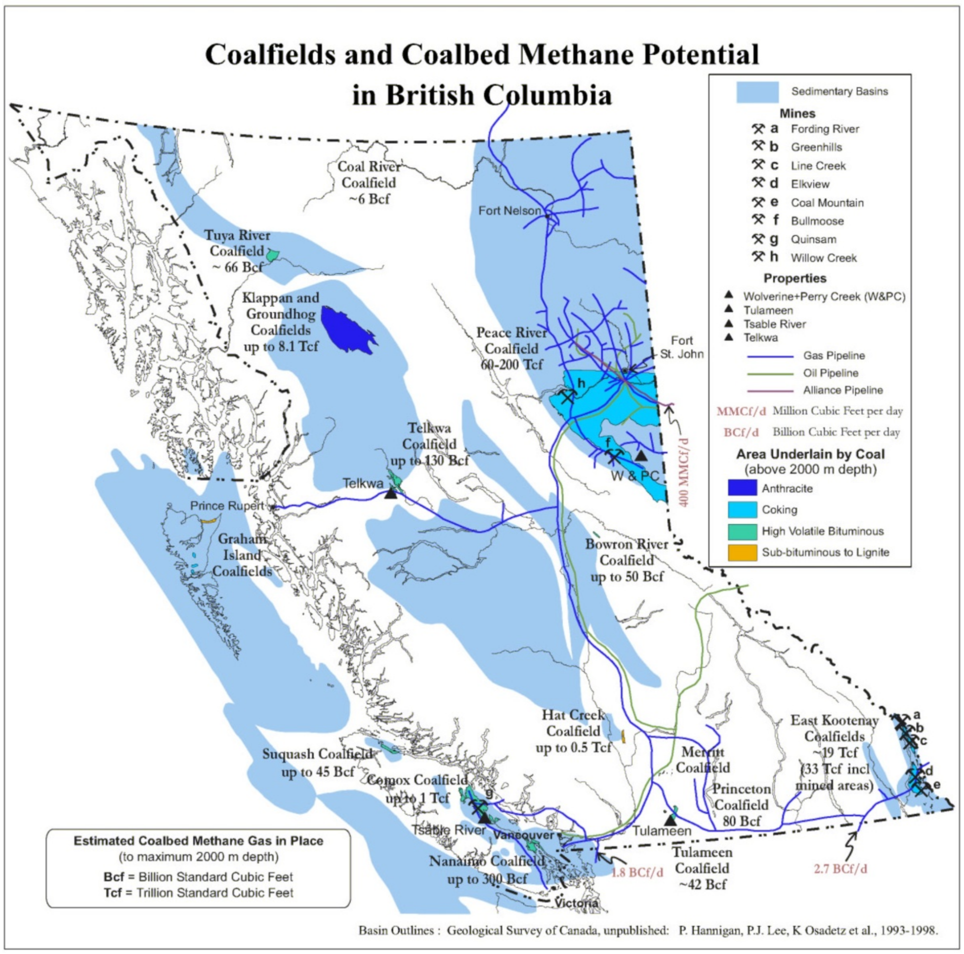


Source: AEUB (2004)

The CBM industry is relatively new in Canada compared to its neighbor, the United States. However, in Alberta alone, there were more than 3,500 CBM wells in place by 2004, with most of these concentrated in Alberta and BC (Snyder, 2005). A forecast report projected annual CBM production of 14.5 billion m^3 by 2015 for all of Canada (NAEWG, 2005; Amazouz, 2006).

The first Canadian methane production began in 2002 in the Horseshoe Canyon region in Alberta. The Horseshoe Canyon coals are dry and relatively close to the surface, enabling easy gas recovery. Therefore, these fields accounted for 90 percent of the producing wells in Alberta in 2005 (Snyder, 2005), generating more than 2.8 million m^3 per day of methane. Alberta's CBM production in 2005 totaled 2.5 billion m^3 (Amazouz, 2006). By 2008, there were 6000 wells producing 5.2 billion m^3 per year, all located in Alberta (International, 2008). By 2010, a total of 14,000 wells had been drilled (not all of which are active) and production is approximately 7.2 billion m^3 per year (Ember, nd).

Figure 6-5. CBM Potential in British Columbia



Source: BC (2002)

Additional CBM Exploration and Production

A number of companies have explored CBM projects on Vancouver Island where the coal rank is bituminous with cumulative coal seam thickness of 23 feet. Priority Ventures Ltd. conducted some test drilling in 2001, while Quinsam Coal Corporation allied with CornerStone Gas to explore CBM development on the island (BC, 2009).

Trident Exploration worked with Husky Energy to develop CBM in the Fenn Rumsey area. The joint venture started in 2002, was extended in 2004, and planned to drill some 400 exploratory wells by 2006 (Husky, 2005). In a second project, Trident worked with Nexen and Red Willow to start the first CBM venture in the Mannville formation in Alberta (BennettJones, 2005), and by 2008, they had completed 650,000 meters of drilling in Mannville (Trident, 2008). Royal Dutch Shell had licenses for tenure to explore for CBM in the Klappan area of northwest BC, but a four-year moratorium has been declared on development of CBM resources in that region (Shell, 2008) and the BC government officially ruled the Klappan region off-limits for further gas exploration (Vancouver Sun, 2012). BP had tenure at its CBM project at Mist Mountain in southeast BC, but later sold its Western Canadian upstream gas assets to Apache Corporation (BP, 2010).

By mid-2008, approximately 60 CBM exploration wells had been drilled outside of Alberta but no commercial production existed. The BC and Nova Scotia coals generally exhibited low permeability, and coals in Ontario and Saskatchewan showed insufficient gas for commercial production (International, 2008). But by December 2008, GeoMet Inc. began the first commercial delivery of CBM from the Peace River project in BC (GeoMet Inc., 2009). By January 2009, Nova Scotia also had three CBM projects, two of which are Stealth Ventures Inc. projects in Cumberland and Stellarton basins. The third project is in the Sydney basin of northern Nova Scotia (Prospect Profile, 2009).

In April 2012, Toyota Tsusho Corp. invested more than $600 million to acquire a share of Encana Corporation's extensive CBM reserves in southern Alberta, and the Japanese company will acquire a 32.5 percent royalty interest in about 5,500 existing and future Encana CBM wells (Encana, 2012).

6.4 Opportunities and Challenges to Greater CMM Recovery and Use

Canada is a signatory to both the UNFCCC and the Kyoto Protocol (see Table 6-7). As an Annex I Party, its emissions target under the Kyoto Protocol is to achieve a 6 percent reduction of 1990 greenhouse gas emission levels by 2010.

Table 6-7. Canada's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	December 4, 1992
Kyoto Protocol	April 29, 1998	December 17, 2002

Source: UNFCCC (2014)

Canada has demonstrated its commitment to addressing climate change by providing international climate finance in support of mitigation actions by developing countries and support for adaptation by the poorest and most vulnerable countries. This included Canada's fast-start financing contribution of $1.2 billion (from 2010 to 2012) to support a range of climate change projects in more than 60 developing countries, as announced in Durban (Government of Canada, 2014).

Canada withdrew from the Kyoto Protocol agreement in 2012, and began extending its efforts beyond the UNFCCC by working with other countries through complementary forums such as the Arctic Council, for which Canada has assumed the two-year chairmanship through 2015, and the Climate and Clean Air Coalition (CCAC) to develop practical and collaborative initiatives to reduce

GHG emissions and short-lived climate pollutants (Government of Canada, 2014). In 2013, Canada announced its commitment of an additional $10 million—on top of its $10 million commitment in 2012—to the CCAC. Canada, together with the United States and Mexico, is also leading international efforts to use the expertise and institutions of the Montreal Protocol to phase out hydrofluorocarbons production and consumption.

6.4.1 MARKET AND INFRASTRUCTURE FACTORS

The major issues that concern the Canadian CBM industry are geology, land consolidation and access, freehold leases, water disposal (both brine and fresh), regulatory matters, and CBM technology (Ziff, 2004). In general, all CBM projects are private-industry-driven in Canada, with companies typically forming partnerships (i.e., joint ventures) to commercially develop CBM projects.

Canada joined the Global Methane Initiative (formerly the Methane to Markets Partnership) in July 2005. Canada's efforts thus far, however, have been largely limited to the oil and gas industry (Canada is a member of the GMI Oil and Gas Subcommittee). Long-term consumption of natural gas is expected to grow steadily in Canada, while domestic production of conventional natural gas is believed to have peaked in 2003 (Amazouz, 2006). The expected shortfall will be met by a number of alternative natural gas resources:

- Mackenzie Delta and Beaufort Sea fields
- Other remote gas fields (north of 60th parallel)
- Liquefied natural gas importation
- Offshore East Coast and West Coast gas fields
- CBM reserves estimated at 4.7 trillion m^3 (CAPP, 2004)

Canada is also pursuing other avenues of alternative gas resources. In 1996, Natural Resources Canada's Canmet Energy Technology Centre –Varennes initiated the development of a catalytic reactor that could, both technically and economically, recover the methane of coal mine ventilation air. The technology, called CH4MIN, recovers the energy of the dilute ventilation air methane, with an efficiency varying between 40 and 95 percent, depending on the methane concentration in the ventilation air (Amazouz, 2006). The CH4MIN was tested at bench scale at the CANMET lab in Quebec and large pilot-scale at the now closed Phalen Coal Mine in Nova Scotia. CANMET has licensed the technology to several companies including the current global license holder, Sindicatum Sustainable Resources. Sindicatum built and operated a commercial-scale 15 m^3/sec (32,000 cfm) demonstration reactor to test the CH4MIN technology under field conditions. The company is exploring the economic viability of the CH4MIN technology in China (Talkington, 2014).

Further on R&D front, the Alberta Research Council (previously known as the Alberta Chamber of Resources) has been collaborating with the American, Canadian, and other international governments to improve CBM recovery efficiency (ACR, 2003). Non-nuclear government R&D spending is managed by Natural Resources Canada. The Program of Energy Research and Development (PERD), managed by Natural Resources Canada's Office of Energy Research (OERD15), is the major source of government funding for non-nuclear public and private research and development. Natural Resources Canada's Energy Technology Branch (ETB), which includes three laboratories in the Canada Centre for Mineral and Energy Technology, is the largest federal participant in, and manager of, non-nuclear science and technology programs. ETB receives a large share of PERD funds.

Canadian infrastructure is also being adapted to keep in step with its growing CBM/CMM industry. The Alberta Energy and Utilities Board (AEUB) recently approved Canada's major pipeline network for natural gas transportation, TransCanada PipeLines, to reconfigure its system to allow the low-pressure intake of CBM (BennettJones, 2005). CBM has to compete with other sources of Canadian gas in order for it to be purchased by pipelines that transport the gas to the U.S. or Canadian consumers.

6.4.2 Regulatory Information

Initially, there was controversy regarding the ownership of CBM rights in Canada since coal and natural gas come under different jurisdictions. CBM rights in both BC and Alberta now follow the legal framework for natural gas. The provinces own and can sell the rights to develop CBM at their discretion. The *Coalbed Gas Act* clearly attributes all CBM rights to the owners of natural gas mineral rights and none to the owner of coal rights (ASB, 2004). This was upheld by the Alberta courts in 2011 (Canadian Energy Law, 2011). Canadian regulations enforce consultation with affected stakeholders and governments before development begins (CAPP, 2003). In BC, a potential producer must get Petroleum and Natural Gas tenure rights before production (BC, nd). In Nova Scotia, the *Petroleum Resources Act* recognizes coal gas as a distinct resource but has included it with the definition of petroleum as "coal gas, existing in its natural condition in strata." A specific coal gas agreement is also required before exploration, development, or production of CBM (Blakes, 2006). In Saskatchewan, CBM is defined by The Petroleum and Natural Gas Regulations of 1969 and is administered just like any other petroleum or natural gas development (Saskatchewan, nd).

Canada does not have federal tax credit incentives in place to stimulate investment in CBM technologies because legislative power rests largely with provincial governments. BC relies on a royalty incentive program to encourage CBM production. Recent amendments to the BC Petroleum and Natural Gas Royalty Freehold Production Tax Regulation allow water treatment costs to be included in the producer's cost of service allowances for CBM wells, place the production threshold at 17,000 m^3/day before a royalty is imposed on a CBM well, and raise the royalty credit on each well to $50,000 (BC Royalty, nd).

In the *Petroleum and Natural Gas Act*, CBM projects are not subject to well-spacing regulations (more wells are often required per field compared to natural gas resources) and CBM production data can stay confidential for an extended period (ASB, 2004).

CBM producers are subject to strict rules that apply at every stage of project development. All the federal and provincial wildlife and environmental laws and the elaborate industry-specific regulations apply to the CBM producers as well (CAPP, 2003).

6.5 Profiles of Individual Mines

Ardley and Lower Edmonton Mines, Alberta

General Overview

Total mining area, km^2	Several hundreds
No. of coal seams	1-30
Total methane resource	0.84 trillion cubic meters
Rank of coal	Sub-bituminous, high-volatile
Cumulative thickness	Up to 25 meters
Depth of mining	200 to 700 meters
Moisture	Dry
Gas content average	1.87 m3/tonne
Mining method	Surface

Upper Mannville Mines, Alberta

General Overview

No. of coal seams	2-5
Total methane resource	4.76 trillion cubic meters
Rank of coal	Bituminous
Cumulative thickness	Up to 20 meters
Depth of mining	800 to 1500 meters
Moisture	High (dewatering required)
Gas content average	9.4 – 15.6 m^3/tonne
Mining method	Surface

Source: Sproule (2004)

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7 China

7.1 Summary of Coal Industry

7.1.1 Role of Coal in China

Coal accounts for 69 percent of total national energy consumption in China (EIA, 2014a). Ranking first in the world in production of coal, China exported 16.5 million tonnes (Mmt) of coal in 2011; a sharp decline from a peak of 108.8 Mmt in 2003 (EIA, 2014b). Historically, a net coal exporter, China became a net coal importer in 2009 for the first time in more than two decades (EIA, 2014a). Table 7-1 provides recoverable reserve and recent coal production data for China.

Table 7-1. China's Coal Reserves and Production

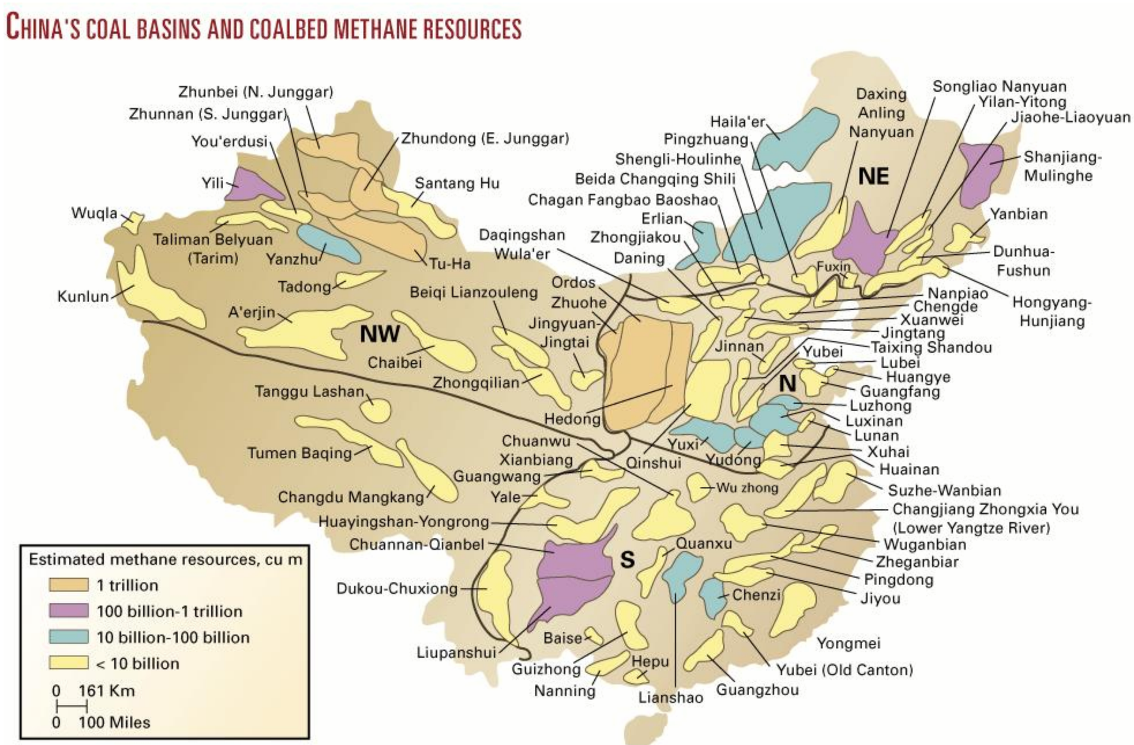
Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2011)	62,200	52,300	114,500	3 (12.9%)
Annual Coal Production (2012)	3,510.2	141.5	3,651.8	1 (46.3%)

Note: Numbers may not add due to rounding
Source: EIA (2014b)

As shown in Figure 7-1, the following major coal basins are located in four regions of China (USEPA, 1996):

- Sanjuang-Mulinghe, Songliao, Donhua-Fushun, and Hongyang-Hunjiang basins in the Northeast;
- Taixing-Shandou, Qinshui, Daning, Ordos, Hedong, Yuxi, Xuhuai, and Huainan basins in the North;
- Chuannon-Qianbei, Huayingshan-Yongrong, and Liapanshui basins in the South; and
- Tarim, Qaidam, and Junggar basins in the Northwest.

Figure 7-1. China's Coal Fields



Source: Liu (2006)

7.1.2 STAKEHOLDERS

Table 7-2 identifies some of the key stakeholders for coal mine methane (CMM) project development in China.

Table 7-2. Key Stakeholders in China's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Large coal groups, such as: ▪ Chongqing Energy Investment Group ▪ Datong Coal Group ▪ Fushun Mining Group ▪ Hebi Coal Industry Group ▪ Henan Energy and Chemical Group ▪ Huaibei Mining Group ▪ Huainan Mining Group ▪ Jincheng Anthracite Coal Group ▪ Panjiang Coal & Power Group ▪ Shenhua Group ▪ Shenhuo Group ▪ Shuicheng Mining Group ▪ Songzao Coal & Power Group ▪ Tiefa Mining Group ▪ Xinji Group	Project hosts

Table 7-2. Key Stakeholders in China's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies (con't)	▪ Yangquan Coal Group ▪ Zhengzhou Coal Group	Project hosts
Equipment manufacturers	▪ Atlas Copco ▪ Capstone Turbine Corporation ▪ Caterpillar ▪ GE Jenbacher ▪ Shengli Power Machinery	Methane treatment and utilization equipment
Developers	▪ China National Petroleum Corporation ▪ China United Coalbed Methane Corporation Ltd. ▪ CBM Exploitation and Development Company of the PetroChina Company Ltd. ▪ Far East Energy ▪ Lanyan CBM Company of the Jincheng Anthracite Coal Mining Group ▪ Sindicatum Carbon Capital, SCC Americas ▪ See also www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, consultancy, and related services	▪ China Coalbed Methane Clearinghouse, affiliated with the China Coal Information Institute ▪ Guizhou International Cooperation Center for Environmental Protection ▪ See also www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities, Research Establishments	▪ China Coal Research Institute ▪ China University of Mining and Technology ▪ China University of Petroleum, Beijing ▪ China National Administration of Coal Geology ▪ China Coal Information Institute	Technical assistance
Regulatory Agencies and Government Groups	▪ National Development and Reform Commission ▪ National Institute for Occupational Safety ▪ State Administration of Coal Mine Safety, within State Administration of Work Safety ▪ China National Coal Association ▪ International Exchange Center of National Work Safety Administration	Project identification and assessment support

Source: GMI (2005), Huang (2007)

7.1.3 Status of Coal and the Coal Mining Industry

China is the world's leading producer of coal, producing almost 3.56 billion tonnes of coal in 2012 (Table 7-1). In 2013, production continued to rise at nearly a one percent increase on a year-on-year basis, with 3.68 billion tonnes (Huang, 2014).

Coal is produced throughout China in 28 provinces. Northern China, particularly Shanxi, Inner Mongolia, Shaanxi, and Xinjiang Provinces, contain most of China's easily accessible coal and virtually all of the large state-owned mines (EIA, 2014a).

China has a large number of coal mines but has been attempting consolidation. It is estimated that in the mid-1990s, there were nearly 100,000 coal mines in China (IEA, 2009). The majority of these mines belonged to villages and towns. In the last decade, China has implemented programs to close down underperforming or unsafe mines, especially town and village coal mines. China's State

Council has mandated the phasing out of mines producing less than 90,000 tonnes of coal per year. China's National Energy Administration (NEA) reports that 1,725 small-scale mines will be closed in 2014, with a total capacity of 117.48 Mmt (NEA, 2014).

As of 2014, there are approximately 12,000 coal mines operating in China (EIA, 2014a). Of these, 2,059 mines are owned by large, state-owned coal mine groups (known as "key coal mine groups"), accounting for 61.7 percent of total coal production. An additional 10,067 mines are operated by villages and towns (Guoquan, 2010). See Table 7-3 below.

Most coal mines in China are underground mines. As of 2012, underground mining accounted for 90 percent of Chinese coal production (Huang, 2013a).

Table 7-3. China's Mines by Category and Percent of Total Production (2004)

Mine Category	Number of Mines	Percent of Total Production
Local State-owned Key Coal Mine Groups	1,190	12
Other State-owned Key Coal Mine Groups	869	49.7
Mines Belonging to Villages and Towns	10,067	38.2

Source: Guoquan (2010)

7.2 Overview of CMM Emissions and Development Potential

Large, state-owned coal mines dominate Chinese coal production and CMM emissions. About 44 percent of large, state-owned mines are considered gassy (Huang, 2013a). Large, state-owned mines accounted for more than 86 percent of CMM emissions (2000), and produced 42 percent of total national coal production in 2004 (Zhang et al., 2004).

7.2.1 CMM Emissions from Operating Mines

Increasing numbers of Chinese mines are installing drainage (degasification) systems. By 2006, more than 300 mines had installed CMM drainage systems (Huang, 2007) and as of 2011 this number had increased to 1,047 (Huang, 2013a). China's CMM drainage volume experienced a five-fold increase between 2005 and 2013, reaching 12.6 billion cubic meters (m^3), up from 2.2 billion m^3 in 2005 (Huang, 2014). Approximately 80 percent of all CMM drained was from key, state-owned coal mines (Huang, 2007). The volume of CMM recovered and used in 2012 was 3.75 billion m^3, more than six times 2005 levels (Huang, 2013a).

In 2011 China's mines emitted more than 19 billion m^3 of ventilation air methane (VAM), almost 8 billion m^3 of which was emitted from large, state-owned mines (Huang, 2013a).

Table 7-4 shows historical data (where available) for CMM emissions, drainage, and utilization levels in China.

Table 7-4. China's CMM Emissions (million cubic meters)

Year	CMM Emissions	CMM Drainage	CMM Utilized
2000	9,435*	870	318.4
2005	18,005*	2,300†	900†
2010	20,694*	7,500**	2,500††
2011		9,200**	3,500^
2012		11,400**	3,500^^
2013		12,600‡	4,250‡
2015(projected)	22,490*		

Sources: GMI (2005); *USEPA (2012a); **Huang (2013a); †Huang (2007); ††CCII (2011); ^Huang & Liu (2012); ^^Huang (2013b); ‡Huang (2014)

In China, the main types of CMM use projects are town gas, electricity generation, industrial boiler fuel feed, vehicle fuel, and thermal applications (e.g., office space heating). Some Chinese CMM projects involve multiple end uses. As of 2013, China's CMM use projects utilized 4.25 billion m^3 of methane (Huang, 2014). CMM-to-power projects generated a total of more than 1,500 MW of power by the end of 2011 (Huang, 2013a). Additionally, approximately 4,000 vehicles operate on CMM as fuel (Huang, 2010).

As technology has advanced, the utilization efficiencies of CMM projects have also improved, increasing the size of individual projects (Huang, 2007).

The largest CMM power project in the world is located at the Sihe Mine in Jincheng, Shanxi Province. This project uses Caterpillar engines to generate electricity at a 120-MW capacity power plant. The project utilizes more than 187 million m^3 of both coal bed methane (CBM) and CMM from the Sihe mine (USEPA, 2006; Huang, 2008; Huang, 2013a; Sun, 2014). The Sihe project avoids the release of more than 3 million metric tons of carbon dioxide equivalent ($MMTCO_2E$) annually (Sun, 2014).

Use of CMM resources is being expanded for application in the chemical industry in China. For example, formaldehyde and carbon black are being produced using CMM in Fushun, Huainan, Zhongliangshan, Songzao, and Tianfu.

Information on individual CBM/CMM use projects in China can be found in the Global Methane Initiative (GMI) International CMM Projects Database, which includes information on more than 350 current and planned CMM projects around the world (GMI, 2014). The database includes 67 active CMM projects in China, all at active underground mines. Of these projects, seven use CMM as boiler fuel; four provide methane for industrial use; 29 use CMM for power generation; 14 provide town gas; two provide vehicle fuel; and three are VAM mitigation projects (GMI, 2014).

China is host to the first VAM project approved by the UNFCCC. The VAM abatement and energy recovery project was commissioned in October of 2008 in Zhengzhou and provides hot water for local use (Mattus, 2012). Annual emission reductions average 382 thousand $MTCO_2E$ (UNFCCC, 2008). Additionally, at the Datong mine in Chongqing Municipality, hosts the largest VAM abatement system in the world, operating since mid-2011. This project, which includes hot water for local use, reduces greenhouse gas (GHG) emissions by approximately 184 $MTCO_2E$ per year (Mattus, 2012; UNEP, 2014).

Chongqing Energy Investment Group Corporation, Chongqing Songzao Coal and Electricity Co., Ltd. and DKT Technology, signed a joint venture for construction and operation of a CMM project at the Songzao coal mines. This project is a result of a feasibility study funded by the U.S. Environmental Protection Agency (U.S. EPA). DKT will construct a CMM to liquefied natural gas (LNG) plant that will connect to Songzao's gas pipeline network. The plant will use CMM with a concentration of 30 percent methane in air as feed gas. The plant capacity is designed to process 15,000 standard m^3 of CMM per hour yielding 35 million m^3 of methane per year. Due to expected fluctuations of CMM flow and concentration, production will vary from 30 to 40 million m^3 (25,000 - 30,000 tonnes) of LNG per annum (DKT, 2015).

7.2.2 CMM Emissions from Abandoned Coal Mines

The China Coal Information Institute (CCII) established the Abandoned Mine Methane Project Advice Centre (AMMPAC) to advise and promote the country's abandoned mine methane (AMM) use (CCII, 2010). Initially funded by the UK Foreign and Commonwealth Office through its Climate Change Challenge Fund, the program was designed to help build capacity for CCII to provide guidance and disseminate training to mining enterprises and project developers, through activities ranging from assistance evaluating and developing AMM schemes to technical guidance documents to assistance finding potential investors and technical specialists (Creedy et al., 2010). Further information about this program is available at http://www.coalinfo.net.cn/cnuk/eprojects/05.htm. Additionally, GMI funded a cooperative agreement to investigate abandoned mine methane emissions in China entitled, "Methane Emissions from Abandoned Coal Mines in China." Information about this project and results of analysis can be found at www.chinamethane.org.

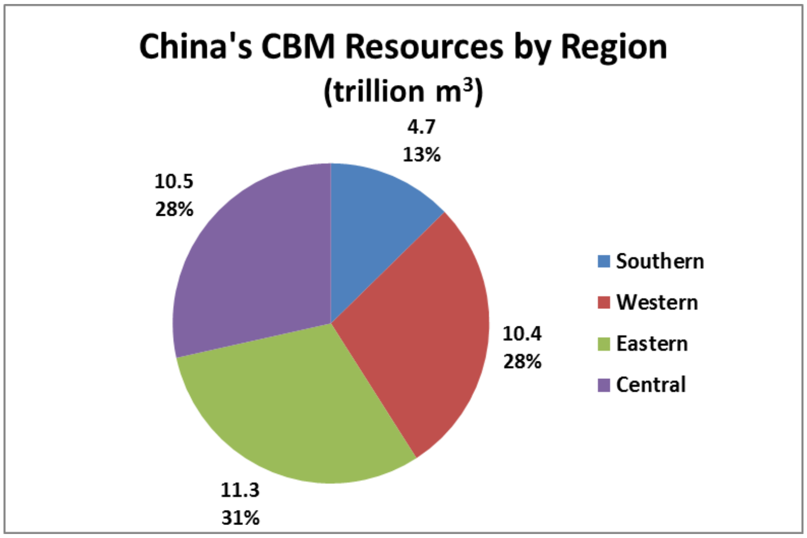
The closing of state-owned coal mines and town and village coal mines that do not meet production and safety requirements has left a large number of abandoned mines throughout China. Hundreds of coal mines have been abandoned since the 1950s and abandoned reserves are estimated at more than 30 billion tonnes. To date, no AMM projects have been initiated in China.

CCII's Xi'an branch has also studied AMM resources in China, focusing on detailed geological conditions, characteristics of AMM reservoirs, gob/goaf area and coal reserve estimation, ground water study and mine gas sampling, and AMM resource estimation (CCBMC, 2004).

7.2.3 CBM from Virgin Coal Seams

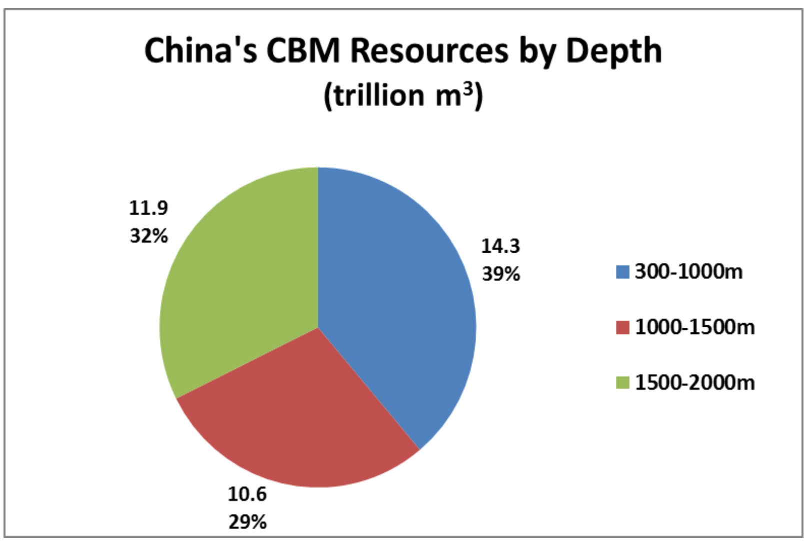
China's CBM resources contained in bituminous and anthracite coal deposits at depths between 300 and 2000 meters are estimated to be 36.8 trillion m^3 (Huang, 2010; Huang, 2013a). Figures 7-2 and 7-3 display China's distribution of CBM resources by region and depth.

Figure 7-2. China's CBM Resources by Region



Source: Huang (2013a)

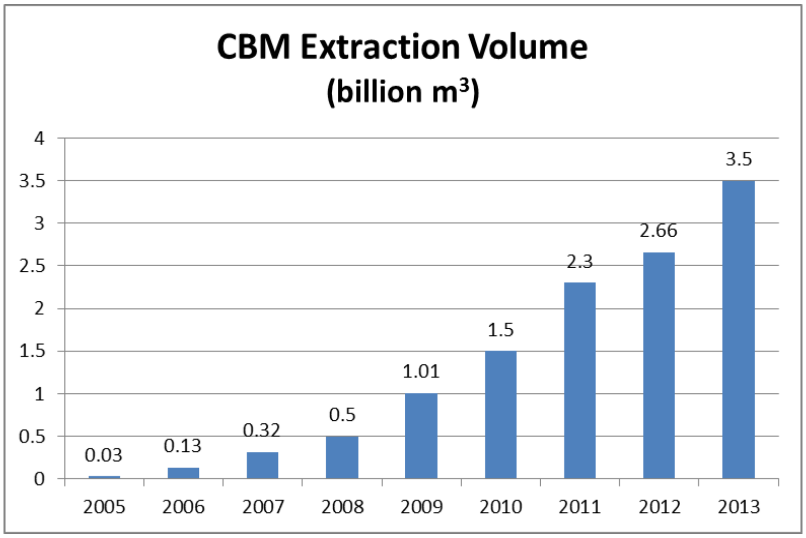
Figure 7-3. China's CBM Resources by Depth



Source: Huang (2013a)

The total production of CBM has increased dramatically within the last decade as shown by Figure 7-4. Total Chinese CBM production was estimated to be 3.5 billion m³ in 2013. The national production target for CBM is 10 billion m³ by 2010 (Huang, 2007; EIA (2009); Merrill, 2007).

Figure 7-4. China's Annual CBM Production



Source: Huang (2013a)

By the end of 2012, a total of 12,547 CBM wells had been drilled in China. Of these, 4,420 wells have been drilled by the Jincheng Anthracite Mining Group (JAMG). JAMG had 2,650 wells in production in 2012, producing 3.9 million m^3 per day for an annual total of 713 million m^3 (Huang, 2013a).

Between 2011 and 2015, China National Petroleum Corp. (CNPC), China's largest oil and gas producer, is investing $1.14 billion in drilling 371 horizontal wells in the Zhengzhuang, Qinnan, Mabi, and Xiadian blocks of the Qinshui Basin in Shanxi Province to increase annual production capacity (China Coal Resource, 2010; CNPC, 2013). In 2011, CNPC enhanced CBM production capacity in the Qinshui Basin and expanded into the eastern edge of the Ordos Basin, supplying 420 million m^3 of commercial CBM. In 2012, CNPC proved 78.8 billion m^3 of CBM in place, built an additional 1.35 billion m^3 of production capacity, and supplied 600 million m^3 of commercial CBM (CNPC, 2013).

7.3 Opportunities and Challenges to Greater CMM Recovery and Use

China is a signatory to both the UNFCCC and the Kyoto Protocol (Table 7-5). As a Non-Annex I Party to the Kyoto Protocol, China was eligible to host GHG mitigation projects, such as CMM projects, under the Clean Development Mechanism (CDM). The CDM created additional revenues for CMM projects in China through carbon credits trading. As of 2014 China had 3,750 registered CDM projects. Of these, 83 are CMM projects (UNEP, 2014).

Table 7-5. China's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 11, 1992	January 5, 1993
Kyoto Protocol	May 29, 1998	August 30, 2002

Source: UNFCCC (2014)

Though China has no emissions targets under the UNFCCC or Kyoto Protocol, China's government announced in November of 2009 that it would cut emissions of carbon relative to economic growth by 40 percent to 45 percent by 2020 compared with 2005 levels (Huang and Wu, 2010). In 2010, the Chinese government announced its Twelfth Five-year Plan, which required the development of an emissions trading scheme (ETS) in China. In 2011, the National Development and Reform Commission (NDRC) General Office published the "Notice on Carbon Emissions Trading Pilot," in which Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei and Shenzhen, in total, seven provinces and cities were assigned as ETS pilots in China. As of early 2014, programs have been initiated in six of these regions as shown in Table 7-6 (Environomist, 2014). These pilot programs are expected to serve as testing ground for a national ETS to be implemented after 2016 (Carbon Market Watch, 2013).

Table 7-6. China's Regional Pilot Emissions Trading Schemes

	Guangdong	Hubei	Shanghai	Tianjin	Shenzhen	Beijing	Chongqing
2015 Emission Reduction Target (compared to 2010)	19.5%	17%	19%	15%	15%	18%	17%
Reporting Obligations	Industrial companies emitting more than 10,000 tons of CO_2	Companies consuming more than 8,000 tons of standard coal per year	Companies emitting more than 10,000 tons of CO_2 per year	Carbon-intensive industries such as iron and steel, chemical, power, heating, petrochemical and exploitation and those of civil buildings, which emit more than 10,000 tons of CO_2 annually	Companies emitting more than 3,000 but less than 5,000 tons of CO_2 annually, and other enterprises and buildings in specific area	Companies consuming more than 2,000 tons of standard coal per year in the provincial area	Pending
Compliance Coverage	Companies emitting more than 20,000 tons of CO_2 in industries of power, cement, iron and steel, ceramic, petrochemical, textile, non-ferrous metals, plastics, and paper	Industrial companies consuming more than 60,000 tons of standard coal annually	Carbon-intensive industries such as iron and steel, which emit more than 20,000 tons of CO_2 annually; non-industrial enterprises which emit more than 10,000 tons of CO2 annually	Carbon-intensive industries such as iron and steel, which emit more than 20,000 tons of CO_2 annually	Enterprises and institutional organizations which emit more than 5,000 tons of CO_2 per year, large public buildings over 20,000 square meters, office buildings for governmental agencies over 10,000 square meters	Companies emitting more than 10,000 tons of CO_2 annually, both direct and indirect	Pending
Commenced	December 2013	December 2013	November 2013	December 2013	June 2013	November 2013	Pending

Source: Environomist (2014)

7.3.1 MARKET AND INFRASTRUCTURE FACTORS

Coal provides 69 percent of the energy consumed annually in China, with only four percent provided by natural gas. The NEA's Twelfth Five-year Natural Gas Development Plan called for the natural gas percentage to reach about eight percent by year-end 2015, and it is commonly projected that the percentage will exceed 10 percent by 2020 (EIA, 2014a; USEPA, 2012b).

Methane that occurs in coal has gradually evolved from a pure mine safety concern to a valued commodity and a significant component of the natural gas resources that the government plans to develop under its Twelfth Five-year Plan. The Twelfth Five-year Natural Gas Development Plan explicitly includes CBM for the first time, targeting consumption to rise to 20 billion m^3 by 2015, or about eight percent of the total. The NEA's Twelfth Five-year Plan for CBM and CMM is even more ambitious, calling for total production to rise to 30 billion m^3 by 2015 – 16 billion for CBM and 14 billion for CMM. The utilization rate for pumped CMM is called to rise to 8.4 billion m^3 from the 2010 level (NEA, 2011).

Of the 16 billion m^3 of CBM captured through surface drilling, the NEA projects that 10 billion should come from the Qinshui Basin, 5.4 billion from Ordos Basin, with the remaining 600 million coming from smaller developments in 1) the Tiefa and Fuxin areas of Liaoning Province, 2) from "experimental" programs in the Jiaozuo and Pingdingshan areas of Henan Province, 3) the Anshun and Zhijin areas of Guizhou Province, and 4) other areas in Xinjiang, Anhui, Sichuan, and Gansu Provinces, where drilling conditions are more challenging. Significantly, the plan also calls for the construction of 13 pipelines with total length of more than 2,000 kilometers and 12 billion m^3 per year total transport capacity, signaling a significantly stepped-up effort to integrate CBM into the largest natural gas economy. These efforts were already underway in the latter part of the 2000s, with the construction by CNPC of a one billion cubic meter per year CBM processing facility in the Qinshui basin with the intent to inject its own and third-party CBM into the nearby first West to East pipeline.

The NEA's Twelfth Five-year Plan for Development of CBM/CMM calls for CMM to be used primarily as a local fuel, with the number of residential users to approximately double to about 3.3 million households between 2010 and 2015, and power generation capacity to quadruple to 2850 MW as overall CMM utilization rises by about 5.5 billion m^3. The Plan also calls for CMM power generation capacity to quadruple to 2,850 MW between 2010 and 2015, and reiterates that, while the power should be consumed by the mines themselves when possible, the policies regarding off-take by the grid should be implemented. Given the limited ability of the mines to absorb all of the power, the fulfillment of the Twelfth Five-year Plan targets will depend on more rigorous adherence by the grid to the off-take policies (NEA, 2011).

The focus on local consumption of CMM poses challenges, as many of the coal mines recovering CMM have exhausted the possibilities for burning the CMM to generate power for their own use, or supplying CMM to customers in the immediate vicinity of the mines. Additionally, given the rapid construction of electricity generation capacity in China since 2003, including many projects still outstanding, there is a distinct possibility that power generation capacity will outstrip demand in many parts of the country through 2015-2017.

Only a few local governments such as Jincheng, a municipality of approximately two million people in the Qinshui basin area, have mobilized to invest in region-wide CMM distribution infrastructure. Jincheng has advantages that other localities do not necessarily share, including the ability to mix higher methane-content CBM with its CMM, and a supportive provincial government, which has granted CMM producers an additional 0.3 yuan per cubic meter rebate for CMM sales for civil and industrial use on top of the 0.2 yuan offered by the national government. Despite the booming demand for natural gas, municipalities such as Chongqing have not found it cost-effective to construct the medium-distance pipelines necessary to transport unprocessed CMM from large producers such as Songzao into the city proper in view of the gathering, pipeline investment, and processing costs.

The government's Twelfth Five-year Plan for CBM and CMM addresses the barriers to the further popularization of CMM in general terms, acknowledging the unfavorable economics of many CMM utilization projects, the difficulties winning power grid company acceptance of the existing regulations requiring them to accept CMM-generated power at premium prices, and the need for stronger government incentives to promote CMM utilization. Follow-through on removal of these barriers will be vital to enforcing the power dispatch and CMM pricing policies and achieve the power generation targets.

As with CBM, the purification and liquefaction of CMM offers a potential solution to the market barrier problems. Technologies to remove impurities of CMM at low temperature have been proven outside of China, and are under development in China itself; no extra step is required to liquefy once purification has taken place. While it would most likely not be economic to sell the product to the petroleum pipeline companies given the domestic gas pipeline transmission pricing structure, transportation by tanker truck would allow the CMM plants to sell directly to near or distant distribution companies. In general, the economics of purified and liquefied CMM should be attractive under conditions where overall supply continues to be tight, and imported gas is a significant component of the overall natural gas sales base.

While many coal mining companies have considered the LNG option for utilization of their CMM, most have hesitated to move ahead in view of the high up-front cost relative to other options such as small distributed power plants, and the lack of reference CMM to LNG units in China. As of mid-2012, only small demonstration facilities constructed by Chinese purification technology developers were in operation.

The number of mines with degasification systems in China has more than tripled since 2006; however, still relatively few of China's underground mines have installed degasification systems. Even where degasification systems have been installed, they have encountered challenging geologic conditions for which degasification technologies commonly used in China are often unsuitable (Huang, 2005; Huang, 2013a). Even where there are drainage systems in place, there are still a number of challenges to effectively recovering and using the methane from mine drainage systems. These barriers include small project size, fluctuating methane production, the high capital cost of utilization projects, and limited infrastructure.

Currently, with China's underdeveloped natural gas market, many do not have access to natural gas, limiting the potential market for CMM. Of the estimated 664 million people living in Chinese cities, suburbs, and towns, only 145 million had access to natural gas at year-end 2010. Entire provinces, such as Guizhou, Yunnan, Guangxi, and Ningxia offered virtually no gas to their urban residents, and even highly-developed provinces such as Guangdong and Jiangsu only offered gas to 12 and 22 percent of their respective city and town dwellers. As for CMM, most of the mines in China are located in remote mountain areas, where the terrain makes it difficult to construct long-distance pipelines to deliver drained CMM to cities. The first West-East Natural Gas Pipeline, between

Xinjiang and Shanghai, began operating in October 2004, and has a capacity of 17 billion m^3 of natural gas, which is supplied to 10 provinces across China's Eastern and Western regions. However, only a few coal mining areas are close enough to the pipeline to have the possibility of accessing it for delivery of CMM. The second West-East Pipeline commenced operation and connects Xinjiang to Guangdong with a capacity of 30 billion m^3.

The price structure in China has historically favored use of CMM over natural gas, with the consumer price of CMM for civil and industrial consumption set far lower than that of natural gas (GMI, 2005). In April 2007, the Ministry of Finance provided a subsidy of 0.2 Yuan/m^3 for CMM utilization; the local finance departments are allowed discretion to increase their own subsidies based on this standard (Huang 2007; Guizhou, 2008; Huang, 2012). The government also provides a 0.25 yuan/kilowatt-hour subsidy for CBM/CMM-fueled power generation, which is the same subsidy offered for biomass power generation. Since 2007, the central government has awarded subsidies of 1.8 billion yuan to support CBM/CMM development, which accounted for 9.2 billion m^3 (Huang, 2012).

Large-scale development of shale gas could lower the cost structure of the national gas industry as it has in the United States, also working against the interests of CMM producers. Given the time that will be required to develop shale gas expertise, this is likely to be a long-term rather than a medium-term issue.

Many organizations in China and abroad have financially sponsored the research and development of CMM projects (GMI, 2005). They include the China Coalbed Methane Clearinghouse of CCII, National Development and Reform Commission (NDRC), State Administration of Coal Mine Safety (SAWS), U.S. Trade and Development Agency, World Bank, Asian Development Bank (ADB), Global Environment Fund, Clean Development Mechanism, and Japan Development Fund.

A detailed discussion of China's market for CMM may be found in the United States Environmental Protection Agency document *China's Energy Markets: Anhui, Chongqing, Henan, Inner Mongolia, and Guizhou Provinces*, at http://epa.gov/cmop/docs/2012ChinaEnergyMarket.pdf.

7.3.2 Regulatory Information

In China, recovery and utilization of CMM can only be exercised by coal enterprises with legal mining licenses. CMM projects require approval from the NDRC at the county, provincial, and central government level, depending on the size and type of project. CMM power generation projects that are connected to the power grid must be approved by the investment administration of the provincial government. CMM projects generating power used only by the mining company must be recorded by the investment administration of the local government. The investment administration of provincial governments shall report both approved and recorded projects to the investment administration of the State Council (NDRC, 2007).

A CBM or CMM pipeline project with the capacity to transport more than 500 million m^3 a year or crossing provincial boarders shall be approved by the investment administration of the State Council. A CBM or CMM pipeline project with capacity to transport less than 500 million m^3 a year shall be approved by the investment administration of the provincial government (GOSC, 2006).

China has established a number of financial incentives to encourage CMM projects. Developers are exempt from the prospecting and licensing fees on CBM development, and no royalties are levied on

CBM through 2020. Value added tax (VAT) collected from coal mines recovering and utilizing CBM/CMM is returned to the coal mining companies, and no income tax is paid by enterprises developing technologies for CMM recovery and utilization. Coal mine owners or developers investing capital in CMM projects through loans or self-equity financing can claim 40 percent of the capital value to offset income taxes (Huang, 2012; IEA, 2009).

These policies have the potential to encourage CMM project development; however, it is notable that in order to obtain the aforementioned subsidies and tax exemptions, a developer must request them at the appropriate level as well as follow up on a regular basis.

Additionally, China's Central Government provides 3 billion CNY for coal mine safety projects each year, most of which is used for mine gas recovery projects. Coal mines can collect 15-20 CNY per ton from coal sales to be applied to mine safety projects (Huang and Wu, 2010).

All exploration and mining activities must be approved by the Ministry of Land and Resources (MLR) or with provincial land and resources bureaus (LRBs) to obtain exploration or mining rights. Large coal mines in excess of 100 million metric tons of reserves must obtain licenses through the MLR; however, smaller mines may obtain permission from provincial LRBs as a result of government restructuring in the late 1970s. Oil and gas activity must be registered through the MLR as the central government did not transfer management power to local levels as it did in the coal industry. China's Mineral Resources Law was passed in 1986 and did not list CBM independently as a mineral resource until it was amended in 1996, clarifying that CBM is one of China's 34 mineral resources, amongst other issues.

The rights to exploration and development of CMM or CBM projects in China have been modified to be more inclusive. Initially, the China United Coalbed Methane Corporation (CUCBM) had the monopoly rights to CMM or CBM exploration, development, and production in cooperation with foreign firms. If a commercial CBM field was found, CUCBM and the foreign party would jointly establish an organization and conduct development and production. However, on September 24, 2007, the State Council modified the relevant regulations, "Regulations of the People's Republic of China on Exploitation of On-shore Petroleum Resources in Cooperation with Foreign Countries," to effectively eliminate the CUCBM monopoly. The law now includes the option for "other companies designated by the State Council" to join with foreign businesses in exploiting CMM resources (Huang, 2007). Alternatively, if a CMM development project is to be realized by foreign grants or free technical assistance (i.e., if the projects are non-profit and non-commercial in nature), it is not necessary to involve CUCBM (CBMC, 2004).

Exploration and mining of CBM is registered in the same manner as conventional oil and gas, and since 1998 three centrally-controlled state-owned enterprises (SOEs), CUCBM, CNPC, and China Petroleum and Chemical Corporation registered for exploration rights of approximately 65,000 m^2 of CBM blocks, comprising more than half of the total CBM blocks, while other SOEs such as China Petro-Chemical Corporation (SinoPec) registered for smaller shares (Lin, 2011).

All CMM projects must conform to relevant environmental and safety regulations before operating. Projects should focus on waste water drainage, atmospheric pollution, and noise pollution. Energy use during the projects should be in accordance with the "Energy Conservation Law of the People's Republic of China" and the energy-saving regulations and measures of the state and local governments. The State Administration of Work Safety (SAWS) monitors worker safety in China.

Laws and regulations such as the "Coal Mine Safety Regulation" should be followed when developing CMM exploitation and utilization projects.

China's Ministry of Environmental Protection issued an Emission Standard of CBM/CMM in 2008 for new coal mines and drainage systems. The standard requires operators of CMM drainage systems with greater than 30 percent methane concentration to use or flare the gas. As of 2012, anecdotal evidence indicated this policy was creating a perverse incentive in some areas to maintain gas concentrations below 30 percent by dilution, ignoring best practices and safety standards (USEPA, 2012b).

For a detailed discussion of ownership and policy issues related to CBM and CMM in China and worldwide, see the United States Environmental Protection Agency document *Legal and Regulatory Status of CMM Ownership in Key Countries: Considerations for Decision Makers*, at http://www.epa.gov/cmop/docs/CMM-Ownership-Policy-White-Paper-July2014.pdf.

7.4 Profiles of Individual Mines

Feasibility studies for CMM projects at a few Chinese mines, profiles of some individual mines in China, and descriptions of CMM project opportunities are available on the following web sites:

- Global Methane Initiative (GMI): http://www.globalmethane.org
- U.S. EPA: http://epa.gov/cmop/international/china.html
- China Coal Information Institute (CCII): http://www.nios.com.cn/cbmproject.html

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8 Colombia

8.1 Summary of Coal Industry

8.1.1 Role of Coal in Colombia

Coal accounted for eight percent of Colombia's energy consumption in 2007 and one-fourth of total exports in terms of revenue in 2009 (EIA, 2010a). As the world's tenth largest producer and fourth largest exporter of coal (World Coal, 2012; Reuters, 2014), Colombia provides 6.9 percent of the world's coal exports (EIA, 2010b). It exports 97 percent of its domestically produced coal, primarily to the United States, the European Union, and Latin America (EIA, 2010a).

Colombia had 6,746 million tonnes (Mmt) of proven recoverable coal reserves in 2013, consisting mainly of high-quality bituminous coal and a small amount of metallurgical coal (Table 8-1). The country has the second largest coal reserves in South America, behind Brazil, with most of those reserves concentrated in the Guajira peninsula in the north (on the country's Caribbean coast) and the Andean foothills (EIA, 2010a). Its reserves of high-quality bituminous coal are the largest in Latin America (BP, 2014).

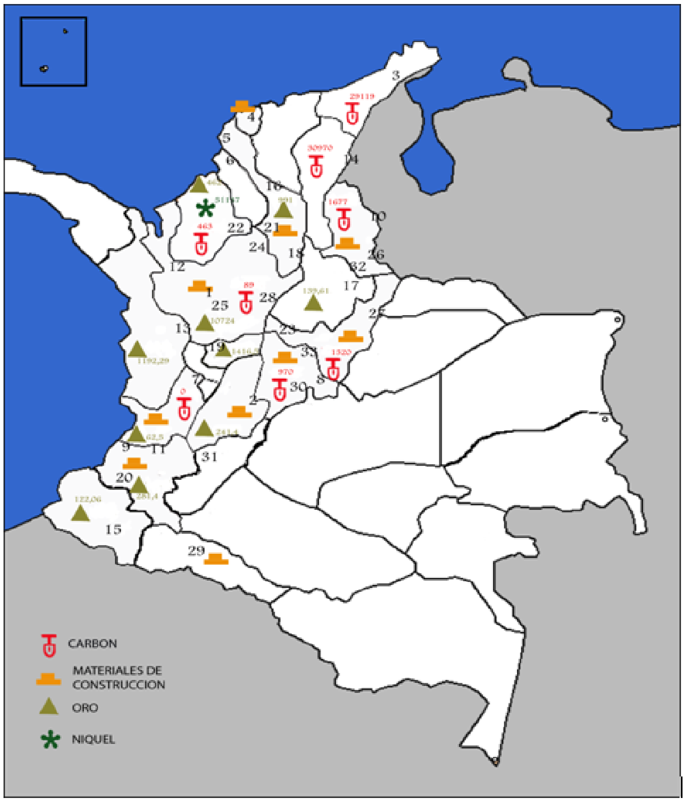
Table 8-1. Colombia's Coal Reserves and Production – 2013

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2013)	6,746.0	0.0	67469.0	11 (0.8%)
Annual Coal Production (2013)	85.5	0.0	85.5	10 (1.4%)

Source: BP (2014)

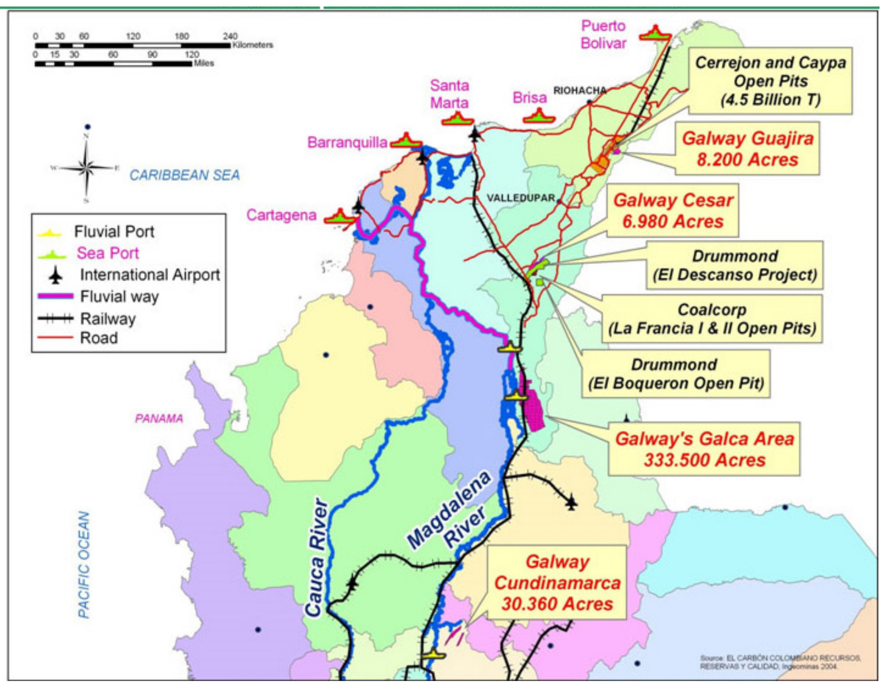
Coal production for export occurs mainly in the northern states of Guajira (Cerrejón deposit), Cesar, and Cordoba. There are widespread small and medium-size coal producers in Norte de Santander (metallurgical coal), Cordoba, Santander, Antioquia, Cundinamarca, Boyaca, Valle del Cauca, Cauca, Borde Llanero, and Llanura Amazónica (MB, 2005). Figures 8-1 and 8-2 illustrate the locations of coal deposits and mines in Colombia.

Figure 8-1. Map of Colombian Minerals



Source: ANDI (2010)

Figure 8-2. Map of Colombian Coal Mines



Source: Galway (2007a)

8.1.2 STAKEHOLDERS

Table 8-2 lists potential stakeholders in Colombia's coal mine methane (CMM) industry.

Table 8-2. Key Stakeholders in Colombia's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ Prodeco (owned by Xstrata) ▪ Carbones de La Jagua (owned by Glencore) ▪ Cerrejón Coal Company (joint venture of Anglo-American, BHP, and Xstrata) ▪ Anglo American (AA) ▪ BHP Billiton (BHB) ▪ Glencore Xstrata ▪ Vale SA ▪ Carbones del Cerrejón LLC ▪ C.I. Prodeco S.A. ▪ CCX ▪ MPX ▪ Carbones de La Jagua S.A. ▪ SATOR ▪ Minas PazdelRio ▪ CoalCorp ▪ CERX ▪ Drummond Ltd. ▪ Acerías Paz del Río, S.A. ▪ New Age Exploration (NAE)	Project hosts
Equipment Manufacturers	▪ Wood Group Power Solutions, Inc. (part of the Gas Turbine Services Division of John Wood Group PLC ▪ GE Transportation Systems – Electric drive systems (loaders and haulage) ▪ Goulds Pumps – Slurry and process pumps (pumps, compressors, valves and actuators) ▪ Grindex – Submersible drainage, sludge and slurry pumps (pumps, compressors, valves and actuators) ▪ Hansen Transmissions – Gear units and power transmission products (power supply, engines, transmission and drives) ▪ Voith Turbo GmbH & Co. KG – Start-up components (power supply, engines, transmission and drives)	Methane treatment and utilization equipment
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Natural Gas Transmission & Distribution Companies; Power Companies	▪ Andina Electrica	Pipeline sales for power generation
Natural Gas Production and Transport	▪ Chevron ▪ Ecopetrol	
Government Groups	▪ Ministry of Mines and Energy	Regulation and policymaking

Sources: MT (2007); World Coal (2012); BP (2014)

8.1.3 Status of Coal and the Coal Mining Industry

Colombia produced 85.5 Mmt of coal in 2013, while only consuming 4.9 Mmt. Colombian coal production is exclusively carried out by private companies and has increased about 78 percent in the past decade (Mining, 2014). Colombia's mining minister Carlos Rodado said coal output will reach 100 Mmt by 2015 and 144 Mmt in 2020 (Sourcewatch, 2012a).

Tables 8-3 and 8-4 list available specifics on Colombia's coal mining companies as of 2010.

The largest coal producer in Colombia is the Carbones del Cerrejon consortium, composed of Anglo-American, BHP Billiton, and Xstrata. The consortium operates the Cerrejon Zona Norte (CZN) project, the largest coal mine in Latin America and among the largest open-pit coal mines in the world. CZN is an integrated system of mine, railroad, and a Caribbean coast export terminal (EIA, 2014).

The open pit mine produces 33 Mmt per year (2013) and plans to increase production up to 50 Mmt per year are being considered, owing to the $1 billion investment by Carbones del Cerrejon (MT, 2007). The country's second largest coal mine, La Loma, is a mine-railway-port project operated by Drummond, which produced 25 Mmt in 2011 (Drummond, 2014). In 2008, Colombia gave Drummond permission to open the El Descanso Mine, which is expected to produce up to 25 Mmt by 2015 (Sourcewatch, 2012b).

Also in 2008, Galway began exploration drilling in the Carboluis project in San Luis Coal basin located in Santander—an area with some 300 Mmt of coal (Galway, 2007b) — but the company has put that project on hold while it looks for equity partners (Union, 2010).

Colombia's coal is relatively clean-burning, with a sulfur content of less than one percent.

Table 8-3. Major Colombian Coal Producing Companies\Regions

Mine	Production in 2010 (million tonnes)
Cerrejón Coal Company (2013)	33
Drummond (2013)	25
Prodeco	10.2
Otros	3.8
Boyacá	2.7
Cundinamarca	2.1
Norte de Santander	2.2

Source: ANH (2014)

Table 8-4. Major Colombian Coal Mines

Mine	Type	Location	Owner	Production (million tonnes per year)	Mineable Reserves (million tonnes)
Cerrejón Zona Norte	surface	La Guajira	Cerrejón Coal Company	28.4 (2010)	1,600
Carbones del Cerrejón	surface	La Guajira	Cerrejón Coal Company	3.7 (2010)	-
EI Cerrejón Corte	surface	La Guajira	Cerrejón Coal Company	5.6 (2010)	-
Mina Pribbenow /La Loma	surface	Cesar	Drummond	18.1 (2010)	485
El Descanso	surface	Cesar	Drummond	3 (2010)	960
El Hatillo	surface	Cesar	Vale S.A.	1.8 (2008)	500
Calenturitas	surface	Cesar	Glencore/Prodeco	5.2 (2010))	
La Jagua	surface	Cesar	Glencore/Prodeco	8.5 (2003) 4.4 (2009)	260
La Jagua	underground	Cesar	Glencore/Prodeco	0.9 (1994)	-
GALCA	exploratory	Cesar	Galway/Prodeco	exploratory	60-200
La Francia	surface	Cesar	Goldman Sachs (from CoalCorp Mining)	1.5	
Caypa	surface	Cesar	Carbones Colombianos del Cerrejon/CoalCorp Mining	0.175 (2007)	8.8
Río de Oro		Norte de Santander	Geominas		60-320
Paz del Río		Boyaca	Acerías Paz del Río S.A.	2.6 (2010)	
Puerto Libertador	surface	Cordoba	SATOR-	0.1 (2010)	-

Sources: Jahnig (2007); USGS (2008); ANDI (2010); Mining Weekly (2008); Mining Weekly (2010); MB (2005); ANH (2014)

8.2 Overview of CMM Emissions and Development Potential

8.2.1 CMM Emissions from Operating Mines

A pilot project to measure methane emissions is underway at the La Loma/Pribbenow Mine, operated by U.S.-based Drummond Company, Inc., one of the largest coal producers in Colombia, and located near La Loma in Cesar Department; the mine has estimated reserves in excess of 534 Mmt of high-Btu, low-ash and low-sulfur coal. There have been no published results although the project was confirmed by a general engineer at Drummond Inc., USA. Drummond estimates that there are 62.2 billion cubic meters (2.2 trillion cubic feet) of coal bed methane (CBM) in its mines and it has signed a contract with Ecopetrol to extract CBM from the La Loma and El Descanso mines (EIA, 2014).

Table 8-5 provides Colombia's total CMM emissions.

Table 8-5. Colombia's CMM Emissions (million cubic meters)

Emission Category	2000	2005	2010	2015 (projected)
Total CH4 Emitted (= Total liberated – recovered & used)	231.1	357.1	511.2	651.3

Source: USEPA (2012)

The current potential for CMM projects in Colombia is limited to pre-mine drainage as most coal is surface mined; however, as mines target deeper seams, there should be significant potential for CMM projects.

8.2.2 CMM Emissions from Abandoned Coal Mines

No data on CMM from abandoned mines are available for Colombia at this time.

8.2.3 CBM from Virgin Coal Seams

Colombia has included CBM in its tender for oil and gas exploration and production contracts beginning in 2014. Drummond and Cerrejon have both announced that they will develop a CBM gas project in Colombia's La Guajira department. The project will be developed in Cerrejon's mining area where Drummond holds the right to produce methane gas. The companies are expected to soon reach an agreement (SeeNews, 2014).

8.3 Opportunities and Challenges to Greater CMM Recovery and Use

Colombia signed and ratified the UNFCCC and Kyoto Protocol, as indicated in Table 8-6. As a Non-Annex I Party to the Kyoto Protocol, Colombia has no national emissions targets and is eligible to host mitigation projects under the Clean Development Mechanism. Therefore, Colombia is eligible to secure project revenues from the sale of greenhouse gas (GHG) emission reduction credits.

Table 8-6. Colombia's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC*	June 13, 1992	March 22, 1995
Kyoto Protocol**	---	November 30, 2001

Source: UNFCCC (2014)

In 2012, the Colombian government launched the Colombian Low Carbon Development Strategy (CLCDS). While recognizing that Colombia's carbon emissions are low relative to developed countries, without mitigation actions they could increase significantly based on the country's projected economic growth. The strategy states that Colombia should consider international financial incentives to promote sustainable growth and prepare the economy for a "future carbonconscious global economy." The CLCDS is a medium and long-term development program led by the Ministry of Environment and Sustainable Development (MADS), the Department of National Planning (DNP), and the Industry, Energy, Mining, Transport, Housing, Waste, and Agriculture ministries of Colombia. The goal of CLCDS is to strengthen Colombia's economic and social development while concurrently meeting global requirements of efficiency, competitiveness and environmental performance.

The strategy of CLCDS is to:

- Identify and assess different actions that would reduce greenhouse gas emissions and support sectoral growth,
- Develop Mitigation Action Plans for each Colombian productive sector, and
- Create and promote tools for their implementation.

In 2014, Fundación Natura, a Colombian environmental charity, announced that it would launch a carbon trading platform in 2015 to individuals and companies seeking to offset carbon emissions. The platform is being developed by the Bolsa Mercantil de Colombia (BMC), a commodities exchange used by physical producers and consumers of farm produce (FNC, 2014).

8.3.1 Market and Infrastructure Factors

The International Finance Corporation (IFC) has financed a project to increase production of coal in Colombia and to help privatize the coal sector. Several large international corporations are involved in coal mining in Colombia such as the Drummond Company, Anglo American, BHP Billiton, and Glencore (MB, 2005).

Colombia has an open, emerging market economy, and it is known that the Colombian mining authorities are supportive of CMM development initiatives. The most significant challenge to CMM/CBM production in Colombia is the ability for this unconventional gas to compete with conventional natural gas that is produced in offshore fields. Conventional natural gas is transported to Bogotá and other cities via a pipeline and sold for about $0.50/Mmcf (million cubic feet); whereas CBM/CMM will require a wellhead price of around $1.50/Mmcf to become marginally profitable. Voluntary carbon trading schemes, such as the one initiated by Fundación Natura Colombia, could encourage investment in the CMM/CBM industry.

8.3.2 Regulatory Information

The key governmental body involved in the energy sector in Colombia is the Ministry of Mines and Energy, which is responsible for formulating and adopting policies directed towards the sustainable use of the country's mining and energy resources in order to contribute to the country's economic and social development. This is done by establishing policies that regulate:

- The exploration and extraction of hydrocarbons,
- The exploration, extraction and export of minerals,
- The production, expansion, distribution and supply of energy services, and
- The distribution and consumption of fuel gas.

On 25 March 2014, the Ministry of Mines and Energy adopted Resolution 90325, which allows mining companies to utilize the methane gas released during mining operations to provide energy for the mine. A draft of the implementation plan was scheduled for release at the end of November 2014.

8.4 Profiles of Individual Mines

No profiles are available for Colombia at this time.

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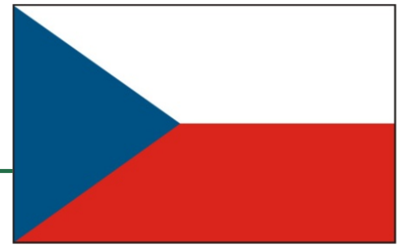
9 Czech Republic



9.1 Summary of Coal Industry

9.1.1 Role of Coal in the Czech Republic

The Czech Republic domestically provided for 1.06 Quadrillion Btu of its total energy consumption of 1.572 Quadrillion Btu in 2012 (EIA, 2014). Coal comprises 40.8 percent of the country's indigenous energy supplies (IEA, 2013). The Czech Republic ranks 27th globally in coal production, producing 54.97 million tonnes (Mmt) of coal in 2012. Its total recoverable coal reserves are estimated at approximately 1.05 billion tonnes (see Table 9-1).

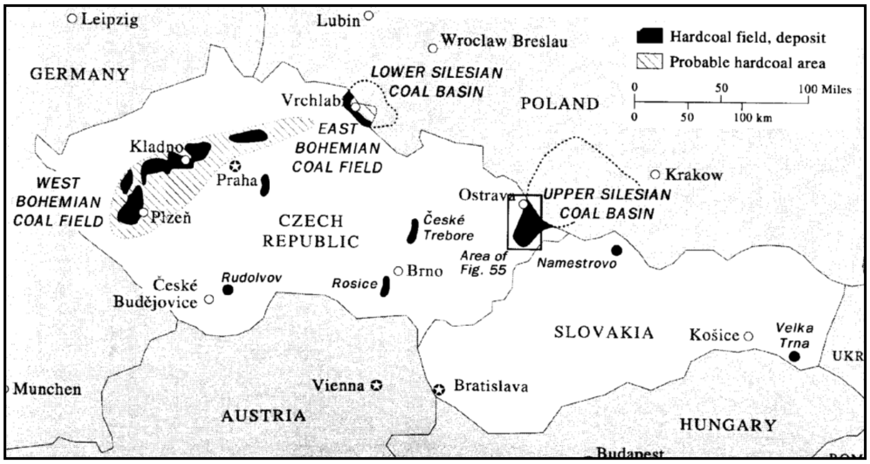
Table 9-1. The Czech Republic's Coal Reserves and Production

Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2011)	181	871	1,052	27 (0.118%)
Annual Coal Production (2012)	11.44	43.53	54.97	16 (0.70%)

Source: EIA (2014)

Hard coal occurs mainly in the eastern Silesian region, with the Ostrava-Karviná coalfields (known as "OKR") in the Upper Silesian Coal Basin being the most important black coal field in the country. Brown coal (lignite) is found mostly in the Northern Bohemian Brown Coal Basin (Euracoal, 2014). Other coal basins include the Lower Silesian coal basin (Zacler coal field) and the East Bohemian Coal Field (Kladno district) (Schwochow, 1997). The Republic is an exporter of coking coal to Slovakia, Austria, Hungary, and Poland mainly for steel production (IEA, 2010). See Figure 9-1 for locations of coal deposits.

Figure 9-1. Coal Basins of the Czech Republic



Source: (Schwochow, 1997)

9.1.2 STAKEHOLDERS

Table 9-2 lists potential coal mine methane (CMM) development stakeholders in the Czech Republic.

Table 9-2. Key Stakeholders in the Czech Republic's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Ostravsko-Karvinské Doly (OKD) ▪ Severočeské Doly a.s.(SD) ▪ Severní Energetická (formerly Litvínovská uhelná a.s.[LUAS]) ▪ Vršanská uhelná, a.s. (VUAS) ▪ Sokolovská Uhelná a.s. (SU)	Project hosts
Energy Companies	▪ Green Gas DPB ▪ Energie - stavební a báňská a.s. ▪ Unigeo a.s. ▪ CEZ Group ▪ Czech Power Company	CMM project identification and investment
Engineering, Consultancy, and Related Services	▪ RWE Energo ▪ See also http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Developers	▪ Essar Global ▪ See also http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Natural Gas Transmission & Distribution Companies	▪ RWE GasNet (distribution) ▪ RWE TransGas (transmission) ▪ Moravske Naftove Doly	Gas storage and trade Gas transmission Gas production and storage
Regulatory Agencies and Government Groups	▪ Ministry of the Environment ▪ Ministry for Regional Development ▪ Ministry of Industry and Trade ▪ Energy Regulatory Office	Regulation, licensing, permitting

Sources: IEA (2010); Euracoal (2014)

9.1.3 Status of Coal and the Coal Mining Industry

The coal industry is important to the Czech Republic's economy and coal will likely remain a key critical energy source through 2030 (Green Gas DPB, 2012). Table 9-3 characterizes the Czech Republic's coal mining industry as of 2008, stating production tonnage for each mine type.

Table 9-3. The Czech Republic's Coal Mines and Coal Production (2008)

Type of Mine	Production (million tonnes)	Number of Mines
Underground (active) mines – total	13.4	6
Surface (active) mines – total	47.0	6

Source: IEA (2010)

The country extracts all bituminous coal through underground mining, using the longwall method, primarily in the Upper Silesian Basin (USGS, 1994), specifically OKR (see Figure 9-1 on previous page). Lignite comprises less than 1 percent of the total coal produced, most of which (90 percent) is extracted through surface mining.

The Czech Republic's accession to the European Union has driven several structural reforms for the country's energy industry, beginning in 1999. As of 2013, the hard coal and brown coal sectors have been completely privatized, comprising five companies (Euracoal, 2014). Ostravsko-Karvinske Doly (OKD) is the last remaining hard coal mining company, which operates 4 underground mines—Karvíná, ČSM, Darkov, and Paskov—producing 12.8 Mmt annually (IEA, 2010).

The remaining companies mine lignite (IEA, 2010 [unless noted]):

- Czech Coal Group—comprised of Severní Energetická (formerly Litvínovská uhelná, a.s. [LUAS]) and Vršanská uhelná, a.s. (VUAS)—operates 2 opencast or surface mines that produced 15 Mmt in 2008.
- Severočeské Doly (SD) operates 2 opencast or surface mines—Doly Nástup Tušimice and Doly Bilina producing 22.8 Mmt of brown coal in 2012, increasing SD's share of brown coal production to nearly 50 percent (Euracoal, 2014).
- Sokolovska Uhelna (SU) operates 2 opencast or surface mines, the Družba and Jiří mines. In 2012, its output was 6.7 Mmt (Euracoal, 2014).

Despite a healthy coal mining industry, the country reduced its coal consumption by more than a third from 1993 to 2012 (EIA, 2014).

9.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database identifies one CMM project in place at an active underground mine in the Upper Silesian Basin. The methane is injected into a gas pipeline for delivery, using 77 million m^3 of CMM and 32 million m^3 of abandoned mine methane—avoiding a total of approximately 1.56 million metric tons of carbon dioxide equivalent ($MMTCO_2E$) of emissions (GMI, 2014).

9.2.1 CMM Emissions from Operating Mines

Methane emissions in the Czech Republic totaled 351.5 million cubic meters (m^3) in 2000, are expected to decrease to 294.1 million m^3 by 2015, and then anticipated to further decrease to 282.2 million m^3 by 2030 (see Table 9-4).

Table 9-4. The Czech Republic's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	351.5	325.6	306.7	294.1

Source: USEPA (2012)

Green Gas DPB has been a major player in CMM development in the Czech Republic since the1990s. The company operates mining leases for gas extraction at all closed mine locations in the OKR mining district. The company also purchases superfluous volumes of mine gas from active mines that are incapable of utilizing for their own needs. As the holder of appropriate licenses, Green Gas DPB is also engaged in survey, extraction, distribution and the sale of mine gas (Green Gas DPB, 2014a).

Recognizing the importance and value of CMM, starting in 2004, Green Gas DPB expanded its CMM utilization projects and began installing combined heat and power (CHP) units at active and abandoned mines. The pilot project used gas from closed strata in the Vrbice coalmine and from the Paskov operational coalmine in the Chlebovice region of the Czech Republic and a total of 28 TEDOM CHP units were in operation by 2008, producing 320 terrawatt hours annually (PowerGen, 2009). For example, in 2008, Green Gas DPB installed two CHP units at the Lazy mine where gas-powered engines use mine gas drained from the gas drainage station, which helps ensure the coal miners' safety. Additional projects include ČSA mine, with the first CHP unit installed in 2009 and a second in 2011. Electricity from many of the CHP projects is delivered into local distribution networks and heat is delivered into boiler rooms for mine heating purposes (Green Gas DPB, 2014b).

Other vested companies include a British company, Marine & Mercantile Securities, and Energie - stavební a báňská a.s., entered into a joint venture as Eurogas a.s., to explore existing wells and drill new ones in OKR coalfields between Ostrava's abandoned mines and the Polish border centered around Cesky Tesín and in the south below Frydlandt. Eurogas a.s. is currently researching alternative energy sources, including CMM and coal bed methane (CBM) with the experts from the VŠB - Technical University of Ostrava, Institute of Geonics AV CR, and others in academia (Energie - stavební a báňská a.s., 2014).

9.2.2 CMM Emissions from Abandoned Coal Mines

Green Gas DPB utilizes abandoned mine methane from four production areas in the OKR region with 10 abandoned shafts and 4 wells producing 25 million m^3 of methane annually (Green Gas DPB, 2007).

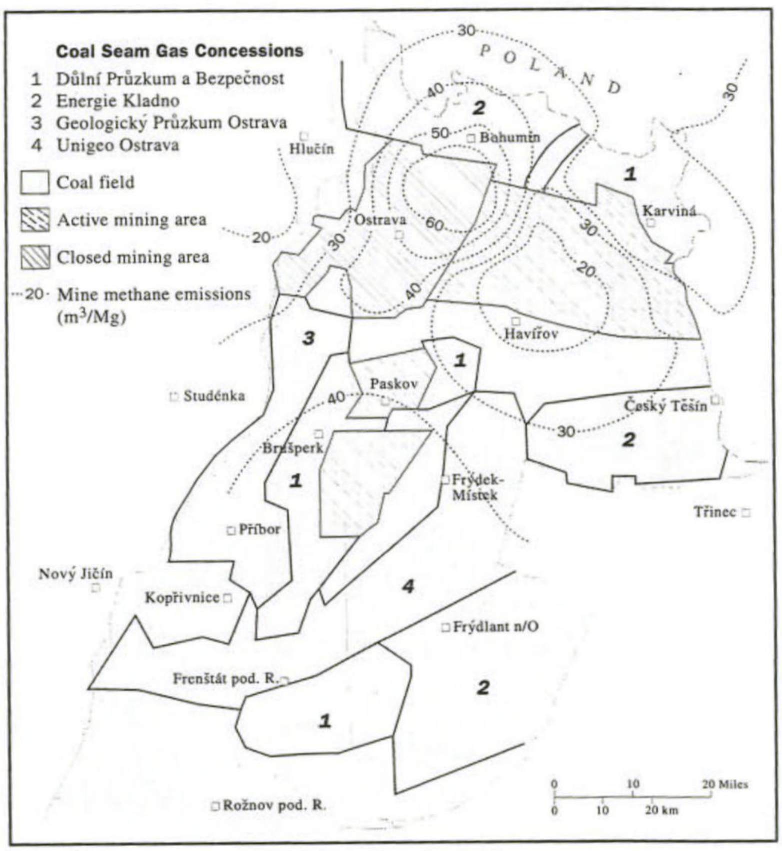
9.2.3 CBM FROM VIRGIN COAL SEAMS

The Czech lignite mines offer no potential for production of CBM from virgin seams or CMM from existing mines (BERR/DTI, 2004).

In 2004, a British study of CBM potential in the Czech Republic reported on the gas in virgin coal seams in OKR coalfields between 1991 and 1998. Twenty surface boreholes were drilled and hydrofracturing was carried out to stimulate gas flow. The survey concluded that the commercial potential for CBM was not viable and further development plans were tabled (BERR/DTI, 2004).

The Czech Ministry for Regional Development and TransGas funded coal seam gas explorations conducted by four companies—Green Gas DPB, Energie stavební a báňská a.s. (via Eurogas, a.s.), GPO, and Unigeo Ostrava –that ultimately received licenses for gas exploration in the OKR coalfields. Figure 9-2 shows the regions of these gas recovery projects (Schwochow, 1997).

Figure 9-2. Mining Areas & Coal Seam Gas Concessions in the OKR Coalfield



Source: Schwochow (1997)

9.3 Opportunities and Challenges to Greater CMM Recovery and Use

The Czech Republic, under the Kyoto Protocol, is committed to an emissions reduction of 8 percent below 1990 levels (UNFCCC, 2006). Its environmental policies are in accord with those stated in

"An Environment for Europe," by the United Nation's Economic Commission for Europe, which limits mining activities that are hazardous to human health and environment and promotes efficient use of non-renewable natural resources. The Czech Republic is an Annex I party to the UNFCCC (see Table 9-5). Many registered Joint Implementation projects have been submitted to the Czech Ministry of Environment, but none involve CMM and the Republic has not implemented any Clean Development Mechanism projects (UNEP, 2014).

Table 9-5. The Czech Republic's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 18, 1993	October 7, 1993
Kyoto Protocol	November 23, 1998	November 15, 2001

Source: UNFCCC (2014)

The Ministry of the Environment is responsible for the implementation of UNFCCC and relevant EU legislation in the Czech Republic. The "National Programme to Abate the Climate Change Impacts in the Czech Republic" (the National Programme) presents the country's climate protection strategy and contains GHG emission reduction goals as well as mitigation and adaptation measures. The National Programme was developed in accordance with EU requirements and was first approved by the Czech government in March 2004. Based on new scientific information and climate negotiations (within the EU and at UNFCCC/Kyoto Protocol Conferences of Parties), the National Programme was reviewed in 2007, and the Czech Government approved preparation of a new Climate Protection policy in April 2008. A similar task regarding the preparation of an Adaptation Strategy was adopted by the Czech Government in November 2009.

The Ministry of the Environment, together with other relevant ministries, is currently revising these strategic documents to include mitigation measures within the climate protection policy, and an adaptation strategy will include estimates of negative impacts, adaptation measures, legal and economic analyses.

9.3.1 Market and Infrastructure Factors

The Czech Republic faces a number of barriers to achieving greater CMM recovery. First, the continuing trend of declining coal production (i.e., down approximately 30 percent since 1993) in the Republic is detrimental to the growth of CMM development. Second, unusual topography in the coalfields hinders CBM recovery projects. Still, because of its large coal deposits, the Czech Republic ranks high globally in its potential for CMM development.

The Czech Republic's electricity price structure favors generation from mine gas fired power plants. The Republic's legislation provides for a "green bonus" for AMM and a "surcharge" for use of CMM in electricity generation (Green Gas DPB, 2007).

New technologies for CMM recovery are available and being implemented, but not broadly. No significant R&D projects were found in place to enhance the current CMM recovery technologies.

Green Gas DPB works with OKD to sell methane from active mines in the OKR district through long-term agreements, and the company is the only entity awarded a state license for exploration and extraction of methane from closed mines (Green Gas DPB, 2012). Over a 5-year timeframe, Green Gas DPB mitigated 5.7 Mmt of carbon dioxide equivalent from the mines in which it operates.

9.3.2 REGULATORY INFORMATION

The Czech coal industry is no longer subsidized. Companies that are no longer operating active coal mines receive subsidies only to pay for rehabilitation of the environment at mine sites, technical liquidation of the mines, and healthcare for former workers (IEA, 2010).

In the 1990s, the Czech government placed restrictions on the extent and impact that coal mining could have on surrounding regions. These restrictions limit the expansion of some coal mines and new coal mine development. In June of 2010, the new coalition government announced that the restrictions would remain for at least four years (Prague Post, 2010).

Starting on January 1, 2005, the Czech natural gas industry began its liberalization (EC, 2007). Vertical unbundling was also accomplished during this period. Producers, distributors, and natural gas storage companies were separated and regulations enforced to prevent possible conflicts of interests of regulated utilities and to improve service costs, transparency, and competition (Mejstrik, 2004).

Although Czech Republic relies on domestic coal for most of its energy needs, it also imports substantial amounts of gas. This makes domestic generation of CMM and CBM an attractive proposition. Holders of CBM production licenses pay a fixed annual fee per unit area and a variable royalty (about 5 percent) based on a percentage of production. However, the gas prices are set centrally by the Energy Regulatory Office, which is hindering the development of the CMM market (Pilcher, 2003).

9.4 Profiles of Individual Mines

Information on individual hard coal mines—including Karviná, ČSM, Darkov, and Paskov Mines—can be found at the OKD website (http://www.okd.cz/en/coal-mining/how-coal-is-mined-in-okd/), and information on both hard and brown/lignite mines can be found in Table 2 of the *USGS 2012 Minerals Yearbook – Czech Republic [Advance Release]* (http://minerals.usgs.gov/minerals/pubs/country/2012/myb3-2012-ez.pdf).

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10 Ecuador

10.1 Summary of Coal Industry

10.1.1 Role of Coal in Ecuador

Ecuador is neither a consumer nor a producer of coal. Ecuador has maintained its position as Latin America's fifth largest producer of oil and is one of the top three exporters of oil in the region. Oil is the keystone to the country's economy, and represents a sizeable portion of all export earnings (EIA, 2014a).

There are estimated reserves of 24 million tonnes of recoverable lignite and sub-bituminous coal, ranking Ecuador 68th worldwide in total coal reserves (EIA, 2014b).

Table 10-1. Ecuador'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)	0	24	24	68 (0.003%)
Annual Coal Production (2012)	0	0	0	Not applicable

Source: EIA (2014b)

Figure 10-1 shows the location of Ecuador's coal reserves.

Figure 10-1. Location of Ecuador's Coal Reserves

Source: Adapted from Biewick et al. (1995)

10.1.2 Stakeholders

Table 10-2 identifies potential stakeholders in Ecuadorian coal mine methane (CMM) development.

Table 10-2. Key Stakeholders in Ecuador's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	Carbones del Cerrejon Ltd BHP Billiton, Newmont Rio Tinto Aurelian Resources, Inc.	Coal operators in neighboring countries/ mining operators in Ecuador
Equipment Manufacturers	Breaker Technology, Inc. (BTI) Kluane International Drilling, Inc. (KID)	Provide equipment to other mining industries in Ecuador
Developers	See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	Cardno ENTRIX MPC Construcciones e Ingenieria See http://www.epa.gov/coalbed/networkcontacts.html	Consultant to other mining industries
Natural Gas Transmission & Distribution Companies	Petroecuador	Pipeline sales
Regulatory Agencies and Government Groups	Ministry of the Environment Inter-Institutional Committee on Climate Change Ministry of Non-Renewable Natural Resources	Regulation, permitting, licensing

Table 10-2. Key Stakeholders in Ecuador's CMM Industry

Stakeholder Category	Stakeholder	Role
Professional Associations	ARPEL – Regional Association of Oil, Gas and Biofuels Sector Companies in Latin America and the Caribbean	Project network

10.1.3 Status of Coal and the Coal Mining Industry

Ecuador's mineral industry includes mining of gold, silver, copper, and steel. Crude petroleum and petroleum refinery products are extracted as well. However, no coal exploration is known and all coal reserves remain unutilized (USGS, 2008).

10.2 Overview of CMM Emissions and Development Potential

10.2.1 CMM Emissions from Operating Mines

There are no operating coal mines in Ecuador.

10.2.2 CMM Emissions from Abandoned Coal Mines

Ecuador has no abandoned coal mines.

10.2.3 CBM from Virgin Coal Seams

There is no commercial coal bed methane development at this time in Ecuador. Ecuador, however, has a fledging natural gas industry. Reserves are relatively small, but the Amistad field in the Gulf of Guayaquil produces 26 million cubic feet (0.7 million cubic meters) a day to produce electricity at a nearby power plant. With little natural gas pipeline infrastructure, all other gas is flared in oil operations (EIA, 2014a).

10.3 Opportunities and Challenges to Greater CMM Recovery and Use

Table 10-3 summarizes Ecuador's climate change mitigation commitment. As a Non-Annex I Party to the Kyoto Protocol, Ecuador has no national emissions targets and is eligible to host mitigation projects under the Clean Development Mechanism (CDM).

Table 10-3. Ecuador's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 9, 1992	February 23, 1993
Kyoto Protocol	January 15, 1999	January 13, 2000

Source: UNFCCC (2014)

In the context of the Kyoto Protocol, Ecuador has proposed two objectives regarding CDM:

Definition and implementation of the CDM Project Validation Process at the national level.

Promotion and implementation of national capacity (public and private) to prepare CDM projects and to generate significant Certified Emission Reduction Units (UNFCCC, 2000).

While there are several biomass energy, landfill gas, and other methane avoidance CDM projects underway in Ecuador, there are none related to coalbed/mine methane. Ecuador's climate change position will be conducive to development of CMM projects, should they arise from future utilization of coal reserves.

Ecuador developed a National Strategy on Climate Change (2012-2025) in 2012. It is available here (in Spanish): http://www.redisas.org/pdfs/ENCC.pdf

10.3.1 Market and Infrastructure Factors

Currently, the market for methane in Ecuador is fairly limited as there is weak domestic demand and support infrastructure for natural gas (EIA, 2014a). However, Ecuador joined the Global Methane Initiative (formerly the Methane to Markets Partnership) and its Steering Committee in 2005, and explores methane capture opportunities in its oil and agriculture industries.

Methane emissions, typically from the flaring of natural gas during oil drilling, currently make up 15 percent of the country's annual greenhouse gas emissions. To date, there are no records of projects underway (M2M, 2005; EIA, 2014a).

10.3.2 Regulatory Information

As there are no existing CMM projects (i.e., Ecuador is neither a coal producer nor consumer), a legal framework regulating them does not exist. The oil and natural gas industries are regulated by the Ministry of Non-Renewable Natural Resources, Hydrocarbons National Directorate. Full Spanish text of Ecuador's hydrocarbon regulations can be downloaded from the Natural Resource Governance Institute website at http://www.resourcegovernance.org/sites/default/files/Ley%20de%20Hidrocarburos.pdf.

10.4 Profiles of Individual Mines

There are no coal mines in Ecuador.

10.5 References

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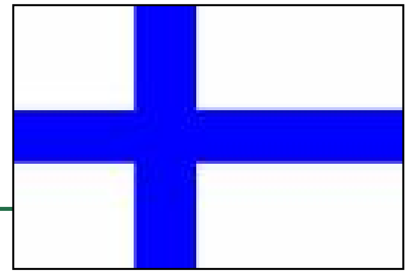
11 Finland



11.1 Summary of Coal Industry

11.1.1 Role of Coal in Finland

Finland is not a producer of coal and imports all of its coal for domestic energy consumption. Approximately 75 percent of coal consumption is used for maintaining the electricity and heating sectors. It should be noted that annual domestic coal consumption varies due to the hydrological condition of Finland (IEA, 2007). Finland has no reported coal reserves nor does the country produce (i.e., extract) coal (Table 11-1).

Table 11-1. Finland'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)	0	0	0	N/A (0%)
Annual Coal Production (2012)	0	0	0	N/A (0%)

Source: EIA (2014)

Figure 11-1. Location of Finland's Coal Reserves

Source: CIA World Factbook (2014)

11.1.2 Stakeholders

Since no coal reserves and/or production exist, there are currently no coal mine methane (CMM) stakeholders in Finland.

11.1.3 Status of Coal and the Coal Mining Industry

Finland's mineral industry includes (but is not limited to) the mining of gold, nickel, cobalt, copper, zinc, diamonds, phosphate rock, wollastonite, and talc (USGS, 2013). Finland does not presently have any identified coal reserves; therefore, no coal mining occurs in Finland.

11.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no CMM recovery projects for Finland, in operation or development (GMI, 2014).

11.2.1 CMM Emissions from Operating Mines

There are no operating coal mines in Finland.

11.2.2 CMM Emissions from Abandoned Coal Mines

Finland has no abandoned coal mines.

11.2.3 CBM from Virgin Coal Seams

There are no commercial coal bed methane development projects in Finland at this time.

11.3 Opportunities and Challenges to Greater CMM Recovery and Use

Table 11-2 summarizes Finland's climate change mitigation commitment. Finland is an Annex I Party to the Kyoto Protocol. Finland has an emissions reduction target of 6 percent below the 1990 levels for 2008-2012.

Table 11-2. Finland's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 4, 1992	May 3, 1994
Kyoto Protocol	April 29, 1998	May 31, 2002

Source: UNFCCC (2014)

Finland's National Strategy for Adaptation to Climate Change was adopted in 2005 as an independent element of the broader National Energy and Climate Strategy which was outlined in 2005, finalized in 2008, and subsequently updated in 2013. None of these documents address CMM (EEA, 2014).

11.3.1 Market and Infrastructure Factors

Finland joined the Global Methane Initiative (formerly the Methane to Markets Partnership) in 2008 and is working with stakeholders to recover and utilize methane produced by Finland's 33 landfills as well as its wastewater treatment facilities. Finland is also providing funding support for other international projects in countries such as Honduras and Nicaragua (USEPA, 2008). Finland currently sits on the GMI Agriculture, Municipal Solid Waste, and Municipal Wastewater Subcommittees.

11.3.2 Regulatory Information

The *Mining Act of 1965* previously provided the legal framework for mining operations in Finland. In late 2008, a working group was formed by the Finnish government to revise the outdated Act. The new Mining Act entered into force in July 2011 and supersedes the previous 1965 Act. The new Act includes provisions concerning the rights and obligations of parties engaged in ore prospecting, mining, and gold panning—both during operations and as termination measures are taken (e.g., aftercare). While securing the preconditions for mining and ore prospecting more effectively than before, the new Act takes account of environmental issues, citizens' and landowners' rights, and municipalities' opportunities to influence decision-making as well as reconciles various public and private (i.e., competing) interests (MEE, 2011).

11.4 Profiles of Individual Mines

There are no coal mines in Finland.

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12 France

12.1 Summary of Coal Industry

12.1.1 Role of Coal in France

Coal has become less important in France's energy supply, constituting only 4 percent of the nation's total energy consumption in 2011 (IEA, 2013). Nuclear power has replaced most of France's coal-fired power plants. France consumed 17.3 million tonnes (Mmt) of coal in 2012 (EIA, 2014).

France has negligible coal reserves (EIA, 2014) and the country's coal production has virtually ceased, having closed its last coal mine in April 2004 (BBC, 2004). The country's total coal production was 6.2 Mmt in 1999, but reduced to only 0.16 Mmt in 2004; the last year coal was mined.

Table 12-1. France'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)	0	0	0	Not applicable
Annual Coal Production (2012)	0	0	0	Not applicable

Source: EIA (2014)

12.1.2 Stakeholders

Table 12-2 lists key potential stakeholders in French coal mine methane (CMM) development.

Table 12-2. Key Stakeholders in France's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Charbonnages De France ▪ European Gas Limited (EGL) ▪ Future Corporation Australia ▪ PanTerra Geoconsultants ▪ Compagnie Nationale à Portefeuille S.A. ▪ Transcor Astra Group	Project host
Natural Gas Transmission & Distribution Companies	▪ Gaz De France	Gas distribution
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning

Table 12-2. Key Stakeholders in France's CMM Industry

Stakeholder Category	Stakeholder	Role
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Government Groups	▪ Ministry of the Economy, Industry and the Digital Sector ▪ Ministry of Ecology, Sustainable Development and Energy ▪ Commission of Regulation of the Energy (CRE)	Regulatory

12.1.3 Status of Coal and the Coal Mining Industry

There were three main coal-producing areas in France: the Nord-Pas de Calais, the Lorraine basin, and the Central Massif basins. As of now, France does not produce any coal. The country is left with many abandoned coal mines, however, since the coal mining industry in France dates back hundreds of years.

The steady decline in the country's coal sector over the past decades is attributable to cheaper imports replacing the domestic sources, its shift to nuclear power, and its concern for the environment. The state-owned coal monopoly, Charbonnages de France, closed its last production facility in April 2004.

12.2 Overview of CMM Emissions and Development Potential

12.2.1 CMM Emissions from Operating Mines

Over the last century, there have been a number of CMM projects in France utilizing gob gas from active and abandoned mines for power generation and heating applications. However, these projects at active mines closed as the coal mining sector declined overall.

Before domestic production stopped, the majority of the CMM activity to date focused on the coal seams of the Nord-Pas de Calais basin. In 2000, methane emissions totaled 166.0 million cubic meters (m^3) but in the years since, there have been no recorded emissions (USEPA, 2012).

12.2.2 CMM Emissions from Abandoned Coal Mines

In France, several CMM use projects are reported to be operating at abandoned mines. The Global Methane Initiative (GMI) International CMM Projects Database currently identifies three methane recovery and utilization projects at abandoned mines in France. Two projects utilize the recovered methane for industrial use and the third one for pipeline injection (GMI, 2014). Their level of methane emission mitigation is not reported. Updates on future CMM projects in France can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

Among the projects at abandoned mines, Gazonor is a venture of European Gas Limited (EGL) acquired from Charbonnages de France. Several mines are sources for extraction, including Divion, Avion, and Désirée. EGL is permitted for 579 km^2 and further permits are under application for an additional 1500 km^2. Since CMM extraction began in 1979, a total of 2,189 million m^3 have been extracted as of 2008 with an approximate methane content of 54 percent. Annual production for the last five years has averaged 72.1 million m^3. As part of a restructuring announced in May 2011, EGL has entered into a Production Sharing Agreement (PSA) in relation to two large production permits covering 766 km^2 in Northern France. The PSA is between EGL and Gazonor, EGL's former operating subsidiary, which is now owned by Transcor France (EGL, 2011).

EGL is also operating several wells at Lons le Saunier in eastern France, producing about 83.7 million m^3 annually. At Lorraine, EGL estimates that 1,104 million m^3 of methane is available. The permit covers 988 km^2, but actual production had not begun as of 2008. The Gardanne project in L'Arc Base, northeast of Marseille, is estimated to hold up to 20 seams with up to 2,800 million m^3 of gas resource. However, further efforts to advance EGL's mine methane projects in France have been hampered by bureaucratic posturing (Reuters, 2013).

Figure 12-1. CMM Projects in France

Source: EGL (2010)

SNET, a subsidiary of Charbonnages de France, operates two power production facilities that utilize co-fired CMM—Hournaing and Emile Huchet Groupe V—comprised of three units with a design capacity of 253 MWe and six units with a design capacity of 1086 MWe, respectively (GEO, 2014).

12.2.3 CBM from Virgin Coal Seams

In an inventory of coal bed methane (CBM) in the Lorraine Basin, the gas in place was assessed at 11.8 billion m^3 in the Saint Avold area and at 16.3 billion m^3 in the Alsting area (EGL, 2005). No data quantifying CMM recovery from virgin coal seams are currently available.

12.3 Opportunities and Challenges to Greater CMM Recovery and Use

France signed and ratified the UNFCCC and Kyoto Protocol, as indicated in Table 12-3.

Table 12-3. France's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	March 25, 1994
Kyoto Protocol	April 29, 1998	May 31, 2002

Source: UNFCCC (2014)

France has put forth various climate strategies since 1995. These initial climate actions were followed by the National Programme for Combating Climate Change in 2000, which was followed by the country's National Strategy for Sustainable Development published in 2004 and updated in 2006 (Ecologic Institute/eclareon, 2013). The policy for combating climate change was strengthened in late 2007, and eventually named the *Climate Plan: 2004-2012* as France's action plan for meeting its Kyoto commitments.

In advance of its hosting the 2015 Conference of Parties (COP) in Paris, France proposed three climate policy goals, which included: defining an agreement applicable to all, adopting legally binding text, and aiming for an ambitious goal to keep global temperature increase below 2°C (Euractive, 2013).

12.3.1 Market and Infrastructure Factors

There are few companies involved in potential CBM project development in France. Schlumberger, a technology and project management company, offers CBM consulting services as well as its ECLIPSE CBM model, which examines CBM potential of a particular mining site (Schlumberger, 2010). Total S.A., the French petroleum giant, has expanded its portfolio to include CBM assets. In 2010, Total pursued its growth into unconventional gas by acquiring a stake in Australia's Gladstone LNG project, the very first CBM liquefaction project in the world (Total, 2014).

12.3.2 Regulatory Information

France actively encourages its CMM development industry by including mine methane as recoverable energy in renewable tariffs; including it with landfill and sewage methane in renewables targets; treating it as a secure energy resource; and promoting CMM technology as climate change technology in world markets (ACMMO, 2007).

In France, CMM is covered under the Electricity Act 2000, which was modified to include recoverable energy from mine methane, landfills, biomass, and sewage digesters. The feed-in tariff with premium prices for renewable electricity generated from these sources has provided strong incentive to the methane mitigation industry and a large number of new projects are already under way (CRE, 2010; ACMMO, 2007; EREC, 2009).

12.4 Profiles of Individual Mines

Data profiling gassy mines in France are unavailable. The last active coal mine in France closed in 2004 (BBC, 2004).

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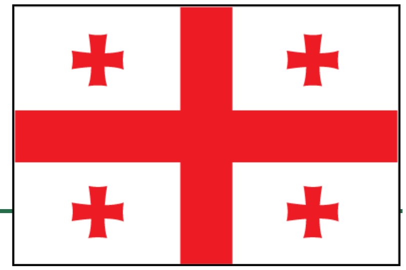
13 Georgia



13.1 Summary of Coal Industry

13.1.1 Role of Coal in Georgia

Coal deposits were discovered in Georgia in the first half of the 19th century, although until the 1930s geological exploration of these deposits was sporadic. Rapid development of the coal deposits in Georgia began after World War II, with produced coal being supplied to the Rustavi iron and steel works. Seven coal deposits have been discovered in Georgia, but only three of them are of commercial importance: the Tkibuli-Shaori and Tkvarcheli bituminous coal deposits and the Akhaltsikhe brown coal deposit (Figure 13-1). Most of the republic's coal reserves are concentrated in these deposits and the Tkibuli-Shaori deposit accounts for more than 75 percent of Georgia's coal reserves, followed by Akhaltsikhe and then Tkvarcheli (UNFCCC, 2009).

Figure 13-1. Georgia's Main Coal Fields

Source: Adapted from UN (2004)

Table 13-1. Georgia'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*) (2013**)	331.1**	75.7**	406.8**	49 (0.0032%)*
Annual Coal Production (2012)	0.254	0	0.254	56 (0.022%)

Sources: *EIA (2013a); **SAQ (2013)

13.1.2 STAKEHOLDERS

Potential stakeholders in Georgia's coal mine methane (CMM) industry are listed in Table 13-2.

Table 13-2. Key Stakeholders in Georgia's CMM Industry

Stakeholder Category	Stakeholder	Role
Coal Producing Enterprise	▪ Georgian International Energy Corporation (GIEC)	Project host State Partnership Fund
Developer	▪ Georgian International Energy Corporation (GIEC) ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering or Consultancy Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities and Research Centers	▪ National Academy of Sciences of Georgia ▪ Georgia National Science Foundation ▪ Tbilisi State University ▪ Ministry of Education and Science - Mining Institute	Technical assistance
Other	▪ KazTransGaz-Tbilisi ▪ OPIC	
Government Groups	▪ Ministry of Energy ▪ Ministry of Environmental Protection and Natural Resources	Licensing and permitting

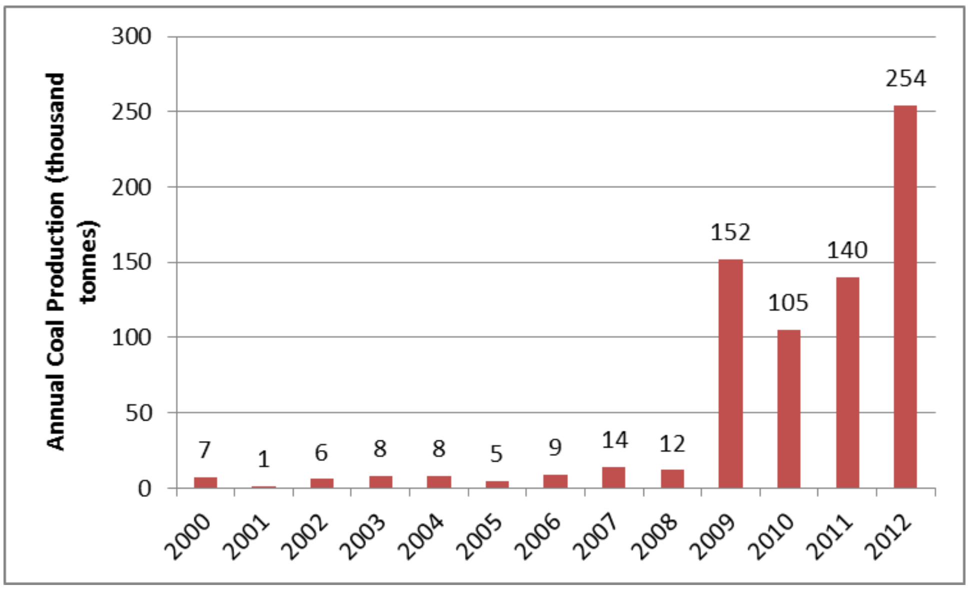
13.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Coal mining in Georgia is made difficult by the depth of the coal seams, the locations of deposits in mountainous areas and, in some areas, the relatively high methane content (14+ cubic meters [m^3] per tonne) of the coal. Insufficient financing of mines in the late 1990s to early 2000s (as State subsidies dried up because of the country's economic crisis), a lack of markets, and costly extraction, led to minimal production at that time. The Georgian government has prioritized the revitalization of the coal mining sector, in the hope of providing much needed jobs and some economic resurgence in the Tkibuli-Shaori and Akhaltsikhe regions (UNFCCC, 2009).

The only underground mine currently producing coal in Georgia is the Mindeli mine in the Tkibuli-Shaori coalfield. The mine, operated by Saknakhshiri LLC, resumed coal extraction in 2008 after a 15-year break. In partnership with the Georgian International Energy Corporation (GIEC), the mine's flooded tunnels have been pumped dry and restored, shaft development projects have taken place, mine buildings have been refurbished, and the mine railway line has been repaired. The total cost for the redevelopment of the mine came to more than $10.8 million (GEL20 million) (GIEC, 2010).

Coal from the project currently supplies cement factories in Kaspi and Rustavi, but Saknakhshiri LLC plans to increase current coal production to accommodate two thermal power plants with generation capacities of 160MW and 300MW, which are to be constructed by GIEC. To meet the coal demand, Saknakhshiri intends to improve coal extraction in current shafts to 0.850 to 0.9 million tonnes (Mmt) per year and construct a new mineshaft to accommodate an additional 2-3 Mmt per year (Figure 13-2). The coal improvement project is under technical review and a feasibility study is underway for the establishment of reserves to support a new mineshaft (SAQ, 2013). Saknakhshiri also holds a license for coal extraction from the Vale coalfield near Akhaltsikhe, in southern Georgia, estimated to have coal reserves of more than 75 Mmt available for open cast mining.

Figure 13-2. Georgia Coal Production (thousand tonnes)



Sources: UNFCCC (1999); EIA (2013a)

An operating open-cast mine is located at Tvarcheli, in the breakaway republic of Abkhazia. Produced coal from this mine is used to supply iron and steel works in Rustavi.

13.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently has no record of any active CMM projects in Georgia (GMI, 2014). One feasibility study, sponsored by the U.S. Trade and Development Association (USTDA), was carried out on the possible development of a CMM drainage and utilization project in the Tkibuli-Shaori coal field.

13.2.1 CMM Emissions from Operating Mines

Limited data is available on Georgia's CMM emissions. Table 13-3 shows data available from Georgia's Second Communication to the United Nations Framework Convention on Climate Change

(UNFCCC). 18.79 million m³ of CMM are estimated to have been emitted in 1990, at which time coal production was 956,000 tonnes per year.

Table 13-3. Georgia's CMM Emissions (million cubic meters)

Emission Category	2000	2005*	2010*	2015* (projected)
Underground coal mines – ventilation emissions	0.139			
Underground coal mines – drained emissions	0			
Total liberated (= sum of all above)	0.139			
Recovered & Used	0			
Total emitted (= Total liberated – recovered & used)	0.139	0.235	0.246	0.280

Source: UNFCCC (2009), *USEPA (2012)*

Coal production operations at the Mindeli mine are being ramped up after being idle for almost 20 years. Production is expected to exceed 200,000 tonnes per year in the near future and when longwall operations are active it is planned to produce 1 Mmt of coal per year. At that time, CMM emissions would be expected to reach their 1990 levels. CMM is not currently drained from the mine, either by in-seam boreholes or via gob drainage. Methane is diluted in ventilation air and carried to the surface where it is emitted to the atmosphere. A March 2010 explosion, which killed four miners and was attributed to a build-up of methane, illustrates the need for improved methane drainage at the mine (Georgian Times, 2010).

13.2.2 CMM Emissions from Abandoned Coal Mines

There are a few abandoned mines in the Tkibuli-Shaori coalfield, but there are currently no methane recovery projects operating or planned in Georgia.

13.2.3 CBM from Virgin Coal Seams

Georgia does not currently produce CBM from virgin coal seams. A USTDA feasibility study evaluated the possible development of a CMM project at the Tkibuli-Shaori and potential CBM extraction from the coalfield. The coal in this area is found in nine distinct layers that vary in thickness from 1 to 10 m, at depths of 500 – 1,500 m. Total coal thickness ranges from 20 to 50 m and in some places exceeds 75 m. Gas contents range from 6-20 m³ per tonne and gas-in-place for the field is estimated to be 11.5 billion m³ (ARI, 2009). The feasibility of CBM drilling is also been studied in the Vale coalfield in southern Georgia. Possible reserves for this area have not yet been estimated.

13.3 Opportunities and Challenges to Greater CMM Recovery and Use

Georgia ratified the United Nations Framework Convention on Climate Change (UNFCC) in 1994 (Table 13-4) as a non-Annex I Party and since then has been actively engaged in the fulfillment of its obligations under the Convention. The government supports the implementation of any projects and programs that will lead to the reduction of greenhouse gas (GHG) emissions, facilitate the drawing of additional environmentally sound investments and transfer the country to a sustainable development pathway (MEP, 2009).

Table 13-4. Georgia's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	NA	July 29. 1994
Kyoto Protocol	NA	June 16, 1999

Source: UNFCCC (2014)

13.3.1 Market and Infrastructure Factors

Georgia currently operates with a severe energy deficit, producing less than six percent of its domestic fuel requirements from its own resources (USTDA, 2008). 98 percent of Georgia's oil and natural gas supplies are imported. In 2010, Georgia produced 51.4 thousand tons of oil and 11.1 million m^3 of natural gas. Georgia's proven oil and gas resources are modest, according to the Energy Charter Secretariat (EnCharter, 2012). The country's 15 oilfields have confirmed reserves of about 8.3 million tons but larger oil reserves are assumed to exist. The oil potential of the Black Sea shelf is estimated at 70 million to 1.3 billion barrels. (Energy Charter, 2012). Other indigenous energy supplies are limited primarily to hydropower and traditional biomass for residential heating (Energy Charter, 2012; EIA, 2013b).

The majority of oil and natural gas has historically come from Russia since Georgia is an important transit country. To reduce dependency on Russia, Georgia began turning to the Caspian fields for natural gas supply after 2000, and the South Caucasus Pipeline began delivering natural gas to Georgia in 2007. Total capacity on the pipeline is 8 billion m^3 per year (EIA, 2013b).

The Georgian government is looking to further diversify its energy base and is encouraging the continued redevelopment of the coal industry, along with potential development of thermal power stations near coalfields. Georgia also has sizeable hydropower capacity, which is a growing component of its energy supplies. The Ministry of Energy has announced plans to rehabilitate older hydropower plants, and build new ones to increase generation capacity (EIA, 2013b).

Utilization options for produced methane include on-site electricity generation or direct use by local residents, a policy in line with the government's recent push to supply gas to rural areas. But CMM will have to compete with hydroelectric power and other renewable energy resources such as geothermal energy (currently used for district heating) and wind power.

13.3.2 Regulatory Information

Georgia does not have any specific laws or regulations pertaining to CMM extraction. Potential issues concerning ownership of drained methane from coal mines or coal areas may arise due to the fact that the government has awarded conventional oil and gas licenses that overlap with coal mining areas.

13.4 Profile of Individual Mines

Coalfield data for the Mindeli and Dzidziguri mines is presented in Table 13-5, with a general profile of the Tkibuli-Shaori coal field shown in Table 13-6.

Table 13-5. Tkibuli-Shaori Coal Properties

Mine	Coal Property				
	Ash content (%)	Moisture Content (%)	Sulfur (%)	Volatile Material (%)	Heat Capacity (calories)
Mindeli	37-43	14.0	1.0-1.5	39.5-42.2	4,200-4,600
Dzidziguri	29-35	14.5	1.0-1.5	40-42.8	4,100-4,500

Source: ARI (2009)

Table 13-6. Tkibuli-Shaori Coal Field Profile

Tkibuli-Shaori Field - Mindeli and Dzidziguri Mines			
Mine Status	Active	**Operator/Owner**	Saknakhshiri LLC
Mine Area	47 km^2	**Coal Field**	Tkibuli-Shaori
Mining Method	Room and pillar / Longwall	**Location**	50 kms NE of Kutaisi, Imereti region
Reserves (coking coal)	330 Mt	**2006 VAM volume**	0.139 million m^3
No. of seams mined	9	**2006 Drained CH_4 volume**	0
Depth of seams	500-1,500 m	**2006 Utilized CH_4 volume**	0
Annual coal production capacity	500,000 + tonnes	**Utilization method**	None

13.5 References

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14 Germany

14.1 Summary of Coal Industry

14.1.1 Role of Coal in Germany

Germany was the world's eighth largest producer of coal in 2012 and is the world's largest producer of brown coal (lignite), accounting for an estimated 18 percent of global output in 2012 (EIA, 2014a). Coal is Germany's most important indigenous energy resource, accounting for almost 45 percent of the country's total primary energy production in 2012. Brown coal accounted for over 25 percent of German electric power generation in 2012 and hard coal accounted for just over 19 percent (Mathews, 2013). Nearly all coal production serves the power and industrial sectors (EIA, 2014b). Although total coal production in Germany has been steadily declining to a low of 182 million tonnes in 2010, brown coal production has started to increase in recent years (EIA, 2014a). Brown coal-fueled electricity production in Germany reached its highest level since 1990 in 2013 (Wagstyl, 2014). Germany's coal consumption has increased after Japan's Fukushima reactor accident occurred in March 2011, as Germany has increasingly relied on coal as a substitute for nuclear power (EIA, 2014b). Table 14-1 summarizes Germany's coal reserves and production.

Table 14-1. Germany'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)	48	40,500	40,548	6 (4.6%)
Annual Coal Production (2012)	11.6	185.4	197.0	8 (2.5%)

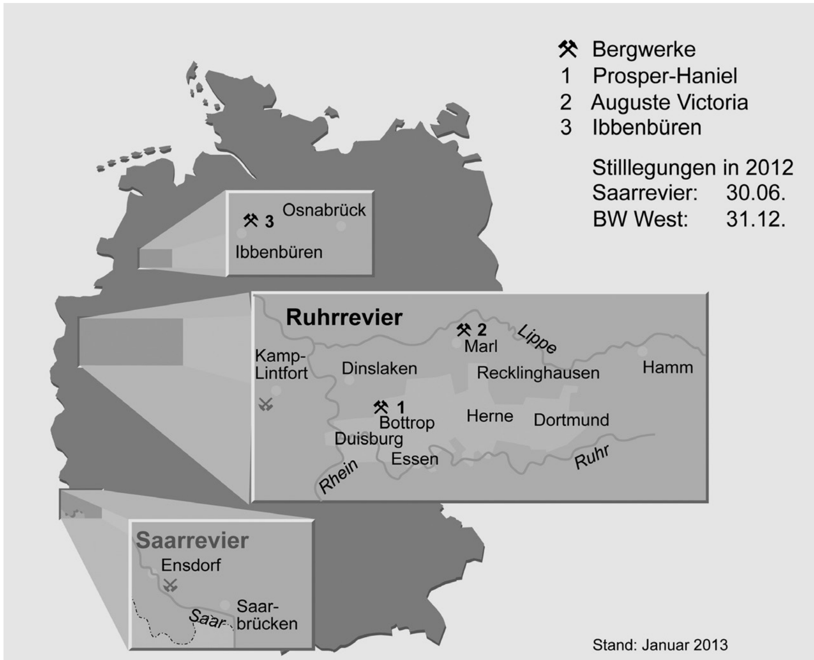
Source: EIA (2014a)

Germany is a net coal importer, importing more than 45 thousand tonnes of hard coal in 2013 from Russia (11.8 thousand tonnes), the United States (11.5 thousand tonnes), Colombia (8.1 thousand tonnes), European Union (EU) countries, Australia, Poland, South Africa, and small quantities from other countries (Statistik der Kohlenwirtschaft e.V., 2014a).

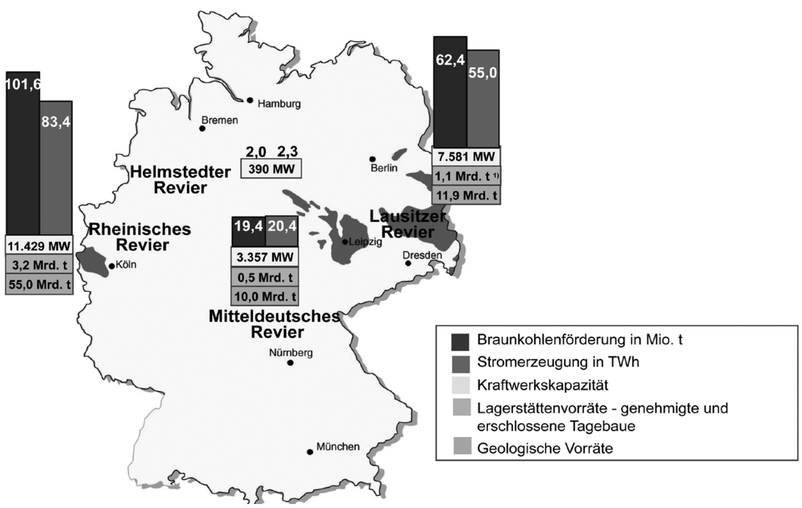
Germany's current hard coal production is from three underground mines—Prosper-Haniel, Auguste Victoria and Ibbenbueren—located in North-Rhine-Westphalia in western Germany (Euracoal, 2013; Euracoal, 2014), while all brown coal production is from surface mines in basins across the country (Figure 14-1).

Figure 14-1. Germany's Coal Fields

Hard Coal Fields



Brown Coal Fields



Source: Statistik der Kohlenwirtschaft e.V. (2013)

14.1.2 STAKEHOLDERS

Table 14-2 lists potential stakeholders in coal mine methane (CMM) development in Germany.

Table 14-2. Key Stakeholders in Germany's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ RAG Deutsche Steinkohle AG	Operator of hard coal mines
Equipment Manufacturers	▪ GE Jenbacher, Deutz Power Systems GmbH & Co. KG ▪ ETW-Energietechnik GmbH ▪ Pro2-Anlagentechnik GmbH ▪ G.A.S. Energietechnik GmbH ▪ LAMBDA-Gesellschaft für Gastechnik mbH ▪ Lennetal Industrie Service	Power generation equipment supplier Power plant engineering and construction
Developers	▪ Minegas GmbH und Mingas Power GmbH ▪ A-TEC Anlagentechnik GmbH ▪ Evonik New Energies GmbH ▪ Stadtwerke Herne AG ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ Deutsche Montan Technologie GmbH ▪ ATEMIS GmbH ▪ Umwelttechnik Bojahr ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Testing, consulting, engineering
Universities, Research Establishments	▪ Fraunhofer UMSICHT ▪ RWTH Aachen ▪ Deutsche Montan Technologie GmbH	Examining, developing, and optimizing technical processes in the areas of environmental, safety, process, and energy technology
Regulatory Agencies	▪ State Ministry for the Environment ▪ Nature Conservation and Reactor Safety	Project identification and assessment support
Government Groups	▪ Bezirksregierung Arnsberg / Abt. 8 Bergbau und Energie	Mining authority
Professional Associations	▪ IVG e.V. ▪ Landesinitiative Zukunftsenergien NRW	Establishes project network, advises members on technical, economic, and legal issues
Other	▪ KfW Banking Group ▪ Emissions-Trader ET ▪ Emissions-Trader ET ▪ Future Camp ▪ Daldrup & Söhne AG ▪ Anger's Söhne ▪ RAG-Stiftung	Investment finance, emissions trading Drilling contractors Coal Mining Foundation

14.1.3 Status of Coal and the Coal Mining Industry

Germany has experienced a recent increase in brown coal production after a post-reunification downturn, in response to an increased demand from power plants and interim power arrangements stemming from Germany's Energiewende. Energiewende is a term coined in the 1980s meaning "energy transition" referring to the country-wide energy infrastructure transition commenced in 2011 when the German parliament voted to abolish nuclear power following Japan's Fukushima disaster. Germany is replacing nuclear energy with renewables and new combined-cycle gas turbines; however, in the interim, power arrangements have involved marginally more coal being burned. Brown coal increased by a full percentage point of German electric power generation in 2012 and hard coal rose 0.6 percentage points (Euracoal, 2014; Mathews, 2013).

There has been a downsizing of the hard coal sector due to incremental reduction of subsidies which are scheduled to fully expire in 2018 (Morris, 2014). In 1991, Germany operated 26 hard coal mines and employed 122,871 miners, while in 2013, only 3 mines were in operation and 12,500 miners employed (Euracoal, 2014).

Table 14-3 provides recent statistics on German coal mines.

Table 14-3. Germany's Coal Mining Statistics 2013

Type of Mine	Production (million tonnes)	Number of Mines
Underground (active) mines - total	7.5	3
Surface (active) mines - total	182.6	14

Sources: Statistik der Kohlenwirtschaft e.V. (2014a); Statistik der Kohlenwirtschaft e.V. (2014b)

14.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies 43 CMM projects operating in Germany (GMI, 2014). Thirty-seven are located at abandoned mines, nine are at active, underground mines, and two are undetermined. The methane from 30 projects is being used for power generation, while the remaining 13 projects use the methane for combined heat and power (GMI, 2014).

14.2.1 CMM Emissions from Operating Mines

Table 14-4 quantifies Germany's recent methane emissions from coal mining. The data in this table may vary from the EPA data presented in the Executive Summary due to differences in inventory methodology and rounding of digits.

Table 14-4. Germany's CMM Emissions (million cubic meters)

Type of Mine	2000	2005	2010	2015 (projected)*
Underground mine	646.65	374.14	180.27	
Post-underground mine	28.45	21.09	10.92	
Surface mine	2.71	2.88	2.74	
Abandoned Mines	189.76	4.22	1.05	
Total liberated (= sum of all above)	**867.57**	**402.33**	**194.99**	**247.0**

Source: UNFCCC (2014a); USEPA (2012)

14.2.2 CMM Emissions from Abandoned Coal Mines

There are substantial abandoned mine methane (AMM) recovery and utilization activities underway in Germany, with 37 individual projects reportedly in operation. These projects are power generation and combined heat and power projects and together account for more than 113

MW of electricity. German AMM projects mitigate more than 400 million cubic meters (m^3) of methane emissions annually (GMI, 2014).

14.2.3 CBM from Virgin Coal Seams

There are no CBM recovery efforts from virgin coal seams in Germany at present. The absence is attributable to high exploration and production costs, and unsuitable available technology. However, with German energy demand and energy prices on the rise, the Technical University of Aachen (RWTH Aachen) is currently reevaluating German CBM potential. A pre-feasibility study was carried out by FUMINCO GmbH and RWTH Aachen in 2007 and 2008, examining the technical feasibility of CBM production by drilling deep wells in the Ruhr and Münsterland area. The pre-feasibility study was the first step in a three phase project, which was financed by the government of North Rhine-Westphalia, Minegas GmbH and Mingas-Power GmbH. The second phase of the project was an economic study of CBM production and the third phase, a risk assessment, has yet to commence (FUMINCO GmbH, 2014). These efforts are primarily motivated by advances in drilling and simulation technologies. Germany has potential in-place CBM resources of 3 trillion m^3, of which 2 million m^3 is concentrated in the mining fields in the Ruhr area alone. Prospects for CBM recovery are thus poised to develop (Mösle et al, 2009).

14.3 Opportunities and Challenges to Greater CMM Recovery and Use

Germany has ratified the Kyoto Protocol. Under Europe 2020, the EU's growth strategy, the EU has a greenhouse gas (GHG) emission reduction target of a 20 percent reduction compared to 1990 by 2020. Germany has set its own national target of a 14 percent reduction compared to 2005 by 2020. The national target on GHG emissions (-14 percent) covers emission sources not already included in the European exchange system of emission quotas (EU Emissions Trading Scheme) and uses 2005 as reference year. The EU target (-20 percent) covers all emissions sources and use 1990 as reference year (EC, 2013a). Germany has also set a national energy efficiency target to reduce primary energy consumption by 20 percent compared to the 2008 level by 2020 (EC, 2013b). Table 14-5 summarizes Germany's commitment to international climate change mitigation agreements. Ratifying the Kyoto Protocol has made Germany eligible to benefit from the growing world market for carbon emission reduction credits.

Table 14-5. Germany's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	December 9, 1993
Kyoto Protocol	April 29, 1998	May 31, 2002

Source: UNFCCC (2014b)

Germany has purchased credits from 207 Clean Development Mechanism (CDM) projects, including from two CMM projects in China. Germany has purchased credits from 27 Joint Implementation (JI) projects and hosted 11 JI projects, three of which are CMM projects including the Methane Capture, Power and Heat Generation from Coal Mine Gas in the Concession HER-TEUTO and Methane Capture, Power and Heat Generation from Coal Mine Gas in the Concession HER-Wan-Thal in North

Rhineland and Mine gas flaring at shaft Nordschacht in Saarland. Table 14-6 shows the breakdown by project type and domestic versus non-domestic project hosting.

Table 14-6. Germany's CDM and JI Activity

Project Types	CDM Projects	JI Projects (non-domestic)	JI Projects (domestic)
Biomass Energy	26	3	
Cement	1		
Coal Mine Methane	2		3
Energy Efficiency	17	6	
Energy Distribution	2	2	
Fossil Fuel Switching	2	1	
Geothermal	1		
HFCs	1		
Hydro	70		
Landfill Gas	17	1	
Methane Avoidance (Waste Water, Composting)	20		
Nitric Acid Destruction	4	8	8
Solar	12	6	
Wind	32		

Source: UNEP (2014a); UNEP (2014b)

14.3.1 Market and Infrastructure Factors

The GHG emissions targets set by the EU as well as the 2011 decision by the German government to phase out nuclear power present an improved market for new energy streams in Germany, particularly from renewable sources. The Renewable Energy Sources Act of 2004 (EEG) established CMM and AMM as renewable energy sources in Germany (Langefield and Agasty, 2013; Schloenbach and Schluter, 2005).

Potential CMM end uses in Germany include both mono- and co-firing boiler systems, combined heat power generation from gas and diesel engines and gas turbines, and secondary fuel sources including methanol, liquid gas, and substitution of natural gas. A 110-km long CMM network in the Saar District currently supplies CMM to a steel plant, the local chemical industry, a coking plant, electrical power plants, and central heating installations (Dinkelbach and Mader, 2003).

14.3.2 Regulatory Information

The legal framework for the economic utilization of mine gas in Germany is set by the Federal Law on Mining and the EEG. Exploration, extraction, and processing of mine gas are administered by the Federal Mining Authority. CMM ownership rights are transferred to a coal mining company for the duration of a coal mining license, after which the capture and utilization of CMM requires a gas license for the subsequent 30-year period (USEPA, 2011). The Federal Mining Authority considers an application for license after the applicant has submitted a utilization program which clearly demonstrates that "planned activities are sufficient and within an acceptable time frame for the type, scope and purpose of the methane extraction." A license can be refused or withdrawn if found to be inadequate with respect to legislatively fixed factors, including the availability of sufficient funds, feasibility of a proposed extraction technology within a given timeframe and public interests (World Bank, 2007).

According to the guidelines defined in the EEG, CMM is a renewable energy source from which electrical power production is supported by federal legislation (Schloenbach and Schluter, 2005).

Germany's primary policy incentive for CMM recovery and use projects is through a feed-in tariff for CMM used to generate power under the Renewable Energy Sources Act of 2004 (RESA). The RESA requires electric grid system operators to connect plants generating electricity from mine gas to their systems, bear the costs of the grid upgrade, and guarantee priority purchase and transmission of all electricity from such plants. RESA provides a guaranteed fixed payback tariff for 20 years through feed-in tariffs or fees paid for electricity produced from mine gas (USEPA, 2011; IEA, 2009).

CMM operators have the authority to sell the carbon credits generated by the project and have the added incentive of paying no local taxes or royalties on CMM projects. Taxes for gas extraction are waived in Germany as long as gas is removed for safety reasons (Backhaus, 2013). Since CMM is included in the RESA category, all CMM projects receive priority attention at all stages of the project development (IEA, 2009).

14.4 Profiles of Individual Mines

There are three main hard coal fields in Germany, the Ruhr, Ibbenburen, and Saar; however, mines are only operating in the Ruhr and Ibbenburen Coalfield as listed in Table 14-7. There are four brown coal districts.

Table 14-7. Germany's Mine Overview

Coalfield/District	Mine
Ruhr Coalfield (Hard)	▪ August Victoria ▪ Prosper-Haniel
Ibbenburen Coalfield (Hard)	▪ Ibbenbüren
Rheinland District (Brown)	▪ Garzweiler ▪ Hambach ▪ Inden
Helmstedt District (Brown)	▪ Schöningen ▪ Restkohle Werkstätten
Lausitz District (Brown)	▪ Cottbus-Nord ▪ Jänschwalde ▪ Welzow-Süd ▪ Nochten ▪ Reichwalde
Mitteldeutschland District (Brown)	▪ Profen ▪ Profen gesamt ▪ Schleenhain ▪ Amsdorf

Source: Statistik der Kohlenwirtschaft e.V. (2014a); Statistik der Kohlenwirtschaft e.V. (2014b)

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15 Hungary

15.1 Summary of Coal Industry

15.1.1 Role of Coal in Hungary

Hungary uses three categories to classify its coal – hard coal (bituminous), brown coal, and lignite. Brown coal and lignite account for approximately 80 percent of the country's total coal reserves, making these the most significant indigenous energy sources (Euracoal, 2014)--used mainly in its thermal electric power plants. These plants cannot use higher quality coal and therefore, rely on the supplies of lower-quality domestic coal.

Hungarians are making efforts to convert from coal to cleaner burning fuels such as natural gas or oil. Overall production of lignite (including brown coal) declined nearly 29 percent from 2002 to 2012 (EIA, 2014). Brown coal production declined more sharply and bituminous production has ceased due to declining reserves (Steblez, 2005). Table 15-1 summarizes Hungary's coal reserves and recent production.

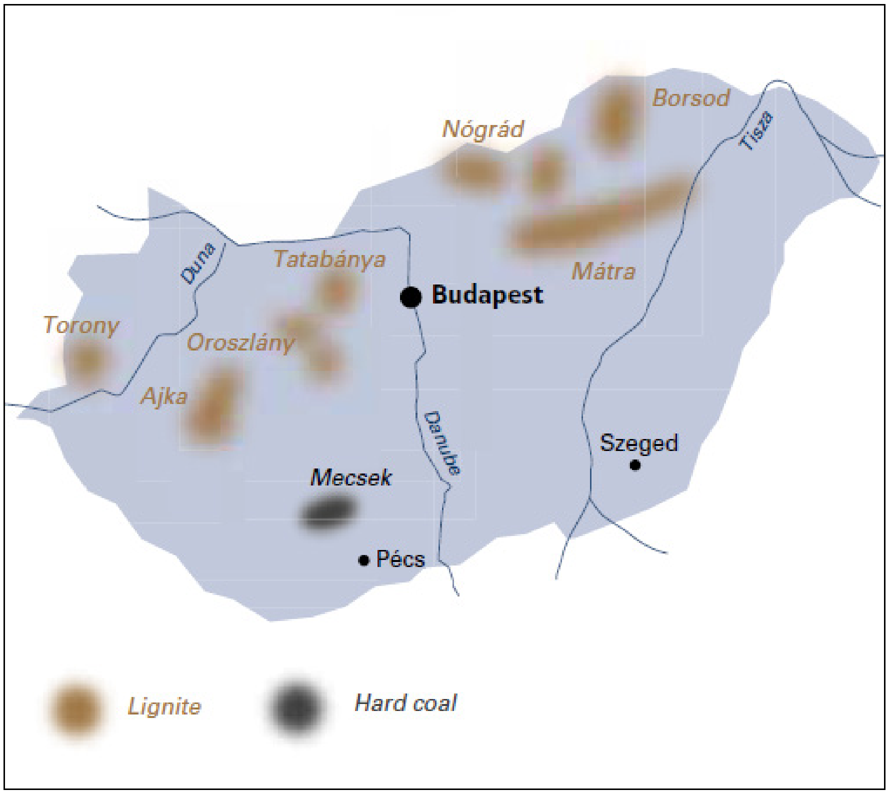
Table 15-1. Hungary's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	13.0	1,647.0	1,660.0	23 (0.19%)
Annual Coal Production (2012)	0	9.29	9.29	27 (0.12%)

Source: EIA (2014)

Hungary's principal bituminous coal basin is the Mecsek Basin in the Mecsek Mountains of Baranya Province (Figure 15-1). Other coalfields include the sub-bituminous/lignite coalfields of Ajka, Borsad, Matra, Nógrad, Oroszlány, Tatabánya , and Varpolata.

Figure 15-1. Hungary's Coal Basin Fields



Source: Euracoal (2014)

15.1.2 Stakeholders

As indicated in Table 15-2, Magyar Olaj es Gaz (MOL), the state oil and gas monopoly, is a prospective stakeholder in the development of Hungary's coal mine methane (CMM) industry.

Table 15-2. Key Stakeholders in Hungary's CMM Industry

Stakeholder Category	Stakeholder	Role
Natural Gas Transmission & Distribution Companies	▪ Magyar Olaj es Gaz (MOL)	Pipeline sales
Energy Companies/Power Generators	▪ MVM Group (Magyar Villamos Művek Zrt.) ▪ MÁTRA (Mátrai Erömü Zrt.)	CMM project identification and investment
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Government Groups	▪ Energy Centre Hungary ▪ Ministry for National Economy ▪ Ministry for Environment and Water ▪ Hungarian Energy and Public Utility Regulatory Authority ▪ Hungarian Office for Mining and Geology	Development of energy policy, project implementation, regulatory

15.1.3 Status of Coal and the Coal Mining Industry

The coal mining industry in Hungary is privatized. No information was found quantifying the proportion of underground mines considered gassy.

15.2 Overview of CMM Emissions, Projects, and Potential

There are significant recoverable gas reserves from coal beds in Hungary (see Table 15-3).

Table 15-3. Hungary's Largest Recoverable CMM/CBM Resources

Location	Amount (million cubic meters)
Algyő	12,700
Hajdúszoboszló	1,500
Pusztaföldvár	1,700
Üllés	2,800
Szank	700
Szeghalom	800
Nagykörű	2,600
Mezősas	3,300
Kisújszállás	800
Lovászi	200
Total	**27,100**

Source: Foldessy (2006)

15.2.1 CMM Emissions from Operating Mines

Methane emissions in Hungary totaled 21.7 million cubic meters (m^3) in 2000, but are projected to decrease significantly to 1.4 million m^3 by 2015, and then remain stable through 2030 (see Table 15-4).

Table 15-4. Hungary's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	21.7	1.4	1.4	1.4

Source: USEPA (2012)

15.2.2 CMM Emissions from Abandoned Coal Mines

No information on methane emissions from abandoned mines in Hungary was found.

15.2.3 CBM from Virgin Coal Seams

Overall coalbed methane (CBM) resources in the country are estimated at 152-159 billion m^3, of which 142 billion m^3 are in the Mecsek Coal Basin. The Mecsek region is thus the target area for

CBM development. The potential of CBM was examined in Hungary in 2006 (Molnar, nd). Various factors such as coal rank, gas content, natural fracturing, history of gas emissions, proximity to guaranteed markets, and the relative dryness of coal and deep mines identify the Mecsek basin as a site for potential CBM development (Schwochow, 1997).The gas in the seams is approximately 95 percent pure, 70-90 percent of which is solid solution and sorbed, and contains 0.8 percent carbon dioxide (Foldessy, 2006).

Four drillhole tests were done between 1994 and 1995, all of which experienced fracturing by fluid carbon dioxide and failed. New projects, proposed by the University of Miskolc, would use steam gas extraction through medium radius drilling to access methane stores.

15.3 Opportunities and Challenges to Greater CMM Recovery and Use

As expressed in Table 15-5, Hungary ratified both the UNFCCC and the Kyoto Protocol, under which it has committed to a reduction of 6 percent of emissions from the base period 1985-1987 (UNFCCC, 2005). Hungary is an Annex 1 country and is eligible to host Joint Implementation (JI) projects. While there are several landfill-related and forest biomass JI projects in Hungary, there are none related to coalbed/mine methane (UNEP, 2014).

Table 15-5. Hungary's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	February 24, 1994
Kyoto Protocol	---	August 21, 2000

Source: UNFCCC (2014)

Hungary's Climate Change Act 2007—based on UNFCCC implementation and its Kyoto Protocol—created a framework for building the country's ability to adapt to climate change. The Act prescribed the preparation of a national climate change strategy for Hungary and in 2008, a National Climate Change Strategy (NCCS) was accepted by the Parliament (EU, nd). The NCCS contained chapters on both climate change mitigation and adaptation, and identified key objectives and actions to be implemented for 2008-2025. The Act also required the Hungarian Government adopt National Climate Change Programmes (NCCPs) every two years. The first NCCP was approved for 2009 and reviewed in 2011.

The first revision of the NCCS (the "Strategy") mandated by the Climate Change Act 2007 was anticipated to take place before the end of 2013. The revised version would extend the strategy's timeframe to 2030, with a 2050 outlook (EU, nd). As part of the revised NCCS, Hungary also intends to prepare a national adaptation strategic framework. At the time of publication, current status of the revised strategy was unknown.

15.3.1 Market and Infrastructure Factors

In the 1990s, the Hungarian government privatized the coal industry, dividing the existing coal mines into supposedly profitable and unprofitable groups. The profitable ones were contracted to power plants and have been supported by government subsidies to varying degrees in the form of price guarantees, subsidies for fuel switching, and government responsibility for most existing liabilities. The introduction of EU regulations and requirements has not changed the landscape for these factors significantly, so continued support for standard fuel sources and systems will likely continue to impede investment in alternatives like CMM (Perger, 2009).

15.3.2 Regulatory Information

No regulatory information regarding development or sales of CMM in Hungary was found.

15.4 Profiles of Individual Mines

Márkushegyi Bányaüzem, Oroszlány Coal Basin, Oroszlány

General Information

Depth of shafts	250 m
Mining capacity	4,167 tonnes/day

General Geologic Information

Coal seam gas content range	2-3 m^3/tonne
Faults	Yes
Total methane resource	0.3-0.5 billion m^3 (coal seams)

Geologic and Mining Conditions

Rank of coal	Sub-bituminous
Depth of mining	250 m
Ash content	Coal in place, run of mine - 30.8 percent
Sulfur content	3.3 percent
Gas content	2-3 m^3/tonne coal
Mining method	Longwall
Roof control method	Caving

Source: Molnar (nd)

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16 India

16.1 Summary of Coal Industry

16.1.1 Role of Coal in India

In 2011, coal represented 41 percent of India's total primary energy supply (EIA, 2013a). The International Energy Agency (IEA) reported that in 2011, 71 percent of the coal produced and imported was used for electric power generation (IEA, 2014). About 57 percent of the installed power capacity, as of 2011, is generated from coal-fired plants. Steel, cement, fertilizer, chemical, paper, and industrial plants are also major coal users, while coal has largely been phased out from the rail transport sector. India's total primary coal production was 589 million tonnes (Mmt) in 2012. Even with high domestic production, India imported 12.7 percent (86 Mmt) of its total primary coal consumption of 675 Mmt (EIA, 2013b). According to the Ministry of Coal's (MOC) 2012 projections, coking coal would represent one-third of the total imports.

The Geological Survey of India estimates the country to possess 293 billion tonnes of total coal resources (MOC, 2012). Of this total resource, BP estimates proved recoverable reserves of 66.8 billion tonnes (BP, 2012). Table 16-1 provides statistics on India's coal reserves and production.

Table 16-1. India'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)	61,840	4,960	66,800	5 (7.0%)
Annual Coal Production (2012)	545.8	43.4	589.3	3 (7.47%)

Source: EIA (2013b)

India's coal demand has grown by more than 7 percent per year over the past decade and production shortfalls have driven the increase of imported coal by more than 13 percent per year since 2001 (EIA, 2013a). Despite this increased consumption, the expanding demand for power has reduced the fraction of energy consumption provided by coal from approximately 68 percent in 2002, to 41 percent in 2011 (EIA, 2013a).

The coal-bearing formations of India occur in two geological horizons, the Lower Gondwana (Permian) and the Tertiary sediments (Eocene-Oligocene) of northeastern India, Rajasthan, Gujarat, Jammu, and Kashmir (Chand, 2001). Coal resources are found in 17 major coalfields in India (GSI, 2010). Reserves in these coal fields are provided in Table 16-2. Figure 16-1 shows the location of major coal deposits in India.

Table 16-2. Coal Distribution in India's Major Coalfields (million tonnes)

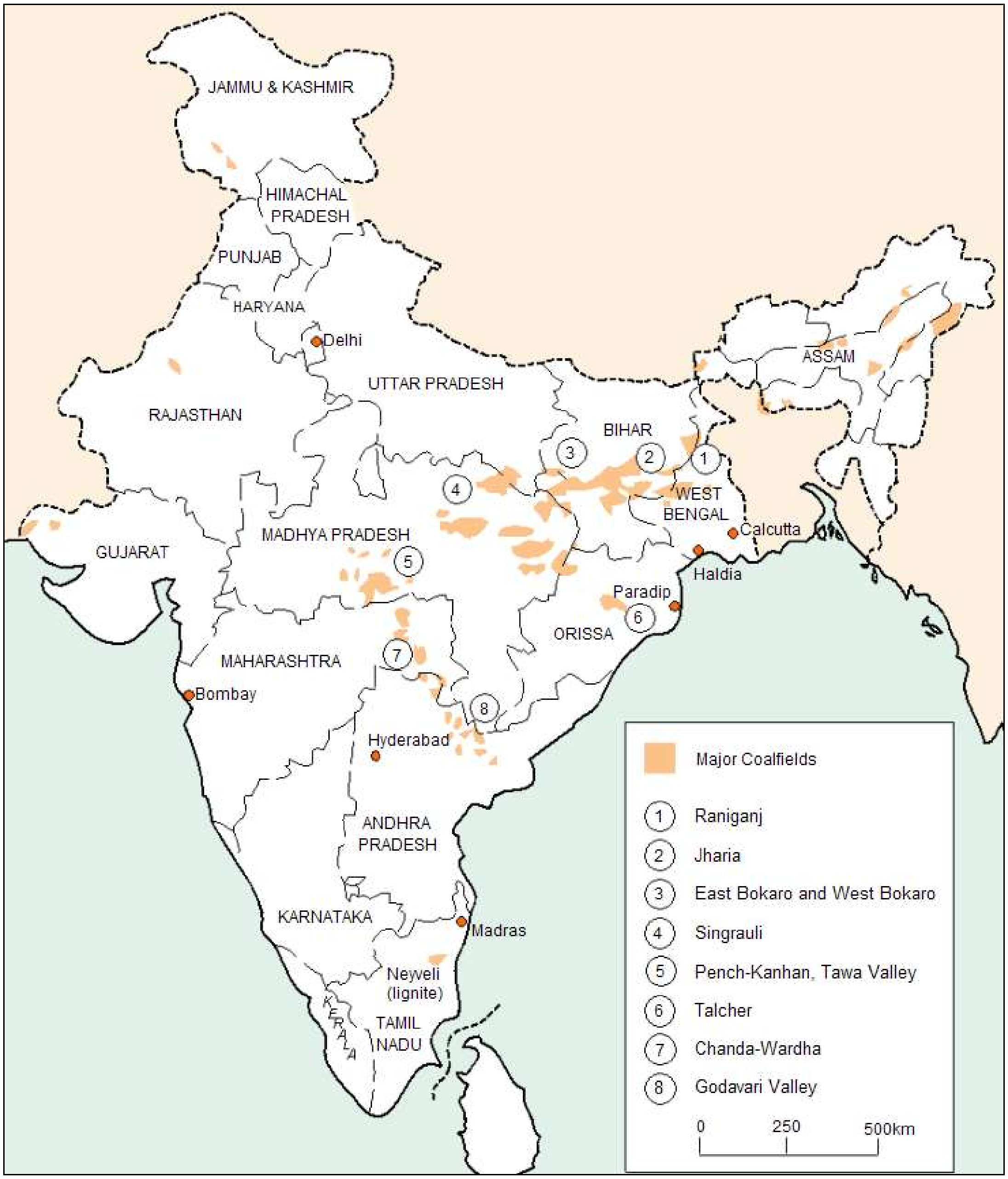
State	Coal Field	Resource	Proved Reserves
Orissa	Talcher	43858.76	14240.08
West Bengal	Raniganj	23730.81	11638.27
Orissa	Ib-river	22448.49	7266.58
Jharkhand	Jharia	19430.06	15077.57
Chattisgarh	Mand-raigarh	22177.64	3880.67
Andhra Pradesh	Godavari Valley	22016.24	9256.51
Jharkhand	N. Karanpura	17073.24	9499.42
Jharkhand	Rajmahal	14338.00	2655.52
Madhya Pradesh	Singrauli	12416.51	4795.00
Chattisgarh	Korba	11704.83	4980.58
Jharkhand	E. Bokaro	8083.29	3351.87
Jharkhand	S. Karanpura	6150.11	2620.41
Maharashtra	Wardha Valley	6044.24	3297.19
Jharkhand	W. Bokaro	5012.49	3629.03
Chattisgarh	Hasdo-arand	4993.70	1369.84
West Bengal	Birbhum	5992.76	0
Madhya Pradesh	Sohagpur	6128.74	1643.20

Note: Where coalfields overlap state borders, the state with the dominant share of resources is shown.
Source: GSI (2010)

Hard coals (anthracite and bituminous) account for approximately 92 percent of the country's proved reserves (EIA, 2013b). The principal deposits of hard coal are in the eastern half of the country, ranging from Andhra Pradesh, bordering the Indian Ocean, to Arunachal Pradesh in the extreme northeast. The States of Jharkhand, Orissa, West Bengal, and Chattisgarh, together account for about 70 percent of reserves (EIA, 2014). The Damodar Valley basins include the significant Jharia and Raniganj coalfields in the east and the Bokaro, Ramgarh, and North and South Karanpura fields in the west.

The high-rank coal seams in deeper coalfields represent a significant target for coal mine methane (CMM) and coal bed methane (CBM) development. In some of the coalfields of the Damodar Valley, there can be up to 25 coal seams, and even in excess of 40 in some areas, with a cumulative thickness of over 100 meters (M2M Profile – India, 2005).

Figure 16-1. India's Coal Fields



Source: Walker (2000)

16.1.2 STAKEHOLDERS

Table 16-3 identifies potential stakeholders in Indian CMM development.

Table 16-3. Key Stakeholders in India's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Coal India, Ltd. (CIL) and its eight regional subsidiaries ▪ Electrosteel Casting Ltd	▪ Project hosts
Engineering, Consultancy and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	▪ Technical assistance
Developers	▪ Reliance Industries ▪ Deep Industries ▪ Great Eastern Energy ▪ Reliance ADA ▪ Essar Oil Ltd. ▪ Oil and Natural Gas Corporation (ONGC)	▪ Project developers
Universities, Research Establishments	▪ Central Institute of Mining and Fuel Research ▪ Central Mine Planning and Design Institute ▪ Indian School of Mines ▪ IIT Madras	▪ Technical assistance
Government Groups	▪ Ministry of Petroleum and Natural Gas (For CBM only) ▪ Directorate General of Hydrocarbons ▪ Ministry of Coal (For CBM/CMM)	▪ Oversight of resources, licensing

16.1.3 Status of Coal and the Coal Mining Industry

In 2000, 27 percent of coal production in India came from underground mines and by 2012 that number was estimated to decline to fewer than 10 percent (MOC, 2012). Deep mines continue to be developed, but more surface mines are also being developed due to the country's vast resource of shallow, low-rank coal deposits. Table 16-4 summarizes the available statistics on coal production by mine type.

Table 16-4. India's Hard Coal Production by Mine Type

Type of mine	Production (million tonnes)	Number of mines (as of 31 March 2008)
Underground (active) mines	51.832	337
Surface (active) mines	488.108	186
Mixed	-	36
Total Active Mines	**539.94**	**559**

Source: MOC (2012)

There is a 3-tier classification system for underground mines in India based on the amount of methane emissions, as shown in Table 16-5.

Table 16-5. India's Classification System and Estimates of Mine Gassiness

Class	Specific Emissions (volume of flammable gas/ tonne of coal produced)	Number of Mines (as of 2007)
Degree I	>0.01 and < 1 m^3	222
Degree II	> 1 and < 10 m^3	102
Degree III	> 10 m^3	18

Source: M2M (2008)

India's coal production faces multiple challenges, including low productivity, distribution problems, and an increased loss of domestic market share to higher-quality, less-expensive imports. India's government embarked on a series of economic reforms in the 1990s, including relaxation of restrictions on foreign ownership and privatization of some industrial enterprises. In 2004, some of these economic reforms were curtailed and continued at a slower pace. In April 2004, 470 of India's 576 mines were under the control of Coal India, Ltd. (CIL), a state-owned entity. Private mines, or investments in mines owned by Indian companies, are allowed only if "captive" to a power plant or factory (MOC, 2004); that is, the captive coal is used for power generation, steel, or cement. Private companies were allocated 60 blocks for exploration and mining in 2006-2007. Further coal-sector liberalization has been attempted, in the form of the Coal Mines Nationalisation Amendment Bill, introduced in 2000, but under pressure from labor unions the bill has stalled and is still under consideration a decade later (MOC, 2010b).

At the end of 2009, a total of 208 coal blocks with reserves of 49 billion tonnes had been allocated for exploration and mining to eligible companies. The government is in the process of amending the Mines and Mineral (Development and Regulation) Act of 1957 to introduce an auction system of competitive bidding on future allocations of coal blocks. This is intended to be a more transparent system of awarding a decreasing number of available coal blocks to an increasing number of applicant companies (MOC, 2010a).

16.2 Overview of CMM Emissions and Development Potential

India's carbon emissions increased by 61 percent between 1990 and 2001, a rate surpassed only by China. In 2005, annual emissions were 1,181.4 tonnes carbon dioxide equivalent (mtCO_2e) and as of 2011, emissions had risen to 1,725.8 mtCO_2e (EIA, 2013b). Large increases in emissions from the electricity, cement and waste sectors, along with rises in the transport and residential sectors, have made India the world's fifth largest emitter after China, the U.S., Europe and Russia. More than a third of India's emissions come from low efficiency coal fired power plants. High capital costs for replacing existing plants, a scarcity of capital, and the long lead time required to introduce advanced coal technologies point to the likelihood that most of India's highly polluting coal-fired power plants will remain in operation for the next couple of decades (EIA, 2004b). In 2010, methane emissions from coal mining were calculated at 18.88 mtCO_2e (USEPA, 2012).

16.2.1 CMM Emissions from Operating Mines

Table 16-6 summarizes India's CMM emissions.

Table 16-6. India's CMM Emissions (million cubic meters)

Emission Source	2000	2005	2010	2015 (projected)
CMM emissions (no utilization)*	1,007	1,077	1,275	1,397

**Actual emissions reductions are unknown.*
Source: USEPA (2012)

While there is some drainage of CMM, there are currently no commercial projects for its recovery or use in India. A USD 14.9 million project of the United Nations Development Programme (UNDP), the Global Environmental Facility (GEF), and the Indian Ministry of Coal called "Coalbed Methane Recovery & Commercial Utilisation" demonstrated the feasibility of utilizing methane gas recovered before, during, and after coal extraction. The lack of commercial CMM projects in India is in part due to the lack of a legal or regulatory framework governing CMM production. Although the Ministry of Coal and the Ministry of Petroleum have been discussing a comprehensive CMM policy in recent years, a resolution to the issue does not appear imminent.

In 2008, the U.S. EPA and the U.S. Trade and Development Association assisted in the establishment of the CMM/CBM Clearinghouse located at the Central Mine Planning and Design Institute's (CMPDI) campus in Ranchi (www.cmmclearinghouse.cmpdi.co.in). The Clearinghouse seeks to promote the deployment of CMM recovery and end-use technologies in India to reduce methane emissions.

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies 21 potential CMM recovery projects in India. However, the majority of these are at the "initial idea" stage and most of them have since been dropped due to the inability to receive a concession to develop the project. Through GMI, U.S. EPA awarded a grant to the Central Institute of Mining and Fuel Research to conduct a feasibility study on CMM recovery and utilization in the Jharia, Bokaro, and Raniganj coalfields. The project provided data on CMM/VAM/AMM emissions in key gassy coal regions of India. VAM data was collected from 10 working mines. More recently, EPA's CMOP program funded a pre-feasibility study for pre-mine drainage at the Sawang Mine located in the Bokaro coalfield. The study will examine the economics of utilizing long, in-seam boreholes to drain gas from the deeper, un-mined portions of the mine.

16.2.2 CMM Emissions from Abandoned Coal Mines

About 5 percent of abandoned mines in India are considered gassy, assuming the same percentage as active mines reported in the First National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). No additional information is available on abandoned mine methane (AMM) in India at this time, although several studies are proposed to gain more information on AMM emissions volumes in India's major coalfields (GMI Projects Database, 2010).

16.2.3 CBM from Virgin Coal Seams

Estimates of India's CBM potential vary. The Directorate General of Hydrocarbons estimates that deposits in 44 major coal and lignite fields in 12 states of India, covering an area of 35,330 km^2, contain 3.4 trillion cubic meters (m^3) of CBM depending on the rank of the coal, depth of burial, and geotectonic settings of the basins as estimated by CMPDI.

In the Jharia Coalfield, the gas content is estimated to be between 7.3 and 23.8 m^3 per tonne of coal within the depth range of 150 to 1200 m. Analysis indicates every 100-m increase in depth is generally associated with a 1.3 m^3 increase of methane content (M2M Profile – India, 2005).

In 1997, the government formed a CBM policy that established the Ministry of Petroleum and Natural Gas as the CBM administrative agency and offered several incentives (see section 16.3.1).

In May 2001, the Indian government for the first time offered blocks for exploration and production of CBM through an international bidding process. Reliance Industries, Essar Oil Ltd., and Oil and Natural Gas Corporation (ONGC) won the bids for the blocks. The government launched a second round of bidding on nine CBM blocks in May 2003, and eight blocks were awarded to Reliance and ONGC. The Directorate General of Hydrocarbons offered an additional 10 CBM blocks during a third round of open international competitive bidding that closed in June 2006. Contracts for this third round of bidding were signed in November 2006. These 26 prospective CBM blocks in the first three rounds of bidding cover an area of around 13,590 km^2 and are estimated to contain 1.45 trillion m^3 of CBM resources (Table 16-7). Expected total production from these blocks is estimated at 39.7 million m^3 per day at their peak production level (DGH, 2010).

More than 200 exploratory (test) and nearly 300 production wells have been drilled in the awarded blocks. Commercial production began in the Raniganj (South) CBM block in July 2007, followed by commercial production from the Raniganj East Block. Current gas production from these three blocks is 0.6 million m^3 per day and by 2015 production is projected to increase to 1.0 million m^3 per day. The fourth round of bidding on 10 new CBM blocks took place in the fall of 2009. The blocks cover an area of approximately 5000 km^2 and are spread over seven states. During the fourth round of bidding, 26 bids were received for eight of the blocks on offer while 2 of the blocks located in the Wardha Coalfield of Maharashtra received no bids. Essar Oil Limited, Arrow Energy and Great Eastern Energy Corporation Ltd. were the successful bidders (DGH, 2010).

Table 16-7. CBM Project Blocks Offered for Lease

Bidding Round for CBM Blocks	Blocks Offered	Area (km^2)	CBM Resource (Bcm)	Expected Production (MMcmd)
First	5	1,930	235	9
Nomination Basis	3	643	163	5
Second	8	5,234	427	10.5
Third	10	5,784	624	15.2
Fourth	10	5,000	NA	NA
Total	**36**	**18,591**	**1,449+**	**39.7+**

Source: DGH (2010)

Table 16-8 contains a list of some of the CBM activity by private companies currently taking place in India.

Table 16-8. CBM Projects Proposed or in Development

Company	Coalfield	Status	Notes
Great Eastern Energy Corporation Ltd (GEECL)	Raniganj	Approx. 100 wells on line and selling about 0.3 MMcmd	GIP estimated at 56.6 billion m³ (Bcm)
	Mannargudi Block	Block awarded to GEECL in 4th bidding round.	Estimated GIP is 28 Bcm
Reliance Industries	Sohagpur	In development phase. Approx. 30 exploratory wells drilled. Plan to commercialize the field starting 2015	USTDA grant for technical assistance on commercial development of CBM
Essar Oil Ltd.	Raniganj	150 CBM production wells drilled – CBM production currently 0/2 MMcmd	Project scope is 500 wells. GIP is estimated to be 130 Bcm with recoverable reserves of 28 Bcm
Oil & Natural Gas Corp. (ONGC)	Parbatpur, Jharkhand	8 exploratory wells drilled. Currently producing 15,000 cubic meters of CBM gas, but ONGC is looking to expand.	Holds 5 CBM blocks in Jharkhand and 1 in Raniganj – all in exploration stage
BP, Deep Industries Arrow, Geopetrol and more		Various stages of CBM exploration	

Source: M2M Expo (2010)

16.3 Opportunities and Challenges to Greater CMM Recovery and Use

India is a non-Annex 1 country under the UNFCCC and it is not obligated to reduce carbon and greenhouse gas (GHG) emissions. In 2012, its second national communication provided emissions estimates for 2000. The emissions are projected to continue to grow as the economy expands (EIA, 2004a). India accepted the Kyoto Protocol in 2002 (see Table 16-9). As a non-Annex 1 party, India is eligible to receive financing for GHG mitigation projects such as CMM projects under the Clean Development Mechanism. However, note that the Kyoto Protocol expired in 2012 and there is currently no follow-on agreement.

Table 16-9. India's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 10, 1992	November 1, 1993
Kyoto Protocol	---	August 26, 2002 (Acceptance)

Sources: UNFCCC (2014)

16.3.1 Market and Infrastructure Factors

Gas demand is rising sharply in India, with consumption rising from 36 Bcm in 2005 to 58 Bcm in 2012 (EIA, 2013b). Gas production rates (29.9 Bcm to 41.3 Bcm over the same time frame) are increasingly lagging consumption rates and the shortfall is made up with imported natural gas and liquefied natural gas (LNG). 12.6 Bcm of natural gas (dry) and 12.3 Bcm of LNG were imported in 2009. In 2011, India became the world's sixth largest LNG importer, with 5.3 percent of global imports (EIA, 2013a; PFC Energy, 2012). No data is currently available for LNG imports as of 2012, but dry gas imports increased to 16.9 Bcm. Gas consumption has grown at an approximate annual rate of 10 percent from 2001-2011 and the Indian Oil and Natural Gas Ministry projects consumption to more than double over the next 5 years (EIA, 2013b).

Current prices for imported coal, gas and LNG make CMM and CBM an economically attractive alternative energy source, provided the pipeline infrastructure is developed (Dube, 2010). Investments in coal and gas transportation infrastructure, including gas gathering, transportation and distribution, are necessary to move CMM and CBM from coal fields to local and more distant end-use markets. One such project is in development by GAIL (India) Limited, India's principal gas transmission and marketing company, which is building a natural gas pipeline in north-east India running through many of the major coal regions. End-use markets for CMM/CBM include rural power generation, commercial power generation, and transportation fuels.

Limitations in cost and investment capital, however, remain significant barriers to technology development, application, and CMM and CBM project development in India.

The following actions were identified as necessary in order to fully develop India's CBM/CMM potential (M2M Workshop – India, 2005), and these are the areas that the CMM Clearinghouse addresses:

- Delineation of prospective CBM/CMM blocks,
- Development of coal field-specific databases,
- Provision of technical and other training,
- Promotion of CBM/CMM research and development,
- Transfer of CBM/CMM development technologies,
- Provision of substantive measures to encourage CBM/CMM development entrepreneurs and maintain constant interaction with and among CBM/CMM developers, and
- Establishment of a clear policy regarding CMM development.

16.3.2 Regulatory Information

A memorandum of understanding between the Ministry of Coal and Ministry of Petroleum & Natural Gas governs the procedures for allotment of blocks for CBM exploration and exploitation. CBM blocks are allocated after mutual consultations between the two ministries (Prasad, 2006). The Ministry of Coal oversees coal resources while the Ministry of Petroleum and Natural Gas oversees CBM resources.

India's heavy reliance on coal, much of it low-quality, is a major cause of the country's relatively high carbon intensity level. However, environmental standards for limiting gas emissions from surface or underground coal mining operations, as well as emissions from coal and gas combustion, are largely lacking. Current guidelines governing CMM emissions apply only to methane concentrations, and not on volume released. Other issues affecting CMM/CBM drainage and use include clarifying gas ownership, expediting private participation and possible government mandates for pre-mining degasification (Dube, 2010). A regulatory framework for CMM is under formation by the Government of India (M2M, 2008).

India has offered several incentives to attract foreign investment for CBM development. The Indian government formed a CBM policy in 1997 that established the Ministry of Petroleum and Natural Gas as the CBM administrative agency and offered following key benefits:

- No upfront payment
- No signature bonus
- No participating interest of the Government of India
- CBM development blocks allotted through a competitive bidding process
- A 7-year tax holiday, beginning with the date of commercial CBM production
- Freedom to market in domestic market at market determined prices
- Imported equipment for CBM development exempted from customs duties
- Walkout option at the end of Phases I & II

Incentives also allow no limitation on cost recovery, unincorporated joint ventures, accelerated depreciation and securitization of interest. India has implemented policy changes to encourage foreign investment, including lowering or eliminating tariffs on capital goods, such as electric power generation equipment (EIA, 2004a).

16.4 Profiles of Individual Mines

Moonidih Mine, Jharkhand			
Mine Status	Active	**Mine Owner**	Bharat Coking Coal Limited (BCCL)
Mining Method	Longwall	**Parent Company**	Coal India Limited (CIL)
Depth of seams	To 500 m	**Location**	Jharia Coalfield, Dhanbad District
		2008 Utilized CH_4 volume	Minimal usage by GEF project

Musilia Unit, Ghusick Colliery, West Bengal			
Mine Status	Active	**Mine Owner**	Eastern Coalfields Limited (ECL)
Mining Method	Room-and-Pillar	**Parent Company**	Coal India Limited (CIL)
Depth of seams	50-65 m	**Location**	Burdwan District
No. of seams	2 (additional 4 to be mined)	**2008 VAM volume**	1.899 Mm^3

Jarangdih U/G Mine, East Bokaro Coalfield, Jharkhand			
Mine Status	Active	**Mine Owner**	Central Coalfields Ltd
Mining Method	Bord & Pillar	**Parent Company**	Coal India Limited (CIL)
No. of seams	22	**2011 CH_4 Emissions**	0.521Mm^3

Mohuda Top U/G Mine, Jharia Coalfield, Jharkhand			
Mine Status	Active	**Mine Owner**	Bharat Coking Coals Ltd
Mining Method	Bord &Pillar	**Parent Company**	Coal India Limited (CIL)

Mohuda Top U/G Mine, Jharia Coalfield, Jharkhand			
No. of seams	8	**Location**	Dhanbad District
		2011 CH_4 Emissions	0.504 Mm^3

Pootkee-Bulliary U/G Mine, Jharia Coalfield, Jharkhand			
Mine Status	Active	**Mine Owner**	Bharat Coking Coals Ltd
Mining Method	Bord & Pillar	**Parent Company**	Coal India Limited (CIL)
No. of seams	18	**Location**	Dhanbad District
		2011 CH_4 Emissions	0.389 Mm^3

Other mine profiles are located at https://www.globalmethane.org/activities/indexact2.aspx?geoFocus=india&sector=coal and https://www.globalmethane.org/expo/posters.html.

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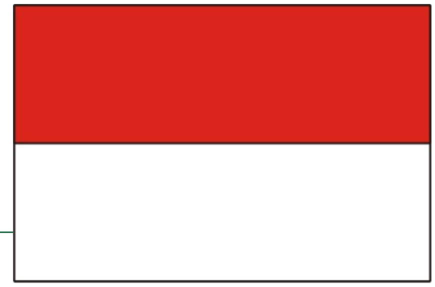
17 Indonesia



17.1 Summary of Coal Industry

17.1.1 Role of Coal in Indonesia

Coal is a critically important export commodity for Indonesia. The country has 28 billion tonnes of recoverable coal reserves (EIA, 2014a). Indonesia produced more than 440 million tonnes (Mmt) of coal in 2012 (see Table 17-1). Coal production has increased dramatically over the past several years, increasing by more than 250 percent since 2005 (EIA, 2014b). Continued growth in coal production is attributable to growing international demand, as well as rising domestic electricity consumption (EIA, 2014b). Indonesia is the world's largest exporter of coal by weight. Exports are primarily to India and China, but also to South Korea, Japan, and Taiwan (EIA, 2014b).

Coal provided for 48 percent of Indonesia's electricity generation capacity in 2012 (EIA, 2014b). Power plants consume almost all, or 99 percent, of coal in Indonesia, and cement plants and metallurgy consume the remainder (Sihite, 2012).

Table 17-1. Indonesia'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)	0	28,017	28,017	10 (3.2%)
Annual Coal Production (2012)	442.8	0	442.8	4 (5.6%)

Note: Numbers may not add due to rounding
Source: EIA (2014a)

Coal is found in 11 distinct basins on the four major portions of the archipelago that comprise Indonesia (Figure 17-1). The province of Sumatra contains 49 percent of Indonesia's total coal reserves and Kalimantan contains 47 percent, with the balance located in Riau, Jambi, and Bengkulu as shown in Table 17-2. However, most production (90 percent) takes place in Kalimantan, which has higher quality coal deposits (US Embassy, 2000; Gushka, 2013).

Table 17-2. Indonesia's Coal Reserves by Province (2011)

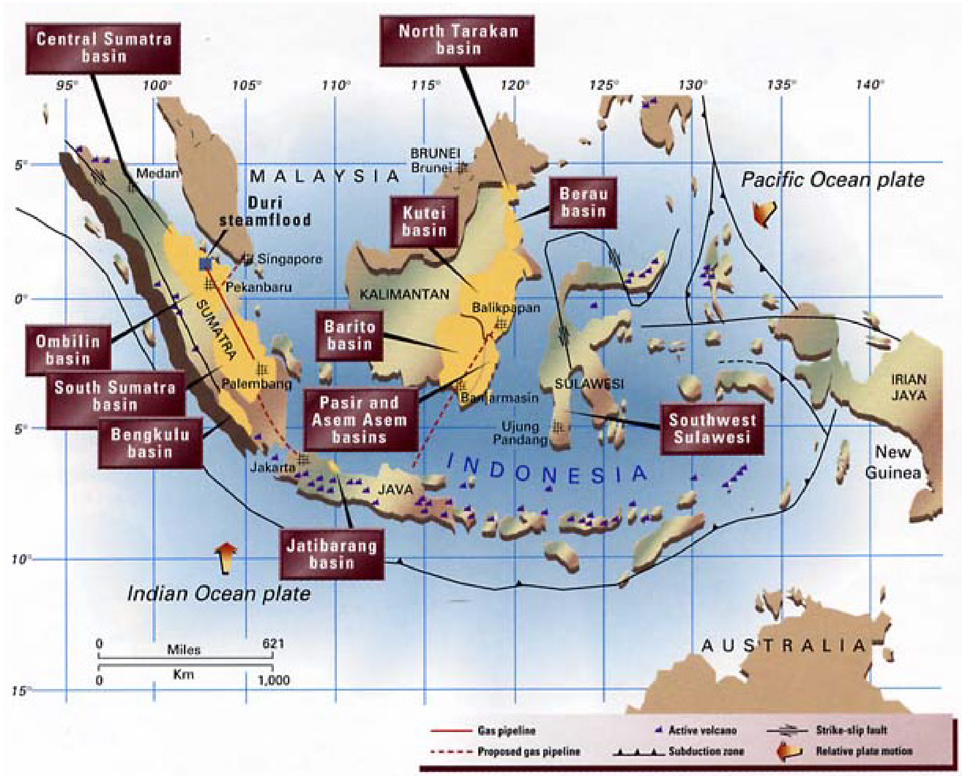
Province	Resources			Total	Reserves
	Inferred	Indicated	Measured		
Banten	5.75	4.86	2.72	18.80	0.00
West Java	0.00	0.00	0.00	0.00	0.00

Table 17-2. Indonesia's Coal Reserves by Province (2011)

Province	Resources			Total	Reserves
	Inferred	Indicated	Measured		
Central Java	0.82	0.00	0.00	0.82	0.00
East Java	0.08	0.00	0.00	0.08	0.00
Nanggroe Aceh Darussalam	346.35	13.40	90.40	450.15	0.00
North Sumatra	7.00	0.00	19.97	26.97	0.00
Riau	168.05	626.38	948.05	1,755.27	645.67
West Sumatra	294.50	231.16	249.45	800.06	158.43
Bengkulu	17.86	104.08	71.21	208.30	19.02
Jambi	656.90	699.08	443.50	1,990.32	351.65
South Sumatra	14,508.95	14,808.82	10,026.59	59,254.35	13,625.22
Lampung	106.95	0.00	0.00	106.95	0.00
West Kalimantan	477.69	6.85	4.70	489.24	0.00
Central Kalimantan	1,838.50	808.28	704.89	3,549.25	577.42
South Kalimantan	3,833.53	3,344.05	3,481.66	10,659.24	3,778.04
East Kalimantan	13,276.66	6,282.62	8,004.19	40,665.00	8,861.90
South Sulawesi	48.81	129.22	53.09	231.12	0.12
Central Sulawesi	1.98	0.00	0.00	1.98	0.00
North Maluku	0.00	0.00	0.00	2.13	0.00
West Irian Jaya	32.82	0.00	0.00	126.41	0.00
Papua	2.16	0.00	0.00	2.16	0.00
TOTAL	**35,625.36**	**27,058.79**	**24,100.42**	**120,338.60**	**28,017.46**

Source: ESDM (2012)

Figure 17-1. Indonesia's Coal Fields



Source: Stevens et al. (2001)

17.1.2 STAKEHOLDERS

Coal mine operators in Indonesia include state-owned enterprises, private national companies, and foreign mining companies (USGS, 2007). The major coal producers are listed in Table 17-3.

Table 17-3. Indonesia's Major Coal Producers

Operators	Annual Capacity (2012) (million tonnes)
PT Kaltim Prima Coal (Bumi Resources)	36.0
PT Adaro Indonesia	35.0
PT Arutmin Indonesia (Bumi Resources)	20.0
PT Tambang Batubara Bukit Asam	19.0
PT Bayan Resources Tbk.	15.0
PT Indominco Mandiri (Banpu Indonesia)	14.8*
PT Berau Coal	13.0
PT Kideco Jaya Agung	12.0
United Tractors	6.5

Sources: USGS (2014); *Indonesia-Investments (2014)

Other key stakeholders involved with the coal industry, the coal mine methane (CMM) and coal bed methane (CBM) industries are listed in Table 17-4.

Table 17-4. Key Stakeholders in Indonesia's CMM Industry

Stakeholder Category	Stakeholder	Role
Developer	▪ British Petroleum ▪ CBM Asia Development Corp. ▪ Dart Energy ▪ Eni ▪ ExxonMobil ▪ Newton Energy Capital Ltd. ▪ Nu Energy ▪ Pertamina ▪ PT Energi Mega Persada Tbk. ▪ Santos ▪ Ephindo ▪ Total ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Government Groups	▪ Ministry of Energy and Mineral Resources (Kementerian Energi Dan Sumber Daya) ▪ Directorate General of Mineral and Coal ▪ Directorate General of Oil and Gas (MIGAS) ▪ Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas)	Licensing

Source: CBM Asia (2013)

17.1.3 Status of Coal and the Coal Mining Industry

Since transitioning to a democracy beginning in the late 1990s, Indonesia's central government has been ceding greater autonomy to regional coal administrators. The central government maintains ownership of coal and associated methane gas, but mine permitting may be done at the central or local government level, depending on whether the mine crosses provincial boundaries (Asia Law, 2009). The government formerly contracted directly with private companies for mine operations; however, the 2009 Mining Law (Law No. 4 of 2009 on Mineral and Coal Mining) replaces the previous "Contract of Work" system with a license-based permitting system that operates through a tender process instead of the former direct application. Licenses are royalty-based, with rates varying based on the size of the mining operation (Platts, 2014). Foreign companies may obtain coal licenses in Indonesia; however, according to regulations enacted in 2010 and 2013, foreign shareholders must progressively divest its shareholding to a minority stake over time, eventually divesting a 51-percent share to Indonesian ownership by year 10 (Scott and Tan, 2014).

Most of Indonesia's coal production comes from surface mines; however, underground mining is on the rise due to environmental concerns and has been identified as an investment opportunity by the Ministry of Energy and Mineral Resources (Pamerindo Indonesia, 2014; Gushka, 2013). Additionally, some mines such as the mine site of PT Gerbang Daya Mandiri located in Kutai Kertanegara, East Kalimantan have started as surface mines and moved operations underground (Karian et al, 2013).

Coal production is expected to continue to rise in Indonesia to meet export and domestic electricity demand. Indonesia has identified a number of objectives and investment opportunities to further the growth of its coal industry. The 2009 Mining Law applied domestic market obligations which require coal and mineral producing companies allocate a certain minimum percentage of total production to the domestic market (Hogarth and Nawangsari, 2010). Due to value-added requirements imposed by the 2009 Mining Law, all mineral ores are to be processed in Indonesia before being exported; thus, Indonesia is encouraging investment in areas of gasification, liquefaction, and coal blending and upgrading (Scott and Tan, 2014; Gushka, 2013). A number of mine mouth power plant projects are underway, with plans for additional plants to meet domestic electricity demand.

17.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no CMM recovery projects in Indonesia, in operation or development (GMI, 2014).

17.2.1 CMM Emissions from Operating Mines

With increased coal production, CMM emissions in Indonesia have increased as well. Table 17-5 summarizes Indonesia's CMM emissions.

Table 17-5. Indonesia's CMM Emissions (million cubic meters)

Emission Category	2000	2005	2010	2015 (projected)
Total CH_4 emitted	71.1	158.4	282.6	309.6

Source: USEPA (2012)

17.2.2 CMM Emissions from Abandoned Coal Mines

No information about CMM from abandoned mines in Indonesia is available at this time.

17.2.3 CBM from Virgin Coal Seams

Indonesia's government promotes exploration of CBM and shale gas, alongside conventional crude oil and natural gas projects. The Ministry of Energy and Mineral Resources estimates that the country has CBM reserves of 12.8 trillion cubic meters based on preliminary studies (EIA, 2014b). The Minister of Energy and Mineral Resources authorized the Directorate General of Oil and Gas (MIGAS) to develop CBM in Indonesia (US Embassy, 2000) and in 2007, the Indonesian government started awarding CBM blocks in the South and Central Sumatra basins on Sumatra Island and the Kutei and Barito basins in East Kalimantan (see Figure 17-2).

The Sanga-Sanga CBM block in East Kalimantan was contracted to Virginia Indonesia Co., LLC (VICO), a subsidiary of BP plc. and ENI S.p.A., in November 2009, and commercial CBM production commenced in 2011 (CBM Asia, 2013; VICO, 2014). CBM from this block is used to generated power, providing electricity for 2,500 homes in Borneo (SKK MIGAS, 2013).

Singapore-based Dart Energy and Indonesian PT Energi Pasir Hitam began CBM exploration activities in East Kalimantan in 2013, with the goal of supplying both power plants and the Bontang liquefied natural gas (LNG) facility (CBM Asia, 2013).

As of 2013, 54 production sharing contracts (PSC) had been signed with the Indonesian government for CBM production (Sirait, 2013). The government anticipates CBM production to reach over 5 billion cubic meters/year by 2020 (EIA, 2014b).

Figure 17-2. Indonesia's CBM Basins

Source: CBM Asia (2012a)

Table 17-6 summarizes Indonesia's CBM resources.

Table 17-6. Indonesia's CBM Resources

Province	Basin	Prospective Area (km^2)	CBM Resources (trillion cubic meters)
South Sumatra	South Sumatra	7,350	5.18
South Kalimantan	Barito	6,330	2.88
East Kalimantan	Kutei	6,100	2.26
Riau	Central Sumatra	5,150	1.5
East Kalimantan	North Tarakan	2,734	0.5
East Kalimantan	Berau	780	0.24
Bengkulu	Bengkulu	772	0.10
South Kalimantan	Pasir/Asem	385	0.085
South Sulawesi	Sulawesi	500	0.060
West Java	Northwest Java	100	0.023
West Sumatra	Ombilin	47	0.014
TOTAL		**30,248**	**12.8**

Source: Stevens and Hadiyanto (2004) via CBM Asia (2012a)

17.3 Opportunities and Challenges to Greater CMM Recovery and Use

Indonesia is a signatory to both the UNFCCC and the Kyoto Protocol. As a Non-Annex I Party to the Kyoto Protocol, Indonesia has no national emissions targets and was eligible to host mitigation projects under the Clean Development Mechanism (see Table 17-7).

Table 17-7. Indonesia's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 5, 1992	August 23, 1994
Kyoto Protocol	July 13, 1998	December 3, 2004

Source: UNFCCC (2014)

17.3.1 Market and Infrastructure Factors

Indonesia is home to more than 3,600 miles of natural gas transmission and distribution pipelines; however, domestic distribution infrastructure is almost non-existent outside of Java and North Sumatra. Indonesia's geography presents a challenge to resource development and makes the switch to natural gas for domestic consumption more difficult; however, declining oil production and strong economic growth in Indonesia have led to increased domestic consumption of natural gas (EIA, 2014b). Roughly half of Indonesia's gas production was consumed domestically in 2012, with the other half being exported as LNG or through two pipeline connections to Singapore and Malaysia. Domestic consumption is expected to continue to rise as reliance on oil and diesel fall; pipeline exports will reportedly cease when contracts expire in coming years (EIA, 2014b; CBM Asia, 2012b). Indonesia's government has sought to meet increasing gas demand by increasing the country's regasification capacity. Indonesia began processing domestic LNG at its first regasification terminal, Nusantara, in West Java, which processes LNG supplied from Indonesia's Bontang and Tangguh plants. Indonesia is in the process of building additional regasification facilities (CBM Asia, 2012b). Indonesia also plans to import LNG. In December 2013, Indonesia signed its first gas import contract with a US firm starting in 2018 (EIA, 2014b).

17.3.2 Regulatory Information

Coal and gas resources are owned by the State. Private companies wishing to extract resources are required to develop a PSC with Indonesia (Sirait, 2013). Production splits for oil and natural gas directed 60 to 80 percent of profits to the government and the remainder to the contractor. In 2003, production splits were adjusted to 65/35 for oil and 55/45 for gas (USGS, 2003). In 2007, the government announced that it would offer a 45 percent production split for CBM developments in order to encourage investors and support the need for unconventional gas supplies (CBM Asia, 2012b). As coal and mineral producers are required to meet domestic market obligations, so are gas producers – 25 percent of natural gas produced from production-sharing contracts in Indonesia must supply the domestic market (EIA, 2014b).

CBM contracts have the same terms as oil and gas contracts and are controlled by the Directorate General of Oil and Gas (MIGAS) (Reuters, 2007). Regulation No. 36 of 2008 on Business Undertaking of Coal Bed Methane is the current primary regulation for CBM development. Open areas are offered by tender or direct offer if proposed by a business entity. Under the regulation, oil and gas contractors are given priority for CBM activities and are given a direct offer in areas where the oil and gas contractor has fulfilled a three year commitment. Existing coal concessions are given priority and coal contractors are given direct offers for CBM activities in areas where the coal contractor has been exploiting coal for at least three years. In areas of overlapping concessions, priority for CBM activities is given to the oil and gas operator (Sirait, 2013).

17.4 Profiles of Individual Mines

No mine profiles are available at this time for Indonesia.

17.5 References

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18 Italy

18.1 Summary of Coal Industry

18.1.1 Role of Coal in Italy

Italy is severely deficient in coal resources and relies almost entirely on imports for its coal supply. Coal's contribution to total energy use in the country was about 8.7 percent in 2012, amounting to a consumption of 23.6 million tonnes (Mmt) (EIA, 2014).

Italy produces about 0.08 Mmt of coal annually (see Table 18-1), sourced entirely from Miniera Monte Sinni, Italy's only active underground coal mine, located in the Sulcis Basin in the south-west of Sardinia Island (Figure 18-1). Estimates of Italy's sub-bituminous and lignite reserves are about 50 Mmt of mineable coal (out of a worldwide total of 900 Mmt) (EIA, 2014).

Table 18-1. Italy's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank
Estimated Proved Coal Reserves (2011)	0	50	50	64 (0.006%)
Annual Coal Production (2012)	0.080	0	0.080	58 (0.088%)

Source: EIA (2014)

Figure 18-1. The Only Underground Coal Mine in Italy

Source: IEA Clean Coal Center (2005)

18.1.2 STAKEHOLDERS

Table 18-2 lists potential stakeholders in Italy's coal mine methane (CMM) industry. SOTACARBO, a 50-percent state-owned company, has joined Carbosulcis in promoting methane recovery from the Sulcis Basin. SOTACARBO partners with University of Caligari and the Istituto Italiano di Geofisica e Vulcanologia (INGV).

Table 18-2. Key Stakeholders in Italy's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies and CBM Developers	▪ SOTACARBO ▪ Kimberley Oil ▪ Carbosulcis ▪ European Gas Limited ▪ Heritage Petroleum ▪ Independent Resources plc ▪ Vico Indonesia (Eni S.p.A. subsidiary) ▪ Shell ▪ Future Corporation Australia ltd	Project hosts
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities, Research Establishments	▪ The Istituto Italiano di Geofisica e Vulcanologia ▪ University of Caligari ▪ National Institute for Geophysics and Vulcanology	Technical assistance
Government Groups	▪ Ministry of Productive Activities – Directorate for Energy and Mineral Resources ▪ Ministry of Environment, Environment, Land and Sea ▪ Energy Authority (Autorità per l'Energia Elettrica e il Gas, AEE)	Licensing, Monitoring and Control

18.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Carbosulcis' Miniera Monte Sinni is currently the only operating coal mine in Italy, and its concession is owned by the Regional Government of Sardinia (M2M, 2005). Like other European countries, however, coal production will be phased out per European Union (EU) directives. The Santa Barbara mine in Tuscany, Italy's single source of lignite, closed in 2003 after production declined sharply from 156 thousand tonnes in 1998 to an estimated 10 thousand tonnes in 2002. The mine was previously operated by Enel (Ente Nazionale per l'energia Elettrica), the state-owned electricity company (USGS, 2002; USGS, 2003).

Italy's EU membership has initiated privatization of the country's energy sector. Ente Nazionale Idrocarburi (ENI), the state-held oil and gas giant, and Enel became joint-stock companies in 1992. The state sill has a 30 percent stake in each company. Consequently, several new participants have emerged in Italy's energy markets this past decade, and both companies have an international presence (ENI, 2014; ENEL, 2013).

Italy is the fourth highest consumer of energy in Europe, with consumption at 7.5 quadrillion Btu in 2011 (EIA, 2014). Fueled by the rising demand for power, Italy has increased its dependence on coal for power generation over the past decade. But consumption has recently plateaued as natural gas use has expanded, and Italy currently relies on coal for only 9 percent of its overall energy needs (EIA, 2014). Planned coal mine and power plant projects have been abandoned in some cases due to political and administrative barriers (USGS, 2007).

18.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Italy, in operation or under development (GMI, 2014). Updates on future CMM projects in Italy can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

18.2.1 CMM Emissions from Operating Mines

Methane emissions in Italy totaled 2.1 million cubic meters (m^3) in 2000, but are projected to decrease to 1.4 million m^3 by 2015, and then remain stable through 2030 (see Table 18-3).

Table 18-3. Italy's Projected CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	2.1	1.4	1.4	1.4

Source: USEPA (2012)

18.2.2 CMM Emissions from Abandoned Coal Mines

There are no current CMM recovery projects in Italy.

18.2.3 CBM from Virgin Coal Seams

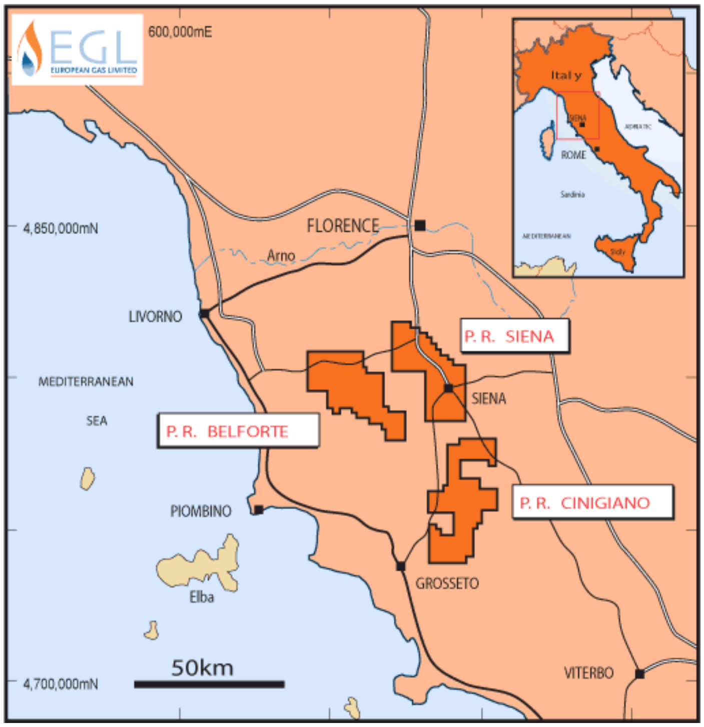
Key companies involved in coal bed methane (CBM) exploration in Italy include European Gas Limited (formerly known as Kimberley Oil NL) and Heritage Petroleum. They have targeted the Sulcis Basin as well as three areas in southern Tuscany. Nearby volcanic centers and geothermal activity in these locations are believed to have created high concentrations of gas (Heritage Petroleum, 2007).

The Sulcis Basin is estimated to have as much as 1,000 Mmt of sub-bituminous coal from the Eocene age. Along with a 150-m thick coal sequence, substantial thicknesses of impure coal and carbonaceous shale also exist, which have the capability to generate significant methane aside from the coal seams. Although coal mining in the eastern region did not indicate much methane, the geological conditions are different in the western region, suggesting significant gas reserves. The Porduttivo formation in the west is overlain by the Oligocene-Miocene volcanic centers. Geothermal activities from this condition would lead to strong maturation of coal seams and high concentrations of gas (Heritage Petroleum, 2007).

Also, SOTACARBO has partnered with Carbosulcis and University of Caligari to promote CBM production. Their main activities include sampling and analyzing Sulcis coal, finding new deeper coal seams, checking the use of CBM methods currently in place in the region, and updating enhanced CBM technologies.

Meanwhile, European Gas Limited and Heritage Petroleum have been granted three research permits in Tuscany (Figure 18-2). These permits cover 1,500 km^2 of three basins containing Miocene coal. Mining in this area was discontinued in 1959 due to a methane gas explosion that killed 42 people. As with the Sulcis Basin, it is believed that geothermal activities and enhanced heat flow in the area have created conditions for high levels of methane production (Heritage Petroleum, 2007; EGL, 2010).

Figure 18-2. European Gas Limited's Tuscany Projects



Source: EGL (2010)

18.3 Opportunities and Challenges to Greater CMM Recovery and Use

Italy is an Annex I partner under the Kyoto Protocol (see Table 18-4) and has agreed to reduce its carbon dioxide emissions by 2008-2012. However, it will do so as a collective target for all the EU countries. Under EU commitment, Italy must reduce its emissions by 6.5 percent below the 1990 level. However, Italy is not on track, unlike other EU countries, to meet its pledge. During the 2009 UNFCCC Copenhagen Conference, the EU community, speaking through the European Commission, pledged to reduce emissions 20 percent unconditionally by 2020. They further pledged a 30 percent cut by 2020 if an international accord was reached (EC, 2009).

Table 18-4. Italy's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 5, 1992	April 15, 1994
Kyoto Protocol	April 29, 1998	May 31, 2002

Source: UNFCCC (2014)

In 2007, the Italian Ministry for the Environment and Territory produced the *Environmental Action Strategy for Sustainable Development in Italy*, aimed at helping Italy comply with greenhouse gas reduction targets under the Kyoto Protocol. However, this document has not been formally adopted by the Italian government. It also does not address energy-related greenhouse emissions, including CMM (UN, 2007).

18.3.1 Market and Infrastructure Factors

Currently, Italy is pursuing several technical issues related to CMM recovery. Developing an effective methane survey system and analysis models for recovery of CMM from the Sulcis Basin is the top priority. Improving gas drainage, identifying CMM utility and measuring emissions at surface mines are among other issues facing Italy. In general, Italy is not prepared for CMM projects in terms of public attitude, R&D efforts, or private financing. The country will benefit by networking with countries with advanced CMM experience.

Italy's natural gas market is highly evolved, providing for about 40 percent of the total energy consumed by the country (IEA, 2009a). Therefore, Italy has a well-established network of pipelines extending for 30,000 km—the third largest pipe network in Europe—and offers open access. As of now, Sardinia is not connected to this gas transportation system but that will soon change with the anticipated Galsi project: a gas pipeline that would transport natural gas from Algeria to Sardinia. With a capacity of approximately 8 billion m^3 per year, the Galsi pipeline will be approximately 830 kilometers long, 270 of which will be on Sardinian territory (ABO, 2014). This would be strategic for implementing CBM marketing in Italy, since the Sulcis Basin in southern Sardinia is the most promising site for CBM.

18.3.2 Regulatory Information

Italy's energy and natural resources policies allow both government and private companies to operate production. Companies may be given concessions that need periodic renewal to recover methane or mine coal. For a given coal basin, mining coal and draining methane can be executed by separate companies.

The CMM recovery work is still in its infancy in Italy, and the country lacks legal regulation for the CMM industry. An extension of the natural gas legal framework may, therefore, apply. ENI has been controlling the gas industry almost completely. But, since 2000, the gas industry is slowly being liberalized in compliance with the EU policies, including freeing of gas prices and decentralizing production and distribution. Italy still has the state involved in response to public opinion. There is no domestic private investment, but foreign private sector investments are involved (EIA, 2008).

All natural resources are owned by the government. Licenses may be given at discretion to private companies for exploration and production; terms of such deals appear open for negotiation. An exploration permit is granted for six years and has to be renewed twice, every three years. A production license runs for 20 years and is renewable. For a license to be granted, the company at hand must possess local knowledge. Royalties are set at 7 percent of the annual net production and the corporate tax rate is set at 34 percent.

Italy is gradually defining stronger environmental regulations, not only to be in compliance with EU standards, but also to respond to domestic opinions. The legal text of EU's environmental laws is in the process of being incorporated into Italian law (EIA, 2008). Contributing to sustainable development, the CMM project outputs (electricity and pipeline gas) may enjoy competitive pricing in a free trade market.

18.4 Profiles of Individual Mines

Sulcis Basin, Sardinia

General Information

Total mineable reserves, million tonnes	50 (EIA, 2014)
Total mining area	615 km^2
Depth of shafts	400 m
Mining capacity	400,000 tonnes/year

Geologic and Mining Conditions

Rank of coal	Sub-bituminous coal
No. of seams	Up to 13
Seam thickness	35 to 40 m cumulative thickness over 13 seams
Depth of mining	150 m
Calorific Value	5,000 kcal/kg
Ash content	Poor quality
Sulfur content	Poor quality
Mining equipment	Longwall

Source: Heritage Petroleum (2007); IEA (2009b)

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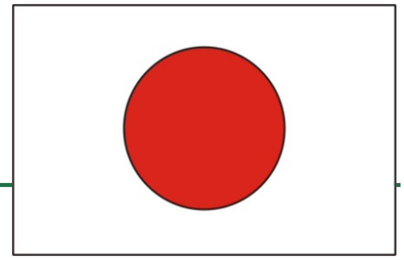
19 Japan



19.1 Summary of Coal Industry

19.1.1 Role of Coal in Japan

Coal accounted for 23 percent of Japan's total energy consumption in 2012 (EIA, 2014a). However, Japan does not have any active coal mines (domestic production ended in 2002) and now imports 100 percent of its coal. For three decades, Japan was the world's largest importer of coal. In 2012, Japan was surpassed by China as the world's largest importer of coal. Japan now accounts for about 15 percent of total world coal imports, primarily from Australia (EIA, 2014a). Sources of imported thermal and coking coal are Australia, Canada, China, Colombia, Indonesia, Mongolia, Russia, and the United States; South Africa is also a source of thermal coal, while New Zealand is an additional source of coking coal (IEEJ, 2012). While Japan does not have any active coal mines at this time, it operated as much as 600 coal mines in the 1960s (M2M, 2005). Its total coal reserves are estimated at 347 million tonnes (Mmt) (Table 19-1) and lie primarily on the Hokkaido and Kyushu islands (see Figure 19-1 on next page).

Table 19-1. Japan'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)	336	11	347	38 (0.039%)
Annual Coal Production (2012)	0	0	0	NA

Source: EIA (2014b)

19.1.2 Stakeholders

Table 19-2 identifies potential stakeholders in Japanese coal mine methane (CMM) development.

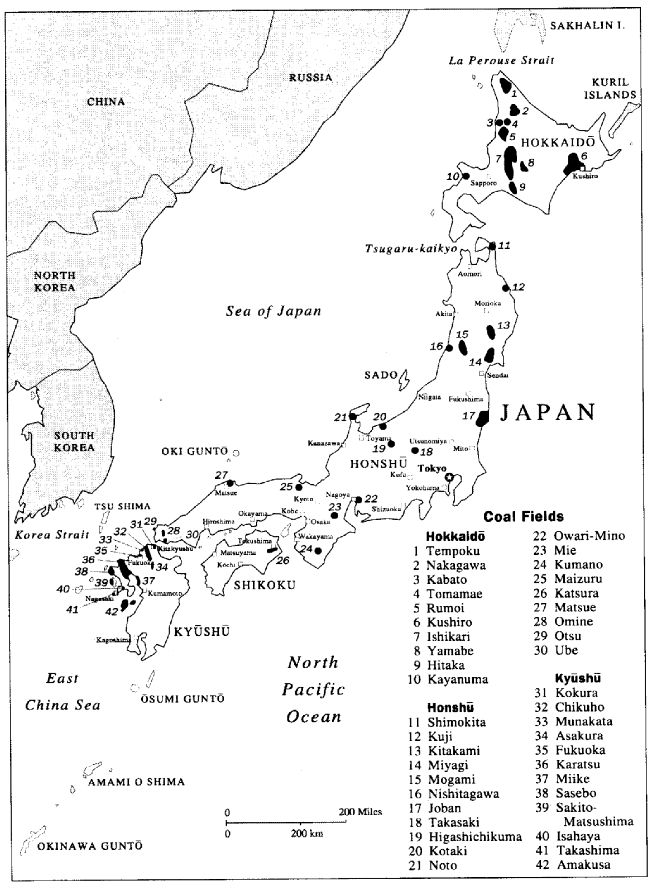
Table 19-2. Key Stakeholders in Japan's CMM Industry

Stakeholder Category	Stakeholder	Role
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Government Groups	▪ Ministry of Economy, Trade, and Industry ▪ Environment Management Bureau – Ministry of the Environment	Permitting, outreach efforts

Table 19-2. Key Stakeholders in Japan's CMM Industry

Stakeholder Category	Stakeholder	Role
Other	▪ Japan Bank for International Cooperation ▪ New Energy and Industrial Technology Development Organization ▪ Japan Coal Energy Center ▪ Macquarie Bank Limited ▪ Mitsui Mining Co. ▪ Mitsubishi Materials Co. ▪ Mizuho Corporate Bank, Ltd.	Finance providers, development assistance providers, carbon credit purchasers

Figure 19-1. Japan's Coal Fields



Source: Schwochow (1997)

19.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Japan's coal industry has declined steadily in the last 50 years. In the 1960s, Japan had about 600 coal mines and produced about 55 Mmt of coal annually. Due to competition with coal imports, production declined to about 3.5 Mmt in 2001 (EIA, 2014b). Production ceased entirely in January 2002 with the closure of the last remaining Kushiro coal mines (EIA, 2008).

19.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database identifies two projects in Japan at abandoned mines as described in Section 1.2.2 (GMI, 2014). Updates on future CMM projects in Japan can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

19.2.1 CMM Emissions from Operating Mines

Methane emissions in Japan totaled 53.9 million cubic meters (m^3) in 2000, but are projected to decrease significantly to 3.5 million m^3 by 2015, and then only rise slightly to 4.2 million m^3 by 2030 (see Table 19-3).

Table 19-3. Japan's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	53.9	4.9	3.5	3.5

Source: USEPA (2012)

19.2.2 CMM Emissions from Abandoned Coal Mines

Two CMM use projects that were operating at abandoned coal mines in Japan in the early 2000s have since closed (M2M, 2006).

19.2.3 CBM from Virgin Coal Seams

There is no commercial development of coalbed methane in Japan at this time.

19.3 Opportunities and Challenges to Greater CMM Recovery and Use

Under the Kyoto Protocol, Japan pledged to reduce its national greenhouse gas (GHG) emissions by 6 percent in the period 2008 to 2012, relative to base year 1990 (UNFCCC, 2003). Table 19-4 summarizes Japan's climate change mitigation commitment. It further pledged to cut GHG emissions 25 percent below 1990 levels by 2020 during the 2009 Copenhagen United Nations Climate Change Conference (UNFCCC, 2009).

Table 19-4. Japan's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	May 28, 1993 (Acceptance)
Kyoto Protocol	April 28, 1998	June 4, 2002 (Acceptance)

Source: UNFCCC (2014)

In November 2013, at the U.N. climate talks in Warsaw, Poland, Japan announced plans to scale back its commitment to reducing GHG emissions from 25 percent below 1990 levels to 3.8 percent below 2005 levels (representing a 3.1 percent *increase* from 1990 levels). This decision, known as The Warsaw Target, was made in large part due to the fact that all of Japan's 50 nuclear reactors, which produced about 30 percent of Japan's electricity, were shut down for safety inspections following the March 2011earthquake. As of late 2013, Japan's nuclear power generation capacity was entirely removed from service (EIA, 2014a). The Warsaw Target, therefore, assumes no nuclear power generation and aggressive GDP growth. The target is tentative, however, and will likely be revised based on future reviews. Japan's long-term commitment to reduce emissions to 80 percent below 1990 levels by 2050 still stands (WRI, 2014).

19.3.1 MARKET AND INFRASTRUCTURE FACTORS

Japan has developed considerable technical resources to develop CMM, including high efficiency CMM recovery and power generation systems, well-developed town gas systems for subsidence areas in coal mining regions, and technologies for dimethyl ether production from CMM (M2M, 2005).

Financing for CMM projects could potentially be acquired through the Japan Bank for International Cooperation (JBIC). JBIC has been increasing financing for projects that address global environmental problems, including global warming and environmental projects, such as those aimed at reducing pollution. JBIC's Official Development Assistance loans give preference to projects that support environmental efforts in developing countries. For example, JBIC is supporting a CMM recovery project in Shanxi province, China. The project has been developed to qualify as a Clean Development Mechanism project; Japanese firms are expected to purchase carbon credits generated from the project (JBIC, 2007).

19.3.2 REGULATORY INFORMATION

Japan lacks specific regulations for CMM industry and gives CMM ownership rights to coal mine owners. The Mining Law provides a basic system that governs mining of mineral resources, while the Mine Safety Law addresses mine safety issues and promotes the safe development of the mineral resources.

19.4 Profiles of Individual Mines

No information profiling individual underground mines in Japan was found.

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20 Kazakhstan

20.1 Summary of Coal Industry

20.1.1 Role of Coal in Kazakhstan

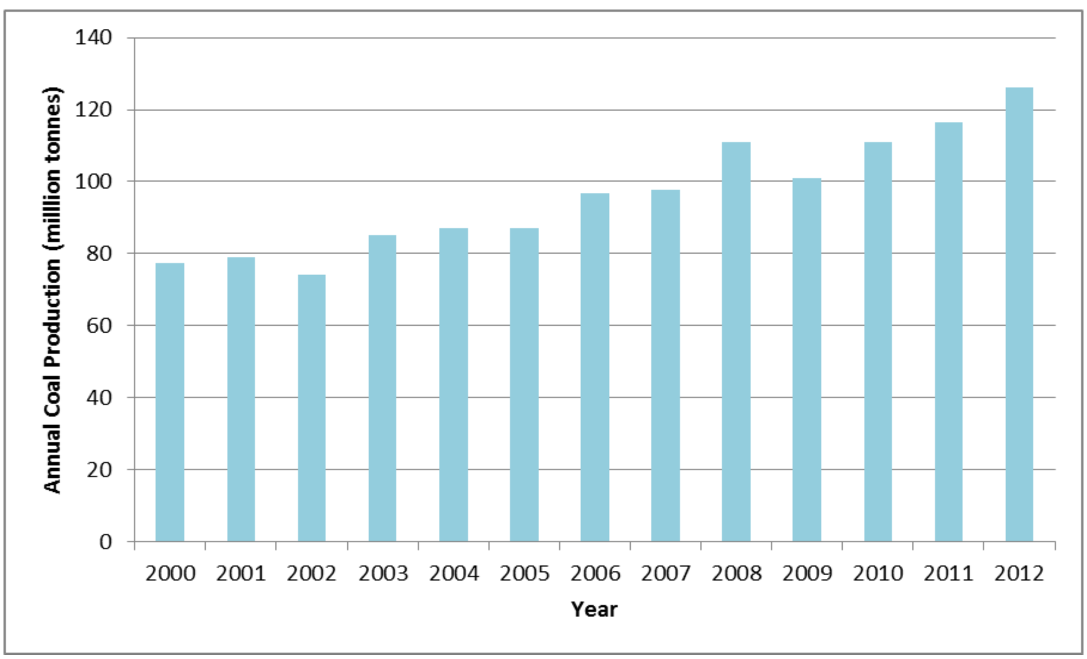
Kazakhstan ranks 10th in the world in coal production, with coal comprising 64 percent of its total energy consumption in 2012 (EIA, 2013). In 2012, it exported 25.3 percent of the coal produced (32 million tonnes [Mmt]), primarily to Russia and Ukraine. In 2011, 85 percent of power generation was coal-fired and net generation totaled approximately 81.2 billion kilowatt-hours (kWh) of electricity (EIA, 2013). Table 20-1 summarizes Kazakhstan's coal resources and recent production, while Figure 20-1 shows historical annual coal production from 2000 to 2012 (EIA, 2013).

Table 20-1. Kazakhstan'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)	21,496	12,097	33,593	8 (3.78%)
Annual Coal Production (2012)	120.5	5.5	126	10 (1.6%)

Source: EIA (2013)

Figure 20-1. Kazakhstan Annual Coal Production



Source: EIA (2013)

Kazakhstan has registered 49 coal deposits in its state reserve balance (USGS, 2010). The main producing regions are located in the central and northern regions of Kazakhstan in the Ekibastuz, Karaganda, Maykuben, Shubarkol and Turgay basins (Table 20-2).

Table 20-2. Kazakhstan's Major Coal Basins Production Capacity in 2012

	Basin				
	Ekibastuz	Karaganda	Maykuben	Shubarkul	Zhelyn
Annual Estimated Production Capacity (million tonnes)	67.3	35.4	4.0	8.9	1.0

Source: USGS (2011)

20.1.2 Stakeholders

Thirty-three companies operate coal mines in Kazakhstan, including 28 of domestic origin, five foreign companies and one joint venture (Energy Charter Secretariat, 2013). The major companies are listed in Table 20-3. The table also lists other potential stakeholders in Kazakhstan's coal mine methane (CMM) industry.

Table 20-3. Key Stakeholders in Kazakhstan's CMM Industry

Stakeholder Category	Stakeholder	Role
Coal Producing Enterprise	▪ JSC ArcelorMittal Termirtau ▪ Bogatyr-Access-Komir, Ltd. ▪ OJSC "Eurasian Natural Resources Corporation" ▪ OJSC "Borly" ▪ "Maykuben-West" joint venture ▪ KomirInvest, Ltd. ▪ Transenergo, Ltd. ▪ "Gefest" Association ▪ Shubarkol Komir	Project hosts
Developer	▪ ZhumysStroiService LLP ▪ KazTransGas JSC ▪ Social enterprise company Saryarka ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity (CBM from virgin seams) identification and planning
Engineering or Consultancy Services	▪ Azimut Energy Services, Ltd. ▪ Promelektronika-K LL C. ▪ Kar-Metan LL C. ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities and Research Centers	▪ Methane Center, Kazakhstan ▪ Karaganda State Technical University ▪ Karaganda Institute for Scientific Research on Industrial Safety	Technical assistance
Other	▪ National Agency for Technological Development ▪ Zhasyl Damu state company (emissions trade system) ▪ National Geological Exploration Company "Kazgeologiya" (assessment of CMM/CBM resources)	

Table 20-3. Key Stakeholders in Kazakhstan's CMM Industry

Stakeholder Category	Stakeholder	Role
Government Groups	▪ Ministry of Energy (absorbed functions of former Ministry of Industry and New Technologies, Ministry of Oil and Gas, Ministry of Environment and Water Resources) ▪ Ministry of National Economy ▪ Ministry of Investment and Development (geology and energy efficiency) ▪ Kazakh Scientific Research Institute for Ecology and Climate (KazNIIEC)	Drafting of legislation, implementation of laws, government oversight

Source: KazNIIMOSK (2002); Energy Charter Secretariat (2013); Alekseev (2010)

20.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Kazakhstan's coal mining industry was restructured and largely privatized between 1995 and 1997 (State, 2005). The Karaganda and Ekibastuz mining associations were dissolved and the mines put up for sale or lease. Many of the coal mining enterprises were closed or reorganized (USGS, 2010; KazNIIMOSK, 2002).

Coal production in Kazakhstan declined by more than 50 percent in the years following independence from the Soviet Union in 1991 through 1999 (BP, 2013). Since then Kazakhstan's coal production has continued to increase with 2012 yielding production comparable to the Soviet times (EIA, 2013). During the Soviet era, coal production was subsidized and mines were not structured to maximize profits. When subsidies were removed and mines had to operate competitively, it became extremely difficult to obtain foreign investment to maintain their economic viability. This fundamental lack of profitability was compounded by other problems, such as restructuring, mine problems, and accidents. Government efforts to significantly improve production by 2015, by encouraging foreign interest in the coal mining industry, appear to have been successful. Since the low point in 1999, annual production has steadily increased to rates above 100 million tonnes, although the world-wide economic downturn in 2009 also affected Kazakhstan coal production with a resultant 8.6 percent decline in production from 2008, but rebounded to a 13.4 percent increase from 2008 to 2012. Consumption has risen steadily since 2000 with exports remaining relatively steady since 1999 (EIA, 2013).

Underground mining only occurs in the Karaganda basin, which produces the coking coals essential to the steel and iron sectors and coke plants in Kazakhstan, Russia, Ukraine, and Georgia, and also to the phosphoric and ferroalloy industries. The share of production from underground mines decreased from about 27 percent in 1990 to just 11 percent in 2000 (KazNIIMOSK, 2002), and back up to 30 percent in 2010 (Alekseev, 2010), following new investment from companies such as the ArcelorMittal Group (USGS, 2010). The ArcelorMittal Coal Division operates eight underground mines in the Karaganda Basin producing 12 Mmt annually (Baimukhametov, 2009). Twenty-six underground mines were reportedly in operation in 1990 (KazNIIMOSK, 2002) with fifteen now currently producing (Energy Charter Secretariat, 2013). Four mines operated by KomirInvest and Transenergo have nearly stopped production. ArcelorMittal's eight underground mines (originally operated by Ispat-Karmet) were expanded in 1986 to stabilize production levels. The Gefest Association also operates in the Karaganda Basin as the association of small mines. By 2007, the Association represented about 30 mines with approximately 1 Mmt per year of combined coal production (UNECE, 2008). For example, the Association represents Mine Batyr, an underground mine in the Karaganda Basin.

Table 20-4 provides mine statistics for Kazakhstan.

Table 20-4. Kazakhstan Mine and Production Statistics

Type of mine	Production (million metric tonnes)	Number of major mines*
Underground (active)	31.5 (2009)	15 in Karaganda Basin
Surface (active)	69.9 (2009)	6 total: 3 mines in the Ekibastuz Basin - Bogatyr, Severny, Vostochny (80% of surface production) 3 others - Borlinskoe deposit, Maykuben Basin, Karaganda Basin (15-20% of surface production)

*Note these figures represent the largest mines. The total number of mines operating in Kazakhstan is 35 (24 underground mines and 11 open pit mines (Energy Charter Secretariat, 2013)

Sources: Alekseev (2010); EOK (2010)

20.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies two CMM projects. One is operating at the Kazakhstanskaya underground mine in the Karaganda basin. The methane currently drained from the mine is being used for boiler fuel in five neighboring mines (GMI Projects, 2014). The mine is planning an expansion of its degasification systems by 8.5 kilometers (km) along with the installation of three KVTS-10 boilers utilizing 13 million m^3 methane per year. Current coal production is 1 million tonnes per year (Mmt/y) with plans to increase production to 1.8 Mmt/y by 2012. The second project is power generation from CMM at the Lenina mine (1.4 MW CHP). In 2013, the CHP unit produced 5 million kWh, operating at 40 percent availability (Baimukhametov, 2014).

20.2.1 CMM Emissions from Operating Mines

The Kazakh coal mines are particularly gassy and prone to violent gas outbursts, and must be degasified and ventilated to prevent explosions and promote worker safety. The underground mines in the Karaganda basin use a variety of pre-mining and post-mining methane drainage techniques. Most of the mines are operated at a depth of more than 500 m and gas contents in these mines average between 18-24 m^3/tonne (Baimukhametov et al, 2009) with specific emissions averaging 33 m^3/tonne (KazNIIMOSK, 2002). Pre-drainage has historically been carried out using in-seam boreholes. Advance degassing from the surface has been trialed with limited success because of the low permeability of the coal seams. The ArcelorMittal Temirtau Coal Division has had recent success in increasing degasification rates, and hence coal production rates, by drilling cross-measure boreholes from a roadway driven 8-12 m below the coal seam. Gob gas is drained with vertical wells from the surface or via galleries driven 20-30 m above the seam (Baimukhametov et al, 2009).

Current drained methane emissions are estimated to be approximately 130 million m^3 resulting from increased underground coal production rates (Alekseev, 2010), However, the level of methane utilization is very low, only about 25 million m^3 annually, which is recovered and combusted in the boiler houses of five mines for mine heating. Surface mines are heavily ventilated and ventilation air with methane concentrations of about 1 percent is vented to the atmosphere (KazNIIMOSK, 2002).

CO_2 emissions from coal mining related activities in 2010 were 1,507 million m^3 (USEPA, 2012). Coal mining related activities were 12.5 percent of the total 12,075 million m^3 of CO_2 emissions released from the consumption of energy in 2010 (EIA, 2013).

Table 20-5 details Kazakhstan's measured and estimated CMM emissions. The data in this table may vary from the USEPA data presented in the Executive Summary due to differences in inventory methodology and rounding.

Table 20-5. Kazakhstan's CMM Emissions (million cubic meters)

Emission Category	**2000**	**2005*** (estimated assuming breakdown from 2000)	**2010*** (estimated assuming breakdown from 2000)	**2015** (projected)
Underground coal mines – ventilation emissions	286.23	472.3	601.8	
Underground coal mines – drained emissions	41	67.7	86.2	
Post-underground emissions	8.0	13.2	16.8	
Surface mine emission	381	628.7	801	
Total liberated (= sum of all above)	716.23	1,182	1,506	1,629.4*
Recovered & Used	12.2		25**	
Total emitted (= Total liberated – recovered & used)	704.03	467	955**	

Sources: KazNIIMOSK (2002); *USEPA (2012); **Shultz & Alekseev (2010)

20.2.2 CMM Emissions from Abandoned Coal Mines

At least 16 underground coal mines in Kazakhstan have been abandoned since 1995. All are considered gassy and every abandoned mine is classified as a high hazard for coal and gas outbreaks. Starting in May 2001, measurement and data processing for gas drain pipes at abandoned shafts, pit-holes, and boreholes have been implemented at 12 abandoned mines in the Karaganda and Abay-Shakhtinsk districts, some abandoned before 1995. In total, approximately 3,000 measurements of methane flow rate and concentration are taken each year and have proven useful in understanding methane released during and after coal mining.

After abandonment some mines have been sealed better than others, thus resulting in varying methane release rates. For example, the "50 Years of October Revolution" mine, which was abandoned in 1998, has the highest methane content of any of the abandoned mines due to being well-sealed both at the surface and between old connections in the underground mine area. No specific information about methane recovery projects at abandoned mines is available but analysis is being conducted to evaluate utilization options for an AMM project at the "50 Years of October Revolution" mine (EU, 2009).

20.2.3 CBM FROM VIRGIN COAL SEAMS

According to the Ministry of Energy and Mineral Resources, Kazakhstan's CBM resources are some of the highest among the coal basins of the world, as illustrated in Table 20-6.

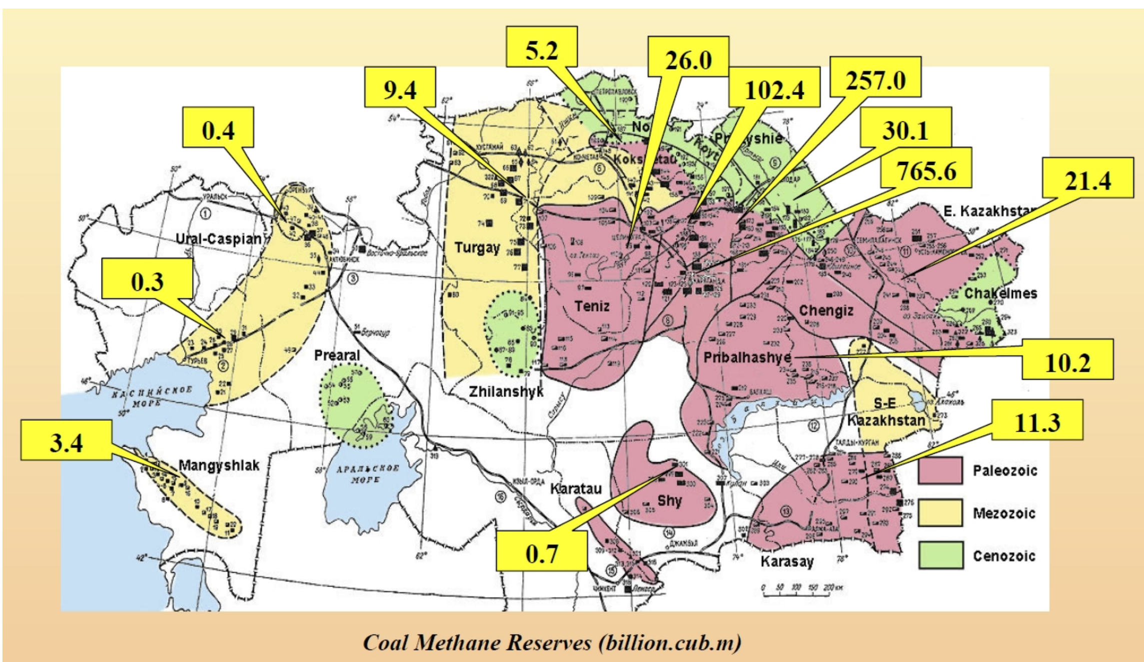
Table 20-6. Summary of Kazakhstan's Selected CBM Resources

Basin or Field	CBM Resources (est.) (billion cubic meters)
Karaganda Basin	550 – 750
Ekibastuz Basin	75 – 100
Zavialov Field	14.6 – 16.8
Samarskiy Field	11.0 – 14.2

Source: Stoupak and Zhukovskiy (2001)

Kazakhstan is one of the few countries actively pursuing to initiate commercial CBM production. Figure 20-2 shows Kazakhstan's coal regions with estimated methane reserves for each region.

Figure 20-2. Kazakhstan Coal Regions and Coal Methane Reserves



Source: Alekseev, et al. (2003)

Zhumys-Stroyservice LLP was awarded a CBM license in 2008 and proceeded with a pre-feasibility assessment (by Schlumberger) and drilled a few pilot wells with a minor gas yield reached so far. Zhumys-Stroyservice, announced (May, 2010) an agreement with the Australian company Arrow Energy Ltd., to perform a feasibility study on the commercial production of CBM in the Karaganda coal basin. Funding would be provided by Arrow Energy with plans for a pilot project to be launched in 2014 (SteelGuru, 2010).

In April 2003, the former Ministry of Energy and Mineral Resources recommended that BogatyrAccess Komyr, Ltd. and Azimut Energy Services, Ltd. pursue a CBM development effort in the Ekibastuz basin. However, the project was ultimately suspended.

20.3 Opportunities and Challenges to Greater CMM Recovery and Use

Kazakhstan is a signatory to both the UNFCCC and the Kyoto Protocol (see Table 20-7). Kazakhstan applied for Annex I status in June 1999, withdrew its application in June 2000, but finally ratified the Protocol in March 2009. With Annex I status obtained, new CMM projects in Kazakhstan are eligible to earn and sell emission reduction credits through the Clean Development Mechanism. Until Kazakhstan is a member of Annex B, their domestic emissions trading system can only affect their domestic market (EDF, 2014). Kazakhstan is currently awaiting status as an Annex B country. Investment for CMM projects could also come from the National Innovation Fund, mine operators, and foreign investors (Zhasyl Damu 2014).

Table 20-7. Kazakhstan's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 8. 1992	May 17, 1995
Kyoto Protocol	March 12, 1999	March 26, 2009

Source: UNFCCC (2014)

The Kazakh Emissions Trading Scheme (ETS) was enacted into law on December 3, 2011, through an amendment to the country's "Ecological Code" (IETA, 2013). In January 2013, the ETS was launched for a one year pilot phase. The program entered its second, two-year phase in January 2014. According to reports, the first allowance transaction took place on 28 March 2014, trading at the price of 455 Tenge (about $2.60) (ICAP, 2014). The Government of Kazakhstan expects about 180 large GHG emitters (mainly industrial enterprises) to be covered under the new environment code starting in 2015. The first official trading session in early 2014 generated a carbon price of USD2.50/tCO2e (Zhasyl Damu 2014). Kazakhstan is also working on a domestic offset system for specific sectors and gases (e.g. CH4) not covered by the scheme.

Reports are that international credits may be allowed in the future, subject to approval of the KAZ CP2 (ICAP, 2014).

20.3.1 Market and Infrastructure Factors

Opportunities to develop the country's coal bed methane (CBM) and CMM resources are a potentially significant source of investment, and Kazakhstan is working to establish an attractive investment climate. The Kazakhstan government prioritizes CMM projects as a means of achieving measurable and verifiable greenhouse gas emission reductions. Recently the government approved proposals for establishing criteria and procedures for screening, review, and approval of GHG emission reduction projects. It also approved similar proposals relating to baseline assessment and validation; emission reduction calculation; monitoring, verification, and registering emission reduction projects; and allocating 5 million metric tons of CO_2 equivalent ($MMTCO_2e$) for transfer to investors in GHG reduction projects. As a next step, the government will promulgate regulations (USEPA, 2005).

Kazakhstan will require significant infrastructure investments to commercialize CBM and CMM development. Gas gathering systems will be required as well as interconnects with distribution pipelines. Some synergies may be available with rapidly developing gas production associated with expanding oil production. Kazakhstan produced 1.4 Tcf of natural gas in 2011. Between 2008 and 2010 Kazakhstan produced sufficient volume of dry gas to satisfy its domestic demand, although increased domestic consumption resulted in Kazakhstan becoming a net gas importer again in 2011 (EIA, 2013). Production has been growing at 22 percent annually over the last decade, compared to consumption growth of 9 percent annually, and Kazakhstan is, therefore, expected to become a net exporter of gas within the next few years. Current and proposed major gas distribution pipelines are routed mainly in the west and south of the country and so opportunities for local CMM/CBM projects in the central and northern coal-fields may arise as a result of proximity to underserved markets in these areas. Regional gas demands are increasing, especially from neighboring China, suggesting adequate markets for all methane that can be produced. Possible end uses for recovered methane include industrial boilers, power generation, heating, and transportation fuel (for fleets and private vehicle conversions).

In 2005, 14,609 million KZT was invested in the mining industry. A large portion of those investments, 5,998 million KZT, went into coal production and improvement (CMAR, 2006). In 2007, the ArcelorMittal Group pledged to invest 500 million USD to increase coal production in the Karaganda region by around 5 Mmt. These large investments in the nation’s coal production could lead to increased CMM development projects.

20.3.2 Regulatory Information

The Government owns all subsurface gas and minerals but has allocated coal reserves to private mine operators as part of their contracts and CMM to contracted coal operators. CMM and CBM project developers must enter into agreements with the coal operators for development and sale of the gas resources (KMIC, nd). Upcoming petroleum legislation and provisional rules for exploration and development will provide a comprehensive and consistent legal framework for CBM exploration and exploitation. At this time, no legislation is in place which distinguishes CMM/CBM production from that of natural gas. When CMM is moved offsite of the mine, it is treated by the same rules and taxes that apply to natural gas. A recent law, “In Support of the Use of Renewable Energy Resources” introduced in July 2009, does not include references to CMM (Alekseev, 2010). Kazakhstan is in the process of developing a new mining code in which CBM and CMM are expected to be included.

Mining companies understand the safety issues and are becoming increasingly familiar with the environmental issues associated with CMM. Coal mine safety is a key concern in surface and underground mines - numerous deaths due to mine explosions and methane outbursts underscore the importance of this problem. Environmental legislation exists that require pollution permits and payment of pollution fines for coal mining activities. Environmental and safety standards are improving, but are also driving up development costs.

20.4 Profile of Individual Mines

Kazakhstanskaya Mine			
Mine Status	Active	**Operator/Owner**	ArcelorMittal Temirtau Coal Division
Mine Area	47 km^2	**Coal Basin**	Karaganda
Mining Method	Conventional Longwall	**Location**	Shakhtinsk District, 30 km west of the city of Karaganda
Reserves (coking coal)	103.4 Mt	**2011 VAM volume**	29.3 million m^3 per year
No. of seams mined	2 (D6 & D10)	**2011 Drained volume**	10.4 Mm^3/y
Depth of seams	650-700 m	**2009 Utilized volume**	7.8 Mm^3/y
		Utilization method	Boilers

Lenina Mine			
Mine Status	Active	**Operator/Owner**	ArcelorMittal Temirtau Coal Division
Mine Area	10.7 km^2	**Coal Basin**	Karaganda
Mining Method	Conventional Longwall	**Location**	Shakhtinskiy District, 60 km west of the city of Karaganda
Reserves (coking coal)	65.6 Mt	**2011 VAM volume**	38.1 million m3 per year
No. of seams mined	8 (D1-D11)	**2011 Drained volume**	24.3 Mm3/y
Depth of seams	650 - 700 m	**Utilization method**	Boilers, Power Generation

Abaiskaya Mine			
Mine Status	Active	**Operator/Owner**	ArcelorMittal Temirtau Coal Division
Mine Area	34.45 km^2	**Coal Basin**	Karaganda
Mining Method	Conventional Longwall	**Location**	Abai District, 35 km from the city of Karaganda
Reserves (coking coal)	81.6 Mt	**2011 VAM volume**	25.9 million m^3 per year
No. of seams mined	6 (K18, K13, K12, K10, K11, K7)	**2011 Drained volume**	44.3 Mm^3/y
Depth of seams	549 m	**Utilization method**	Boilers

Tentekskaya Mine			
Mine Status	Active	**Operator/Owner**	ArcelorMittal Temirtau Coal Division
Mine Area	71.47 km^2	**Coal Basin**	Karaganda
Mining Method	Conventional Longwall	**Location**	Shakhtinskiy District, 60 km from the city of Karaganda
Reserves (coking coal)	134.9 Mt	**2011 VAM volume**	12.8 million m^3 per year
No. of seams mined	2 (D6 & T1)	**2011 Drained volume**	10.1 Mm^3/y
Depth of seams	230-350 m	**Utilization method**	Boilers

More information about these mines of the Karaganda Coal Basin can be found at http://www.epa.gov/cmop/docs/Karaganda.pdf.

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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).

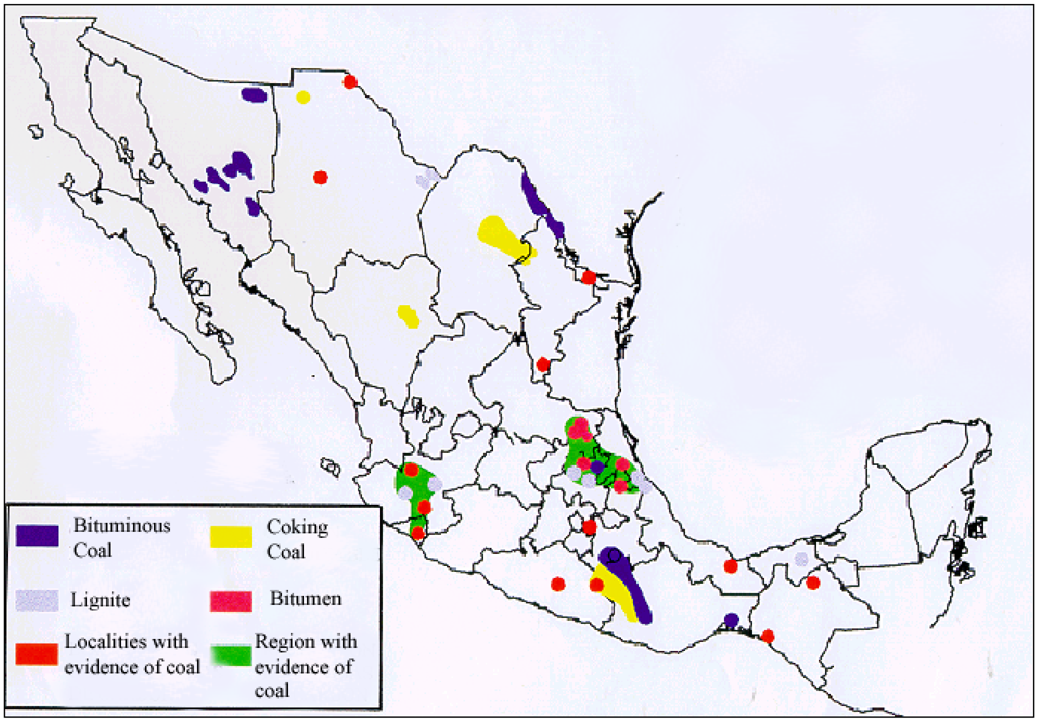
Table 21-1. Mexico's Coal Reserves and Production

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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22 Mongolia

22.1 Summary of Coal Industry

22.1.1 Role of Coal in Mongolia

Mongolia's energy needs are met primarily by coal, which accounts for 73 percent of total energy consumption (IEEJ, 2012). Mongolia presently ranks 22nd worldwide in production of coal. Coal production in Mongolia has seen a six-fold increase since 2000. Mongolia has been a net exporter of coal since 2005, exporting over 22 million tonnes (Mmt) in 2012 (EIA, 2014). Table 22-1 provides proven coal reserves and recent coal production data for Mongolia.

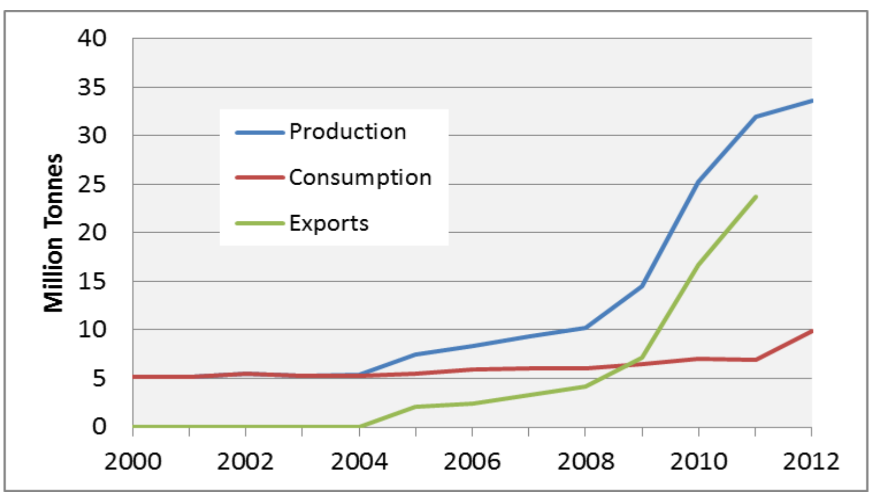
Table 22-1. Mongolia's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)			2,520 (12,200*)	19 (0.28%)
Annual Coal Production (2012)	23.6	9.98	33.6	21 (0.4%)

Sources: EIA (2014), *2008 estimate by Ganbaatar (2008)

Mongolia's coal consumption increased in recent years, from less than 6 Mmt in 2008 to almost 10 Mmt in 2012; however, as a result of decreased export demand and coal price declines, Mongolia experienced a slump in coal production in 2013. Figure 22-1 below shows Mongolia's production, consumption, and exports from 2000 to 2012.

Figure 22-1. Mongolia's Coal Production, Consumption, and Exports (million tonnes)



Source: Modified from EIA (2014)

Mongolia has estimated coal resources of 173.3 billion tonnes (MRAM, 2013) with proved coal reserves of 12.2 billion tonnes, including 2 billion tonnes of coking coal and 10.1 billion tonnes of thermal coal (IEEJ, 2012) in over 370 deposits and occurrences in 15 different basins (shown in Figure 22-2).

Table 22-2 summarizes the reserves found in major coal deposits of Mongolia.

Table 22-2. Coal Resources Found in Major Coal Deposits

Region	Coal Deposit	Estimated Resources (million tonnes)	Coal Rank	Coal Basin
Central Mongolia	Shivee Ovoo	563	Lignite	Choir-Nyalga
	Tevshiin Govi	588	Lignite	Choir-Nyalga
	Tugrugnuur and Tsaidannuur	2,000*	Brown	Choir-Nyalga
	Baganuur	511	Lignite	Choir-Nyalga
	Chandgan Tal	123	Lignite	Choir-Nyalga
	Khuut	87.5	Sub-bituminous	Middle Gobi
	Uvdug Khudag	159.2	Lignite	Middle Gobi
	Bayan Teeg	29.7	Bituminous	Ongyin Gol
	Sharyn Gol	61.3	Sub-bituminous	Orkhon-Selenge
	Ulaan-Ovoo	54	Sub-bituminous	Orkhon-Selenge
	Nalaikh	59	Sub-bituminous	Orkhon-Selenge
	Mogoin Gol	4.1	Bituminous	Orkhon-Selenge
	Saikhan-Ovoo	190**	Anthracite and Bituminous	Orkhon-Selenge
East Mongolia	Adduun Chuluun	241.3	Lignite	Choibalsan
	Tugalgatai	3,000*	Sub-bituminous	Choir-Nyalga
	Chandgana Tal		Lignite	Choir-Nyalga
	Talbulag	81.5	Lignite	Sukhbaatar
West Mongolia	Khushuut	300*	Bituminous and metallurgical	Mongol-Altai
	Zeegt	4.9	Bituminous	Mongol-Altai
	Nuurst Khotgor	143.3	Bituminous	Kharkhiraa
	Khar Tarvagatai	19.7	Bituminous	Kharkhiraa
	Uvurchuluut	3.8	Lignite and Sub-bituminous	South Khangai
South Gobi	Tavan Tolgoi	6400	Bituminous	South Gobi
	Baruun Naran	155*	Thermal and metallurgical	South Gobi
	Naryn Sukhait	220†	Bituminous	South Gobi
	Aman Gol	1,500	Sub-bituminous	South Gobi
	Ovoot Tolgoi	150*		South Gobi

Sources: MNEC (2014); *Ganbaatar (2008); Asia Coal Limited (2014); †MAK (2010)

Figure 22-2. Mongolia's Coal Basins

Source: Schwochow (1997), modified from Chimiddorj (1995)

22.1.2 STAKEHOLDERS

Table 22-3 identifies potential key stakeholders in coal mine methane (CMM) development in Mongolia.

Table 22-3. Key Stakeholders in Mongolia's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Aduunchuluun LLC ▪ Asian Coal Ltd. ▪ Aspire Mining Limited ▪ Baganuur JSC ▪ Bayanteeg LLC ▪ Chandganacoal LLC ▪ Chingisiin har alt LLC ▪ Energy Resources LLC ▪ Erdenes MGL ▪ Gobi Coal and Energy LLC ▪ Gobi Khurakh LLC ▪ Hunnu Coal ▪ Korea Resources Corporation ▪ Leighton LLC ▪ Macmahon Mongolia LLC ▪ Maral Michid Od LLC ▪ MoEnCo LLC ▪ Mongolyn Alt (MAK) Group ▪ Peabody Winsway Resources LLC	Project hosts

Table 22-3. Key Stakeholders in Mongolia's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies (con't)	▪ Prophecy Coal Corporation ▪ QGX Ltd. ▪ Red Hill Mongolia LLC ▪ Big Mogul Coal & Energy LLC ▪ Shivee Ovoo JSC ▪ South Gobi Resources ▪ South Gobi Sands LLC ▪ Tevshiin Gobi LLC ▪ Tsegeen Uuden LLC ▪ Tugrug Nuuriin Energy LLC ▪ Xanadu Mines Ltd.	Project hosts
Developers	▪ KOGAS	Project opportunity identification and planning
Engineering, consultancy, and related services	▪ Geomaster Engineering LLC ▪ MegaWatt Company Ltd. ▪ Center of Mongolian Mining Professional Engineers ▪ Sproule	Technical assistance
Universities, Research Establishments	▪ National University of Mongolia ▪ Mongolian University of Science and Technology ▪ Mongolian Technical University	Technical assistance
Regulatory Agencies and Government Groups	▪ Ministry of Mining ▪ Ministry of Nature, Environment, and Green Development ▪ Ministry of Energy ▪ Mineral Resources Authority ▪ Petroleum Authority ▪ Ministry of Economic Development ▪ Millennium Challenge Account – Mongolia	Project identification and assessment support
Non-governmental Organizations	▪ Mongolian Nature and Environment Consortium ▪ Mongolian National Mining Association ▪ Mongolian Coal Association ▪ Federation Of Energy, Geology And Mining Workers' Trade Unions Of Mongolia – MEGM	

Sources: Mongolian Mining Directory (2013) ; InfoMongolia (2014) ; UNFCCC (2014)

22.1.3 Status of Coal and the Coal Mining Industry

Mongolia produced more than 33 Mmt of coal in 2012 (Table 22-1), consuming only 10 Mmt and exporting the remainder. There are more than 30 surface (or open cast) mines in Mongolia, providing almost 99 percent of Mongolia's coal production. Domestic demand for coal is on the rise with increased power demand, which is expected to reach 1,375 megawatts (MW) in 2015 due to Mongolia's rapidly developing mining-based economy and urbanization acceleration. Mining companies account for 40 percent of Mongolia's total electricity consumption (Kohn, 2013). In 2009, it was reported that almost all of Mongolia's exported coal went to China (Liu, 2012). China has historically produced its own coking coal; however, growing demand for coking coal due to a rapid increase in steel production has led to demand for imports from Australia and Mongolia. In 2008, Mongolia supplied more than half of China's coking coal imports and maintained its position as top exporter until the first half of 2013, when Mongolia's exports of coking coal to China fell by 36 percent while Australia's doubled. As of late 2013, Mongolia's coal made up only 17 percent of

China's imports while Australia supplied 39 percent (Els, 2013). Despite the shorter distance to China's steel mills, Mongolian coal must be trucked to the Chinese border, increasing the cost compared to Australia's seaborne coal. As a result of decreased demand from China, as well as coal price declines, Mongolia experienced a slump in coal production in 2013.

It is expected that installation of a railway will increase the competitiveness of Mongolia's coal in China (Ng, 2013). In Mongolia, many of the more substantial deposits of proven coal reserves remain undeveloped due to the lack of infrastructure. Several infrastructure improvements are planned to accommodate an increase in coal mining as well as mining of other vast and valuable mineral reserves such as copper and gold. In October 2013, a consortium of Mongolian coal mining companies including Mongolia Mining Corporation, Erdenes Tavan Tolgoi, Energy Resources LLC and Tavan Tolgoi JSC as well as Chinese state-owned mining and energy company Shenhua Group Corporation Limited, signed a Memorandum of Understanding with the Mongolian Railway State-Owned JSC (MTZ) to construct a freight railway, primarily for transport of coking coal to China. The rail will connect the Gashuun Sukhait border point south of Tavan Tolgoi with the Ganqimoadu port in China (MMC, 2013a).

In November 2013, a 220-kV overhead transmission line connecting the South Gobi region mines Oyu Tolgoi (copper), Tavan Tolgoi (coal), and Tsagaan Suvarga (copper and molybdenum) and South Gobi region customers with Mongolia's Central Electricity System was completed (MCS, 2013). Additionally, World Bank's International Development Association is providing support to create infrastructure necessary for the development of natural resources (World Bank, 2014).

Mongolia's Ministry of Energy (MOE) has outlined a number of policy goals including increased government support in coal export, reductions in customs taxes for coal export, reduction of rail transport tariffs and appropriate changes in relevant laws, all of which will encourage increased coal production (Ganbataar, 2005).

Several new surface coal mine developments are planned. Tethys Mining LLC discovered a large coal deposit, Tugalgatai, in the eastern Mongolian province of Khentii (spelled Hentiy on the map in Figure 22-2) (Daly, 2008). In 2013, Canadian coal company Prophecy Coal Corp. reported that it was in discussions with Tethys to purchase the Tugalgatai coal licenses. Tugalgatai is contiguous to the company's Chandgana licenses, which host a measured resource of 650 Mmt and an indicated resource of 540 Mmt of thermal coal. The Chandgana Coal Project is expected to begin delivery of coal in 2016 to Prophecy's 600-MW Chandgana Power Plant. The plant was approved by the Mongolian government in early 2014 (Prophecy, 2013a; Prophecy, 2014a; Prophecy, 2014b).

Production at the Zeegt coal mine in Gobi-Altai Province is expected to begin in 2015. Gobi Coal and Energy began exploration work in 2006 around a small, formerly-state owned mine (Gobi Coal and Energy, 2014).

Aspire Mining Limited's Ovoot Coking Coal Project is being developed in Khusvgul Province in northwestern Mongolia. Aspire has signed an agreement with the Mongolian government to provide coal to the planned Sainshand Industrial Complex, which is intended to accommodate coke and steel plants. In order to supply the Sainshand Park with Ovoot Project coking coal, the Erdenet – Ovoot Project Railway connecting to the Trans-Mongolian Railway will need to be completed. Northern Railways, Aspire's Mongolian rail infrastructure subsidiary, has applied to the Mongolian Government for a rail concession over the Northern Rail Line (Proactive, 2014).

South Gobi Resources has outlined plans to develop properties near its existing Ovoot Tolgoi coal mine in Ömnögovi Province, namely the Soumber Deposit 20 km east and the Zag Suuj Deposit, located approximately 150km east. South Gobi is developing an additional deposit, the Tsagaan Tolgoi deposit, 415 km northeast of Ovoot Tolgoi (South Gobi, 2014).

Mongolia is also pursuing development of coal-to-liquids capacity. In August of 2013 a South Korean steelmaker, POSCO, announced a joint partnership with Mongolia's MCS Group to develop a coal-to-liquids plant in Ulaanbaatar's Baganuur district. The joint venture (named the Baganuur Energy Corporation) would build and operate a plant to annually produce 450,000 tonnes of diesel and 100,000 tonnes of dimethyl ether (Oxford, 2013). The Ovdog Hudag mine in Dundgovi Province has also been considered for this purpose (Ariuntuya, 2012).

Mongolia's largest underground coal mine, Nalaikh, near Ulaanbaatar, was closed in 1993 due to a major mine fire. Small shallow depth mining at coal outcrops at Nalaikh began in 1922, for the purpose of supplying coal to customers of the capital city of Ulaanbaatar. In 1954 – 1958, the larger underground mining operations were established with the production capacity of 600 thousand tonnes annually. By 1987, the mine reached full capacity, producing 800 thousand tonnes per year. Official underground mining in this area ceased in 1993; however, after the formal closure of the underground mine, the masses of freshly unemployed and skilled miners turned to illegal mining of the Nalaikh deposit. With nearly 200 shafts and five to ten workers per shaft, there are roughly 2,500 miners working the area during the peak season between September and May. The shafts are dug haphazardly, with little to no coordination between shafts. Mining dangers, such as cave-ins, are becoming more frequent (World Bank, 2004; MNEC, 2014). There is interest in CMM recovery and utilization at the Nalaikh mine, and the mine was subject of a United States Environmental Protection Agency Cooperative Agreement entitled, *Pre-feasibility Study on Methane Recovery & Utilization in Nalaikh Coal Mine*, available at https://www.globalmethane.org/activities/actDetails.aspx?ID=346.

Profiles of Mongolia's major coal mines are located in Section 1.4, Profiles of Individual Mines.

22.2 Overview of CMM Emissions and Development Potential

Other than the minor production from the Nalaikh mine (still formally closed), all of Mongolia's coal production is from surface mines. Thus, CMM development potential in Mongolia lies predominantly in pre-mine drainage in advance of surface mining operations. Underground CMM recovery and utilization at the Nalaikh mine may occur if coal mining resumes and a project proves to be economically feasible.

22.2.1 CMM Emissions from Operating Mines

In Mongolia's first National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), the analysis of GHG emissions by fuel type estimates that methane emissions released during coal mining activities, coal mining, and post-mining activities comprise 1.6 – 3.5 percent of all methane emissions (UNFCCC, 2001). As new mining areas have developed, CMM emissions have increased. Table 22-4 summarizes Mongolia's estimated CMM emissions from 2000 – 2010, with projection for 2015.

Table 22-4. Mongolia's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	6.7	10.5	13.7	15.1

Source: USEPA (2012)

A detailed calculation of methane emissions from Mongolia's coal mines was carried out, under the United States Environmental Protection Agency (U.S. EPA) Cooperative Agreement *Coal Mine Methane (CMM) Resource Assessment and Emissions Inventory Development in Mongolia*. The Mongolian Nature and Environment Consortium (MNEC) has developed basin-specific emission factors which were used to calculate emissions on a basin-by-basin basis. For more information, see https://www.globalmethane.org/activities/actDetails.aspx?ID=1200.

A pre-feasibility study has been completed for the Nalaikh mine, assessing the potential for power generation using CMM. Based on a 3.6-MW design capacity using two internal combustion engines, greenhouse gas (GHG) emissions reductions for this project are estimated to be about 96,000 tons CO_2 equivalent annually for such a power generation project, over a 17-year project life. The *Pre-feasibility Study on Methane Recovery & Utilization in Nalaikh Coal Mine* is available at https://www.globalmethane.org/activities/actDetails.aspx?ID=346.

Pre-feasibility studies were also completed by U.S. EPA at the Naryn Sukhait and Baganuur mines. The Naryn Sukhait study, completed in March of 2013, forecasted water and gas production and estimated that a pilot project could produce enough gas to fuel an 8.55-MW power generation facility, reducing GHG emissions by 187,900 tonnes over the project's 15-year life. The *Pre-feasibility Study for Coal Mine Methane Recovery and Utilization at Naryn Sukhait Mine* is available at http://epa.gov/cmop/docs/Mongolia_%20Naryn%20Sukhait%20Prefeasibility%20Study_FINAL.pdf.

The Baganuur Mine study was completed in December 2013. The pre-feasibility study evaluated utilization of pre-drained CMM for on-site use to fuel an internal combustion power generation facility located in close proximity to the mine's surface facilities. Production modeling performed for this study, estimated CMM production is 54.3 million m^3 of methane over 10 years, equating to an installed capacity of approximately 5.0 MW of combined electrical and thermal generating capacity. The proposed power generation project is estimated to reduce CMM emissions by 104,500 tonnes of CO_2e over the project's 10-year life. The study, entitled *Pre-feasibility Study for Coal Mine Methane Recovery and Utilization at Baganuur Mine*, is available at http://epa.gov/cmop/docs/2013%20Coal%20Mongolia%20Baganuur%20PFS.pdf.

22.2.2 CMM Emissions from Abandoned Coal Mines

Emissions estimates from the closed Nalaikh coal mine indicate that the mine workings are now completely flooded and there are negligible emissions from the abandoned mine (MNEC, 2010). When the mine was operating, the excess mine gas was vented. Emissions rates from the mine prior to its closure (for the period from 1988 to 1993) have been estimated to be as high as 355 liters methane per second (MNEC, 2010).

22.2.3 CBM from Virgin Coal Seams

As no natural gas infrastructure exists in Mongolia, CBM activity is in its infancy. Currently, neither conventional natural gas nor CBM is produced or consumed in Mongolia. Based on coal characteristics, the South Gobi, Kharkhiraa, and Altay-Chamandi basins in southern and western Mongolia appear to be the most likely areas for future CBM development, should it become a viable resource (Schwochow, 1997). The Choir-Nyalga basin within the northwest portion of the Eastern Mongolian coal-bearing province also presents characteristics favorable to future CBM development (MNEC, 2014).

A Canadian company, Storm Cat Energy Corp., acquired a CBM exploration license in the Noyon Uul region of the South Gobi basin in 2004 through a Production Sharing Contract (PSC) with the Petroleum Authority of Mongolia. Results of coring and desorption revealed a total coal thickness of 76.6 meters and gas contents which ranged from 2.34 m^3/tonne to 11.8 m^3/tonne. Storm Cat estimated the potential CBM resource of the area to range from 17 billion m^3 to 34 billion m^3, with a best estimate of 25.5 billion m^3 (Storm Cat, 2005). This resource estimate was based on the volume of coal estimated at depths shallower than the 1,500-meter drill depth, combined with average gas contents obtained from desorption analyses. While the potential resource is relatively large, no gas production has occurred. Storm Cat has determined that further geological review is necessary. Sproule, a Canadian consulting company, also reports to have evaluated CBM resources in Mongolia (Sproule, 2010). Following talks beginning in 2009, Korean Gas concluded the "Korea-Mongolia Gas Partnership," an agreement for joint research and exploration to develop CBM in Mongolia, with the MOE in 2010. The agreement seeks to supply methane to Ulaanbaatar through CBM exploration and production activities undertaken by the Korean Gas Research and Development Division and the Korea Institute of Geoscience and Mineral Resources. Drilling thus far has yielded no tangible results (KOGAS, 2010).

22.3 Opportunities and Challenges to CMM Recovery and Use

Mongolia is a signatory to the UNFCCC (Table 22-5). As a Non-Annex I Party to the Kyoto Protocol, Mongolia has no national emissions targets. Mongolia was eligible to host GHG mitigation projects under the Clean Development Mechanism (CDM), and registered four projects in the wind, hydropower, and supply side energy efficiency improvements sectors. No CMM projects were hosted by Mongolia.

Table 22-5. Mongolia's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	September 30, 1993
Kyoto Protocol		December 15, 1999

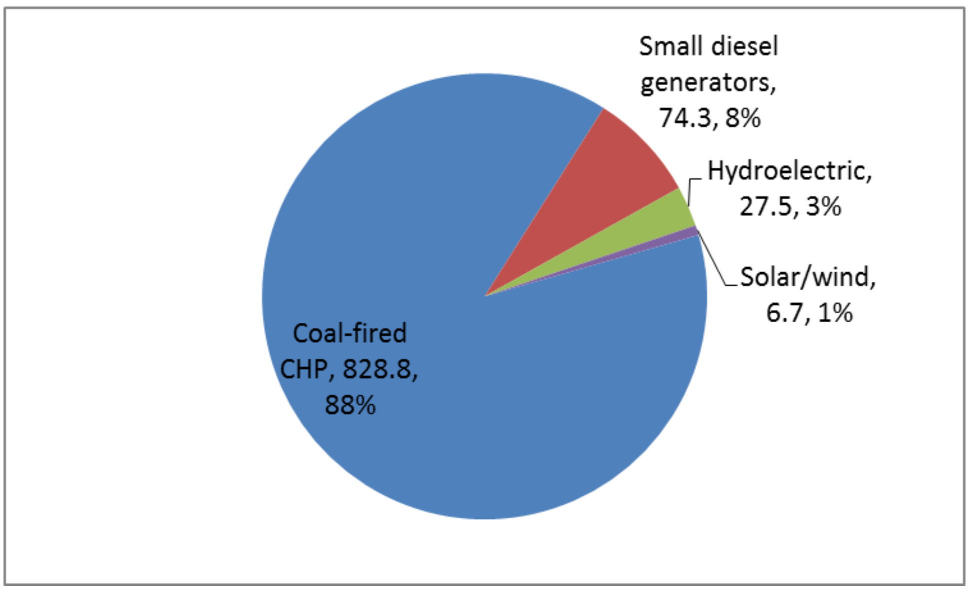
Source: UNFCCC (2014)

22.3.1 Market and Infrastructure Factors

The greatest challenge to CMM recovery and utilization in Mongolia is the lack of current markets or infrastructure to support it. With no natural gas production or imports, other fuel sources, primarily coal, are the principle sources for heat and power. Possible markets for onsite heat and/or power generation include industrial sites and coal mines, based on both their intense electricity demands and extremely harsh winter weather conditions. For example, the Tavan Tolgoi coal mine development will require an estimated 100 MW (Tserenpurev, 2008). In addition, high and steadily increasing costs of petroleum imports to Mongolia may create potential new market demand for liquefied natural gas (LNG) as a vehicle fuel.

Mongolia's installed power capacity is 1,062 MW, most of which is provided by coal (see Figure 22-3); however, only 836 MW (80 percent) is available due to aging power plants operating below design capacity. Mongolia's electricity transmission network connects approximately 70 percent of the country's population, but is considered unreliable, fraught with frequent blackouts occurring in major cities due to aging infrastructure (IEEJ, 2012). Mining accounts for 40 percent of Mongolia's energy consumption, and electricity prices for mining companies that tap into Mongolia's Central Electricity System (CES) will rise by as much as 30 percent according to Mongolia's Energy Regulatory Commission (Kohn, 2013). Electricity demand has increased at an average annual rate of 2.9 percent since 2005, a trend that is expected to continue through 2020.

Figure 22-3. Mongolia's Electricity Supply



Source: IEEJ (2012)

Mongolia's main electricity grid is the CES, which covers 80 percent of Mongolia's electricity supply and includes five coal-fired power plants and an interconnection with Russia for import of electricity. It has a basic transmission grid of 220 kV and 110 kV overhead transmission lines (OHTL). A 220 kV ring system connects the principal generation and load centers of Ulaanbaatar, Darkhan and Erdenet and additional 220 kV connections with load centers of Baganuur and Choir. The Baganuur substation is linked with Power Plant #4 in Ulaanbaatar by a 220 kV two circuit OHTL approximately 130 km long. During peak load periods, electricity is imported from the Russian Federation in order to meet and regulate electricity demand of the system (Prophecy, 2013b). Maximum current import capacity from Russia of 255 MW is expected to be reached (IEEJ, 2012); however, increased imports from Russia are not considered an option for meeting demand as the Mongolian government is concerned about supply security risks attached to reliance on Russian imports as well as the increased expense of Russian electricity.

Mongolia has several laws and resolutions that favor foreign investment in CMM projects. For instance, under the 1993 Law on Foreign Investment, an investor may request a stability agreement providing the investor a legal guarantee for a stable fiscal environment and protection from changes in taxation policy for 10 to 15 years. This protects the contractor from any changes of taxation policy (Chimiddorj, 2006).

The Parliament also passed Resolution #140 on 27 June 2001, which approves a list of favored industries in which foreign investment and involvement will be encouraged. Of these, oil and gas production as well as transmission pipeline construction are included. The MOE's Fuel Division has outlined various development goals which include extraction of petroleum products from coal (Ganbaatar, 2005).

Mongolia's tax policy also appears to be favorable towards CMM project development. Materials and equipment necessary to conduct petroleum operations that are imported by contractors are exempt from customs taxes, value added taxes, and excise taxes. Contractors' earnings from petroleum shares are exempt from income taxes.

22.3.2 Regulatory Information

The Constitution of Mongolia indicates that mineral resources in Mongolia are owned by the state. Coal exploration and production are regulated by the Law of Mineral Resources while natural gas and CBM are regulated by the Petroleum Law (Tumurbaatar and Altanchimeg, 2009).

In 1991, the Petroleum Law of Mongolia was ratified by the Parliament. The Law established a legal foundation for new development of petroleum exploration in Mongolia. In 2004, the Mineral Resources and Petroleum Authority of Mongolia (MRPAM) was formed and authorized by the Government of Mongolia to enter into contracts on the matters of oil and gas exploration, development, production, processing, marketing and supply of petroleum products in Mongolia, and to exercise supervision and assistance towards the implementation of such contracts (MIF, 2006). According to Parliament Resolution #43 and Government Resolution #64, MRPAM was reorganized and divided into the separate entities of the Mineral Resources Authority of Mongolia (MRAM) and the Petroleum Authority under the former Ministry of Minerals and Energy, subsequently the Ministry of Mining (MRAM, 2009).

The primary form of petroleum exploration contract in Mongolia is Production Sharing Contract (PSC). Applications are submitted to the Petroleum Authority which signs a PSC with the contractor on the recommendation of the National Security Council and with permission of the Mongolian Government. All materials and equipment necessary to conduct petroleum operations, imported by contractors, are exempt from all customs taxes, value added taxes and excise taxes. The earnings of contractors from their share of petroleum are also exempt from income taxes (Chimiddorj, 2006).

Mongolia's mineral resources are federally owned and administered through the Ministry of Mining (MOM). MRAM and the Petroleum Authority are implementing agencies under the MOM, and are charged with responsible development of mineral and petroleum resources through licensure, and the enforcement of regulations governing development. MRAM is responsible for development of minerals such as coal under the Minerals Law (2006), and the Petroleum Authority, under authority of the Petroleum Law (1991), which governs the production of liquid and gaseous hydrocarbons. The MOM also houses a Fuel Policy Division.

To date there has been no commercial CBM or CMM activity; however, there have been CBM exploration and PSC such as that entered into by Storm Cat Energy with the Petroleum Authority in 2004. Storm Cat Energy explored for CBM both near Ulaanbaatar (Tsaidam block area) and in the South Gobi region near the present Naryn Sukhait surface coal mine (SEC, 2005). No exploration or PSC have been negotiated for resources distinguished as CMM; however, members of the MRAM have indicated that there are regulations which require coal lease holders to not only assess the value of coal within their leasehold, but also estimate the methane resources associated with coal and surrounding strata.

Both the Minerals Law and the Petroleum Law are being revised. A revised draft of the Minerals Law was published in December 2012. The MOM submitted the renewed draft bill of the Petroleum Law to parliament in June 2013, which was passed and made effective on 1July 2014. This law defines a new category of petroleum resource, unconventional petroleum, which includes bitumen, oil shale, tar sand, gas rich shale, gas sand, and coalbed methane. Conflicts regarding overlap of rights to explore and develop conventional and unconventional petroleum deposits are addressed by encouraging companies interested in developing multiple mineral deposit types and/or oil and gas deposits to apply for the rights to all. If there is overlap of rights among entities, they encourage the leaseholders to find a workable and mutually beneficial approach; if this not possible, the Cabinet will determine the best way forward based on social and economic factors.

Though previous CBM activity has been managed by the Petroleum Authority of the MOM, the MOE claims rights relating to granting permission for research and exploration of methane resources. The primary focus of the MOE has been to supply and distribution of energy. It included a Fuel Division concerned with CBM development and research and asserts that CBM exploration must be permitted through the MOE, but these conflicts may now be resolved internally if the new ministry is created by the merger of MOM and MOE.

22.4 Profiles of Individual Mines

22.4.1 Tavan Tolgoi

The Tavan Tolgoi coal deposit is located in the territory of Tsogt Tsetsii Soum, within the Ömnögovi Province, approximately 540 km south of Ulaanbaatar. Tavan Tolgoi is one of the world's largest untapped coking and thermal coal deposits. It is divided into six coalfields: Tsankhi, Ukhaa Khudag, Bor Tolgoi, Bor Teeg, Southwest and Eastern coalfields. A small coal mine within the Tavan Tolgoi coal deposit has been in operation since 1967, which until 2011, has supplied coal directly into the Mongolian domestic market. After 2011, all coal produced is exported to China. This coal mine is owned by the local government (51 percent) and other private shareholders. The coal production plan for 2013 was 2 Mmt. Ninety-six percent of the Tavan Tolgoi deposit area is owned by Erdenes MGL (a government owned company), with the exception of the Ukhaa Khudag field which is mined by the Mongolian Mining Corporation (Energy Resources LLC). Erdenes Tavan Tolgoi LLC (Erdenes TT), a subsidiary of Erdenes MGL, is managing the development of the deposit. The Tsankhi field is the largest portion of the entire coal deposit, and is divided into the East and West Tsankhi areas. Recent work has been focused in these two areas. Erdenes TT has chosen the joint venture company of Macmahon Holdings and BBM Operta to operate the mine under a five year contract which extends from 2012 – 2017. Production in 2013 from East Tsahkhi mine is expected to be 6 Mmt and 1.5 Mmt from West Tsankhi. The Ukhaa Khudag field, located within the Tavan Tolgoi coal formation is mined by Mongolian Mining Corporation (MMC). The mine is strategically located approximately 240 km from the Mongolian-Chinese border and about 600 km north of Baotou, China, an important railway transportation hub. The hub provides access to the largest steel producing provinces within China.

MMC began mining operations at Ukhaa Hudag in April of 2009 and became profitable in the first year of operations. MMC's coking coal production has steadily increased from 1.8 Mt in 2009 to 3.9 Mt in 2010, 7.1 Mt in 2011 and 8.6 Mt in 2012, with plans to produce 15 Mt in 2014.

The mine serves as an operational hub for processing coal from Ukhaa Khudag and Baruun Naran mines, complete with all necessary utility infrastructure facilities, including an 18-MW on-site power plant and water supply system (MNEC, 2014).

22.4.2 BAGANUUR

The Baganuur mine is a surface coal mine owned and operated by Baganuur Joint Stock Company (Baganuur JSC), located outside of Ulaanbaatar. The mine is 75 percent state owned and 25 percent privately owned. Baganuur mines 3.5 Mmt of coal per year, with plans to increase production to over 6 Mmt per year by 2020. It is estimated that there are 248.97 Mmt of coal within the Baganuur mining area. The expected service life of Baganuur is 60 years (USEPA, 2013a). Baganuur hosted a United States Environmental Protection Agency study entitled *Pre-feasibility Study for Coal Mine Methane Recovery and Utilization at Baganuur Mine*, available at http://epa.gov/cmop/docs/2013%20Coal%20Mongolia%20Baganuur%20PFS.pdf.

22.4.3 NARYN SUKHAIT

The Naryn Sukhait coal deposit is located in remote southwestern Mongolia in Ömnögovi Province, approximately 850 km southwest of Ulaanbaatar, and just 57 kilometers north of the Mongolian – Chinese border. Presently there are three large scaled surface coal mines operating at the Naryn Sukhait deposit: Naryn Sukhait Mine-1 operated by Mongolyn Alt (MAK) Corporation, Naryn Sukhait Mine-2 operated by the Mongolian-Chinese joint venture company, Qinhua-MAK, and the Ovoot Tolgoi mine operated by the Australian company, South Gobi Sands. Projected production of the Naryn Sukhait Mine-1 for 2013 was 10 Mmt. The projected production of the Naryn Sukhait Mine-2 was 1.5 Mmt, while the Ovoot Tolgoi Mine was projected to produce 4 Mmt in 2013 (MNEC, 2014; USEPA, 2013b). MAK hosted a United States Environmental Protection Agency study entitled *Pre-feasibility Study for Coal Mine Methane Recovery and Utilization at Naryn Sukhait Mine*, available at http://epa.gov/cmop/docs/Mongolia_%20Naryn%20Sukhait%20Prefeasibility%20Study_FINAL.pdf.

22.4.4 KHOTGOR

The Nuurst Khotgor coal deposit is located in Uvs Province, approximately 110 km west, southwest of the province center Ulaan Gom. The Nuurst Khotgor Coal Mine began operating as an open cut mine in the Khotgor field in 1963. The mine has produced a total of 4.2 Mmt of coal until it ceased operations in 2013. The coal was utilized by local consumers of the Bayan-Olgii and Uvs Provinces. Presently, mine operations are undertaken in three coal fields (Khotgor, Khotgor Shanaga and Erchim) by different companies. Korea Coal Corporation (KOCOAL), a state-run coal mine developer, purchased a 51 percent stake in the Khotgor Shanaga coal mine for $10 million US and will invest an additional $18.1 million US in mine operations. The mine has a soft coal reserve of 79 Mmt and plans to produce up to 1 Mmt of coal annually. The mine, operated by Mongolian-Korean

Joint Venture Company, was scheduled to produce 410 thousand tonnes of coal in 2013. A portion of that production was planned for export to Russia. KOCOAL was established in 1950 as a government-owned coal company to manage coal mines. Its mission has been further increased with coal export and import businesses, including foreign coal mine development. The company currently operates three domestic coal mines, producing approximately 1.2 Mmt annually. The oldest Khotgor mine will have produced 120 thousand tonnes of coal in 2013 while the Erchim Mine forecasted production of 25 thousand tonnes (MNEC, 2014).

22.4.5 Sharyn Gol

The Sharyn Gol coal deposit is located in the territory of Darkhan Soum in Darkhan - Uul Province. The deposit sits approximately 70 km east of Darkhan city, one of the main stations along the Trans-Mongolian Railway. The Sharyn Gol mine is the oldest coal mine in Mongolia, with over 45 years of continuous production history. The mine began its open pit operation in 1965. Produced coal has been utilized mainly by power plants in Ulaanbaatar, Darkhan and Erdenet. Although the original production capacity was 2.5 Mmt per year, the recent annual production has been on the decline, with 465 thousand tonnes produced in 2012, and a production plan for 2013 of 900 thousand tonnes. The Sharyn Gol mine was privatized on the Mongolian Stock Exchange in 2003. Firebird acquired a controlling position in 2010 and led a complete overhaul of the company, including a 17,000 meter drilling program, resulting in the identification of 374 Mmt of coal resources in a JORC-compliant resource statement. Recently, Sharyn Gol JSC received the government approval required for the launch of operations at its planned new open pit. Sharyn Gol is strategically situated on a rail spur connecting to the Trans-Mongolian Railway. As the only significant supplier of high quality thermal coal, Sharyn Gol can take advantage of growing domestic demand in the Darkhan province and throughout the region. The rail connection also offers the company the option to consider exports to Russia and into the international market through Russian ports. Laboratory tests demonstrated that Sharyn Gol coal can be washed efficiently into a premium export quality coal (MNEC, 2014).

Although the Sharyn Gol mine is principally an opencast mine, the mining company began some underground exploration and development in 2005. Since that time, between 60 and 70,000 tonnes of coal have been mined underground. Maximum annual underground production has been 20,000 tonnes. At times, gas build up in the underground workings has been serious enough to cause work to stop until methane concentrations were reduced. Previously the mine carried out initial research on CBM resources to identify the best extraction technology and how to best transition from surface to underground mining.

22.4.6 Others

The Aduunchuluun mine is located in Dornod Province in eastern Mongolia. The mine is owned by Mongolyn Alt (MAK) Corporation. Small-scale extraction began in 1955 and the mine has produced 600 thousand tonnes of brown coal per year since 1979. It is economically unprofitable to transport thermal coal from Aduunchuluun to local and foreign markets because the coal is high in moisture and low in calorific value, thus MAK has investigated construction of a coal briquette plant. Aduunchuluun has also been considered as a site for coal gasification (Ariuntuya, 2012; MAK, 2014a).

The Baruun Naran mine is located in Ömnögovi Province. Commissioning of the mine took place in January 2012 and commercial coal mining operations started in February 2012. The mine produced 800 thousand tonnes of coal in 2012 and 500 thousand tonnes in 2013 (MMC, 2013b).

The Ulaan Ovoo mine is located in Selenge aimag, 17 km from the Russian border, 430 km from Ulaanbaatar, and 120 km from both Mongolian and Russian rail links. Prophecy Coal Company is the sole owner of the mine and commenced operations in 2010. The mine has an estimated 174 Mmt of measured and 34 Mmt of indicated coal resources (Prophecy, 2014c). The mine's annual capacity is estimated to be 6 Mmt (Ariuntuya, 2012).

The Bayanteeg mine is located in Övörkhangai Province in southern Mongolia. Bayanteeg Shareholding Company established the mine in 1962 with an annual output capacity of 25,000 tonnes of coal and has been supplying nearby towns with coal since then. Bayanteeg mine has estimated reserves of 29.6 Mmt, of which 4.6 Mmt have so far been extracted. Bayanteeg has been considered as the site of a medium-size coal-to-gas plant (Ariuntuya, 2012).

The Tevshiin Govi mine is located in Dundgovi Province and was established in 1990 by the Mongolian government. The mine has since been privatized and produces 50 thousand tonnes of coal annually. The mine has large reserves but is limited by its isolated location (Ariuntuya, 2012).

The Chandgana deposit consists of two properties, Chandgana Tal and Khavtgai Uul. The Chandgana Tal mine opened in 1967 and consists of 124.4 Mmt of measured resource and produces 20 thousand tonnes of coal annually. Khavtgai Uul consists of 509 Mmt measured and 539 Mmt indicated resource and will meet the needs of the planned 600-MW Chandgana Power Plant (Prophecy, 2014b; Ariuntuya, 2012).

The Ovoot Tolgoi mine is located in Ömnögovi Province and is owned by South Gobi Resources. The mine has operated since 2008, shutting down for nine months in 2012-2013 due to lowered coal prices and demand. The mine had planned production of 3.2 Mmt in 2013 (Mining Journal, 2013).

The Eldev mine, owned by MAK, is located in Dornogovi Province. The mine produces 500,000 tonnes per year and sells to both domestic customers including Erdenet Mining Corporation, Khutul Cement & Lime Plant, Darkhan Power Plant, Ulaanbaatar Railway, and Darkhan Metallurgical Plant as well as export markets (MAK, 2014b).

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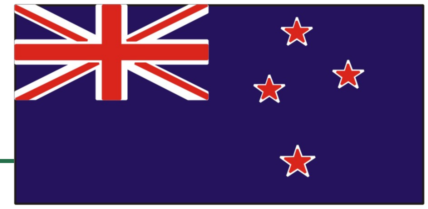


23.1 Summary of Coal Industry

23.1.1 Role of Coal in New Zealand

Coal is New Zealand's most abundant fossil fuel and has been an important energy source since the late nineteenth century. Today, the majority of New Zealand's coal is used for electricity generation (40 percent) and industrial processes (33 percent), with dairy and non-metallic mineral product manufacturing (cement, lime, and plaster) being the largest industrial consumers of coal (MBIE, 2013). In 2013, New Zealand consumed approximately 2.9 million tonnes (Mmt) of coal, with a significant portion used to generate electricity at Huntly, New Zealand's only coal-fired power station (MBIE, 2013; Coal Association, 2012). Further, exportation of New Zealand's premium bituminous coal has been a major growth area since about 1990 and is likely to continue being a good prospect for the future as their coal is valued internationally for its low ash, sulfur content, and other characteristics that allow blending with other coals for use in the steel industry (MBIE, 2013).

Table 23-1 indicates New Zealand's recoverable coal reserves to be about 570 Mmt. The resource itself is far more extensive and may offer greater recovery, ultimately. The total known in-ground resource is estimated to exceed 15 billion tonnes, of which more than half is potentially recoverable (MBIE, 2013).

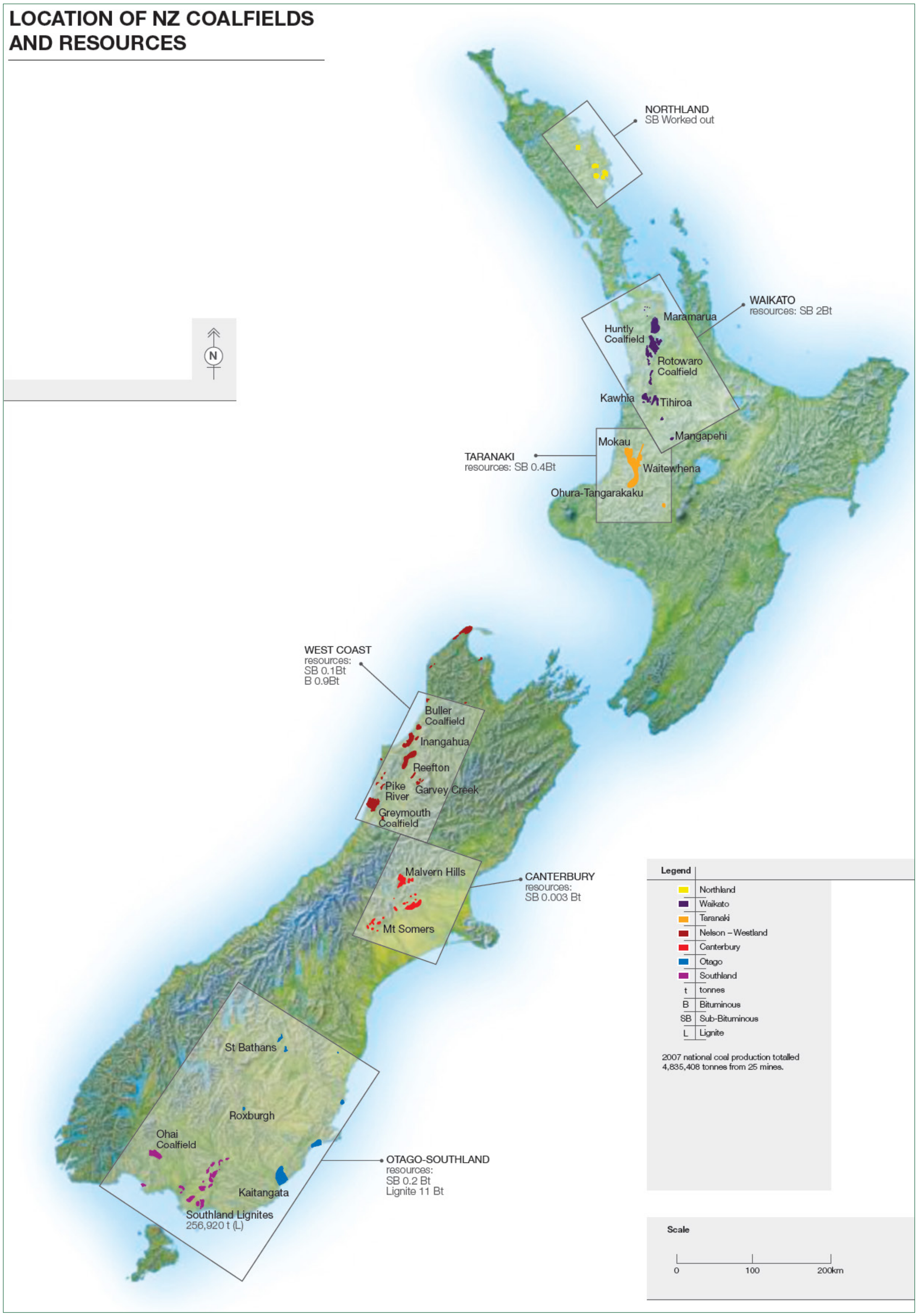
Table 23-1. New Zealand's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	33.0	538.0	571.0	31 (0.064%)
Annual Coal Production (2012)	4.6	0.33	4.93	33 (0.06%)

Source: EIA (2014)

New Zealand is divided up in to North Island and South Island (Figure 23-1). Coal is found in the Northland, Waikato, and Taranaki Coal Regions of the North Island. On the South Island, coal is found in the Nelson, West Coast, Canterbury, Otago, and Southland Coal Regions (USGS, 2004). At least 6.2 billion tonnes of lignite is technically and economically recoverable in 10 major deposits in the South Island regions of Otago and Southland (P&M, 2014). The North Island in-ground resource is about 2.4 billion tonnes and consists of almost entirely sub-bituminous coal (P&M, 2014).

Figure 23-1. New Zealand's Coal Fields



Source: MOED (2010)

23.1.2 STAKEHOLDERS

Only a handful of companies operate coal mines in New Zealand. Most of New Zealand's coal is produced by Solid Energy NZ Limited (P&M, 2014).

Key stakeholders involved in New Zealand's coal and the coal mine methane (CMM) development industries are outlined in Table 23-2.

Table 23-2. Key Stakeholders in New Zealand's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ Birchfield Coal ▪ Canterbury Coal ▪ Cascade Coal ▪ Crusader Coal ▪ Francis Mining ▪ Glencoal ▪ Harliwich Carrying Co. ▪ Heaphy Mining ▪ Kai Point Coal ▪ New Creek Mining ▪ O'Reilly's Opencast ▪ Puke Coal ▪ RJ Banks ▪ Rockies Mining ▪ Solid Energy ▪ Takitimu Coal	Project hosts
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Universities and Research Centers	▪ Commonwealth Scientific and Industrial Research Organisation (CSIRO) ▪ University of Auckland	Technical assistance
Government Groups	▪ Ministry of Commerce – Energy and Resources Division	Licensing

Source: P&M (2014)

23.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

New Zealand's coal industry is vested in 22 surface and underground mines. Roughly 60 percent of national production was from two large opencast operations, located at Rotowaro and Stockton (P&M, 2014). Coal production statistics for 2012 by mine type are presented in Table 23-3. The total number of mines has steadily decreased, and surface mining methods have become more popular.

Table 23-3. New Zealand's Production and Mine Statistics (million tonnes)

Type of Mine	2012 Production	Number of Mines
Underground (active)	0.60	4
Surface (active)	4.33	18
Total	4.93	22

Sources: MBIE (2013); P&M (2014)

Despite increasing competition from hydroelectric power and from imported oil, annual coal production has been sustained at or above the 1.8 Mmt level since 1907. Production has exceeded 3 Mmt since 1992, and it reached a peak of almost 5.7 Mmt in 2006 (MBIE, 2013).

Table 23-4 lists all major coal mines in operation in New Zealand.

Table 23-4. New Zealand's Major Operating Coal Mines

Coal Field	Mine	Coal Rank	Mine Type
Waikato			
▪ Huntly	▪ Huntly East ▪ O'Reilly's	sub-bituminous sub-bituminous	underground surface
▪ Maramarua	▪ Kopako	sub-bituminous	surface
▪ Rotowaro	▪ Awaroa ▪ Pukemiro	sub-bituminous sub-bituminous	surface surface
West Coast			
▪ Buller	▪ Stockton ▪ Cascade ▪ New Creek ▪ Rockies	bituminous bituminous bituminous bituminous	surface surface surface surface
▪ Garvey Creek	▪ Echo	bituminous	surface
▪ Greymouth	▪ Roa ▪ Strongman	bituminous bituminous	underground surface
▪ Inangahua	▪ Berlins Creek ▪ Giles Creek	sub-bituminous sub-bituminous	surface surface
▪ Reefton	▪ Burkes Creek ▪ Reddale Valley ▪ Terrace	sub-bituminous sub-bituminous sub-bituminous	underground surface underground
▪ Canterbury			
▪ Canterbury	▪ Malvern Hills	sub-bituminous	surface
▪ Otago			
▪ Kaitangata ▪ Roxburgh	▪ Castle Hill ▪ Harliwich	sub-bituminous lignite	surface surface
Southland			
▪ Ohai ▪ Waimumu	▪ Takitimu ▪ Newvale	sub-bituminous lignite	surface surface

Source: P&M (2014)

Currently, little exploration for new reserves is taking place, and the industry is concentrating on improving knowledge of reserves within the existing license areas. New Zealand's coal exports will continue to grow—although there has been demand for premium-quality bituminous coal, there is also a growing international market for thermal coals, such as New Zealand's lower-grade bituminous and sub-bituminous coals (USGS, 2004).

23.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no CMM recovery projects for New Zealand, in operation or under development (GMI, 2014). Updates on future CMM projects in New Zealand can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

23.2.1 CMM Emissions from Operating Mines

Most New Zealand coal production is from surface mines producing low rank coals at shallow depths with low methane concentrations. Methane emissions from these coals are vented. The few deep underground mines have high methane concentrations and are generally degasified with ventilation and surface gob wells. To date, no current projects have been identified in surface or underground mines where captured gas is utilized or marketed rather than vented.

Methane emissions in New Zealand totaled 23.8 million cubic meters (m^3) in 2000, but are expected to increase to 29.4 million m^3 by 2015, and then anticipated to further increase to 36.4 million m^3 by 2030 (see Table 23-5).

Table 23-5. New Zealand's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	23.8	23.1	27.3	29.4

Source: USEPA (2012)

23.2.2 CMM Emissions from Abandoned Coal Mines

No data about methane emissions from abandoned mines in New Zealand are available at this time.

23.2.3 CBM from Virgin Coal Seams

Estimates indicate New Zealand has a total of more than 2,000 petajoules or 53 billion m^3 of CBM reserves (Clark, 2008). No commercial wells are in production, but numerous exploratory and test wells have been drilled.

At least 16 licenses had been issued for exploratory drilling and development of coal seam gas in New Zealand (L&M, 2009), but as of 2014, the permits had either been surrendered or were about to expire (SourceWatch, 2014). L&M Coal Seam Gas Ltd. (L&M CSG) previously held numerous licenses, which covered coal resources ranging in rank from lignite to bituminous, with the bulk being in the low rank coals. L&M CSG had drilled 52 exploratory wells and started their first pilot project. In 2009, L&M estimated they had about 1,500 petajoules (40 billion m^3) of CBM reserves (L&M, 2009). However, in 2012, the Director's report stated that although work had continued on the Ohai CSG pilot project, the results had been "disappointing" and commercial gas flow rates had not been achieved (SourceWatch, 2014).

Other CSG explorers/permit holders include Solid Energy (and its U.S. CSG developer partner, Resource Development Technology) and Macdonald-Chartwell, as well as Bridge Petroleum Ltd in partnership with Transworld Exploration Ltd and Westech Energy, (Clark, 2008: RigZone, 2004).

23.3 Opportunities and Challenges to Greater CMM Recovery and Use

As reflected in Table 23-6, New Zealand is a signatory to both the UNFCCC and the Kyoto Protocol. New Zealand is an Annex I Party, and its emissions target under the Kyoto Protocol is to achieve 1990 levels by 2010.

Table 23-6. New Zealand's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 4, 1992	September 16, 1993
Kyoto Protocol	May 22, 1998	December 19, 2002

Source: UNFCCC (2014)

In 2013, the Government announced three national targets for reducing New Zealand's greenhouse gas (GHG) emissions that cover both the medium and long term:

- An unconditional target of 5percent below 1990 GHG emissions levels by 2020.
- A conditional target range of 10 to 20 percent below 1990 GHG emissions levels by 2020, if there is a comprehensive global agreement (e.g., post-Kyoto).
- A long-term target of 50 percent below 1990 GHG emissions levels by 2050 (MFE, 2014).

New Zealand also has an Emission Trading Scheme (ETS), which places a price on GHG emissions (including methane) to provide an incentive to reduce emissions, invest in clean technology and renewable power generation, and plant forests to absorb carbon dioxide. The stationary energy sector (e.g., coal, natural gas, geothermal energy), for example, has obligations to report their methane emissions, then acquire and surrender New Zealand Units (NZUs) or equivalent overseas emission to offset these emissions.

23.3.1 Market and Infrastructure factors

New Zealand gas demand is projected to continue to increase significantly as domestic conventional gas supplies decline more rapidly than expected. New domestic production from CBM/CMM is therefore encouraged. New Zealand has considered imposing a carbon tax, however, in 2005, the government decided to abandon their plans because emission savings were not justified by the cost.

CMM and CBM infrastructure in New Zealand is not well developed; gas gathering, compression, and transmission infrastructure will require significant investments.

Any methane recovered in the future could be utilized by the power generation, heating, and transportation sectors, as well as by the industrial sector for boilers, but it would have to compete against gas suppliers and importers. The University of Auckland, the Commonwealth Scientific and Industrial Research Organization (CSIRO), and other technology organizations are helping to address technology issues associated with recovery of CMM and CBM resources.

23.3.2 Regulatory Information

The New Zealand coal mining industry has undergone major changes over the last 25 years. State-owned coal mines were converted into a government-owned corporation. Natural gas regulations are governed by the "Gas Act," which can be found at www.legislation.govt.nz.

23.4 Profiles of Individual Mines

See P&M (2014) for links to available mine production data. Updates on future CMM projects in New Zealand can be found at http://www.globalmethane.org/coal-mines/cmm.index.aspx.

23.5 References

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24 Nigeria

24.1 Summary of Coal Industry

24.1.1 Role of Coal in Nigeria

Nigeria ranks low in worldwide coal production, with less than 30 thousand tonnes of coal production in 2012 (Table 22-1). Nigeria estimated its coal reserves at more than 2 billion tonnes, with approximately 650 million tonnes (Mmt) as proven (OnlineNigeria, 2014). Other sources cite different estimates, however, as shown in Table 22-1. Although coal was the first energy resource to be exploited by Nigeria, a transition to diesel fuel for rail transport and to gas for electricity generation led to a decrease in coal production. Coal production has dropped significantly from its high of almost 1 Mmt in 1959.

Table 24-1. Nigeria'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)	21.0	169.0	190.0	50 (0.021%)
Annual Coal Production (2012)	0.03	0	0.03	65 (0.0004%)

Source: EIA (2014)

Nigeria's coal resources are located in the Cretaceous Anambra and Makurdi Basins, and Afikpo Syncline (see Figure 24-1) and occur in two levels: the lower Mamu Formation and the upper Nsukka Formation. Coal seams occur in three main stratigraphic levels (Ogunsola, 2008):

- The brown coals (lignite) of Ogwashi-Asaba Formation of Miocene to Pliocene ages
- The upper and lower sub-bituminous coal measures of Maastrichtian age
- The bituminous coals of the Awgu shales of Coniacian age

Its sub-bituminous coal is low in sulfur and ash content, making it attractive for export to Ghana and Egypt and by European nations as well. Nigeria has Africa's largest deposits of lignite. According to a 1987 Federal Republic of Nigeria document, reserves from coal seams in excess of 1 meter thick are: Ogboyoga (100 Mmt) in the north, and Okaba (70 Mmt), Orupka (60 Mmt), Ezimo (50 Mmt), and Enugo (50 Mmt) in the south (OnlineNigeria, 2014).

Figure 24-1. Nigeria's Coal Fields

Source: CIA (2010), *EarthByte (2008)

Table 24-2 identifies potential stakeholders in Nigerian coal mine methane (CMM) development.

Table 24-2. Key Stakeholders in Nigeria's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies/Equity Owners	▪ Kogi State Government* ▪ Nigerian Coal Corporation (NCC) ▪ Behre Dolbear and Company Inc.	Owner/operator Owner/operator Technical Expertise
Developers, Engineers, Consultancy and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification, planning and assistance
Natural Gas Transmission & Distribution Companies	▪ British Gas ▪ BP ▪ Chevron ▪ Conoco ▪ Deminex ▪ ENI/Agip ▪ ExxonMobil	Gas distribution

Table 24-2. Key Stakeholders in Nigeria's CMM Industry

Stakeholder Category	Stakeholder	Role
Regulatory Agencies	▪ Nigerian National Petroleum Corporation – Department of Petroleum Resources	CMM project promotion, registration of exploration and development companies
Government Groups	▪ Ministry of Mines and Steel Development ▪ National Chamber of Commerce, Industries – Mining and Agriculture ▪ Federal Ministry of the Environment	Granting and approval of leases
	▪ Mining Cadastre Office	Responsible for mineral titles
	▪ Mines Inspectorate Department	Health and Safety administration and enforcement
	▪ Small Scale Mining Department	Organization, support and assistance to small scale miners

Sources: EIA (2013); *USGS (2014)

24.1.2 Status of Coal and the Coal Mining Industry

The Nigerian government is seeking to increase the country's level of coal utilization to help stem the loss of its forests to domestic fuel-wood harvesting and to help reduce its overdependence on oil. At present, however, coal remains the smallest contributor to the overall fuel mix. As per the International Energy Agency (IEA), coal is not part of Nigeria's total primary energy supply in 2011 (IEA, 2013).

Current uses for coal in the country are in cement production, brick factories, foundries, laundries and bakeries, tire manufacture, battery manufacture, and domestic cooking fuel (i.e., smokeless coal briquettes). Nigerian coal can be blended with imported coals for coke production, and it is projected that as much as 200,000 tonnes per year of Nigerian coal could be directed to supply coke to the Ajaokuta Steel Plant once it begins full operation. Using coal to manufacture smokeless briquettes for home cooking fuel has the added benefit of producing by-products such as gases, ammonia, tar oils, and various aromatics that can be used as chemical feedstocks. Nigeria has also determined that its coal is suitable fuel for use at the abandoned Oji Power Station, as well as at other proposed power generation facilities.

Nigeria's generation capacity was 6,000 MW in 2012, of which 79 percent was fired by fossil fuels, principally natural gas. Generation capacity is projected to increase to 25,000 MW by 2020, and fossil fuels are expected to account for 20,000 MW of the total capacity (EIA, 2013; Essien & Igweonu, 2014). Plans call for coal to provide for a significant portion of the projected electric power demand due to Nigeria's large reserve base. By 2020, almost 14 percent of generation capacity is expected to be coal-fired growing to 15.6 percent by 2030 (Sambo, 2008). Consequently, coal demand is projected to increase. In addition to such domestic uses, Nigeria estimates that export demand for its coal could reach 15 Mmt per year (M2M, 2006).

Table 24-3 provides an overview of coal mines and mining methods used in Nigeria.

Table 24-3. Nigeria's Coal Mines

Mine	Coal Type	Estimated Reserves (million tonnes)	Proven Reserves (million tonnes)	Depth of Coal (m)	Mining Method(s)
Okpara	▪ Sub-bituminous	100	24	180	Underground
Onyeama	▪ Sub-bituminous	150	40		Underground
Ihioma	▪ Lignite	40	N/A	20-80	Surface
Ogboyoga	▪ Sub-bituminous	427	107	20-100	Surface and underground
Ogwashi Azagba/Obomkpa	▪ Lignite	250	63	15-100	Surface and underground
Ezimo	▪ Sub-bituminous	156	56	30-45	Surface and underground
Inyi	▪ Sub-bituminous	50	20	25-78	Surface and underground
Lafia/Obi	▪ Bituminous (cokable)	156	21.42	80	Underground
Oba/Nnewi	▪ Lignite	30	N/A	18-38	Underground
Afikpo/Okigwe	▪ Sub-bituminous	50	N/A	20-100	Underground
Amasiodo	▪ Bituminous	1,000	N/A	563	Underground
Okaba	▪ Sub-bituminous	250	73	20-100	Surface and underground
Owukpa	▪ Sub-bituminous	75	57	20-100	Surface and underground
Ogugu/Awgu	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Afuji	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Ute	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Duho	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Kurumu	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Lamja	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Garin Maigunga	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Gindi Akwati	▪ Sub-bituminous	N/A	N/A	N/A	Underground
Janata Koji	▪ Sub-bituminous	N/A	N/A	N/A	Underground

Sources: M2M (2006); Ogunsola (2008)

24.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no CMM recovery projects in Nigeria (GMI, 2014). Updates on future CMM projects in Nigeria can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

24.2.1 CMM Emissions from Operating Coal Mines

Table 24-4 reports Nigeria's historical and projected CMM emissions.

Table 24-4. Nigeria's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	23.8	63.7	67.2	70.7

Source: USEPA (2012)

24.2.2 CMM Emissions from Abandoned Coal Mines

No data quantifying methane emissions from abandoned mines were found.

24.2.3 CBM from Virgin Coal Seams

No data quantifying methane production from virgin coal seams were found.

24.3 Opportunities and Challenges to Greater CMM Recovery and Use

Nigeria has signed and ratified the UNFCCC and has ratified the Kyoto Protocol (see Table 24-5). As a non-Annex 1 country, Nigeria is eligible to host Clean Development Mechanism (CDM) projects that can earn revenue from the sale of carbon credits. While there are some CDM projects related to landfill gas and fugitive emissions (e.g., oil and gas systems) in Nigeria, there are presently no CDM projects related to coalbed/mine methane (UNEP, 2014).

Table 24-5. Nigeria's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	August 29, 1994
Kyoto Protocol	---	December 10, 2004 (Acceptance)

Source: UNFCCC (2014)

The Government of Nigeria acknowledged the importance of developing a national response to climate change, and took steps to build a governance structure to manage the issue. The Government first created a national focal point: the Special Climate Change Unit (SCCU) within the Federal Ministry of Environment and also mobilized the Inter-ministerial Coordinating Committee on Climate Change (BNRCC, 2011). In 2010, the National Assembly passed a bill to create a National Climate Change Commission, which facilitated coordination and support for the multi-level and cross-sectoral adaptation responses, development of a National Climate Change Policy for Nigeria, and of a Nationally Appropriate Mitigation Action (NAMA) programme. In 2011, the Government of Nigeria and a number of civil society organizations embarked upon the development of an initial adaptation strategy and climate change action plan for Nigeria. In September 2012, the Federal Executive Council approved the adoption of the National Policy on Climate Change and Response Strategy (NPCC-RS) as a national document for implementing climate activities in Nigeria (Daily Independent, 2012).

24.3.1 Market and Infrastructure Factors

Nigeria's robust natural gas industry provides a market conducive to CMM development. The expected increase in gas infrastructure will enhance the ability to move drained CMM from the wellhead to market. On the other hand, Nigeria has such substantial gas resources that supplemental streams captured at coal fields may appear relatively insignificant in comparison, thereby diluting interest in CMM development. Also, the amount of CMM that can be recovered in conjunction with coal mining has been reduced over time.

24.3.2 Regulatory Information

Nigeria has the largest natural gas reserves in Africa and is among the top 10 holders of natural gas proven reserves in the world. However, due to inadequate gas infrastructure, Nigeria has flared as much as 75 percent of the gas it produces, accounting for about 10 percent of all gas flared worldwide in 2011 (EIA, 2013). New Nigerian policy seeks to reduce gas flaring by using the gas as feedstock in liquefied natural gas (LNG) processing facilities.

The national government, specifically the Nigerian Coal Corporation (NCC), owns 100 percent of the Nigerian coal industry, but the government's monopoly of coal mining is being relaxed. Beginning in 1990, the NCC initiated efforts to privatize the coal industry by entering into several different joint venture arrangements. While the initial joint ventures have not been successful, the privatization efforts are still being pursued (Ogunsola, 2008).

As part of Nigeria's general privatization plan for the energy sector, the NCC is itself being put up for sale by the Bureau of Public Enterprises (BPE), with some assets being sold individually to pay off accumulated debt (Compass, 2009a; Compass, 2009b). Also, as part of the privatization plans, the coal resources of Nigeria have been divided into 10 prospective blocks and put up for auction. Nine of the blocks were bid for and won by four companies – one Nigerian and three foreign – with the expertise and finances to make use of the resources (Africa, 2010). These sales to capable companies should improve the investment and development climate.

The government also regulates and supervises natural gas production through the Nigerian National Petroleum Corporation (NNPC), formed in 1977. In 1988, the NNPC was commercialized into 12 strategic business units (or subsidiaries), covering the entire spectrum of oil industry operations: exploration and production, gas development, refining, distribution, petrochemicals, engineering, and commercial investments. In addition to these subsidiaries, the industry is also regulated by the Department of Petroleum Resources (DPR), a department within the Ministry of Petroleum Resources, that ensures compliance with industry regulations, processes applications for licenses, distributes leases and permits, and establishes and enforces environmental regulations (NNPC, 2014). The Nigerian Gas Company Limited (NGC), one of the 11 NNPC subsidiaries, is charged with the responsibility of developing an efficient gas industry to fully serve Nigeria's energy and industrial feedstock needs through an integrated gas pipeline network (NGC, 2014).

Currently, there exist two types of gas operator agreements in Nigeria: joint operating agreements and production sharing agreements. Coal mining leases can be obtained either through an approved (by the Ministry of Mines and Steel Development) acquisition of an existing mining property or by applying for a Prospecting Right or License. Gas producers must perform gas field optimization analyses on their concessions and the government is responsible for optimization of gas field development overall.

Nigeria's efforts to wean its population away from harvesting timber for cooking fuel may stimulate coal production and CMM development. As mentioned above, however, the current low level of coal production in the country is not conducive to a robust CMM development industry.

24.4 Profiles of Individual Mines

Adequate data to profile individual mines is not available.

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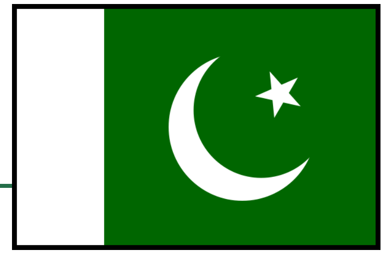
25 Pakistan



25.1 Summary of Coal Industry

25.1.1 ROLE OF COAL IN PAKISTAN

Coal had historically been the primary fossil fuel for Pakistan with the major consumers being railways, cement, fertilizer, and power plants. This held true until large deposits of oil and natural gas were discovered in the 1960s (PakistanEcon, 2001). As of 2011, coal provided for only 6 percent of Pakistan's total primary energy consumption, compared to natural gas at 47 percent and petroleum at 35 percent (EIA, 2014). Pakistan is facing an unprecedented energy crisis due to a surging demand and supply gap. Its current energy needs are heavily dependent on oil and gas and the demand far exceeds its indigenous resources such as coal, hydro, and renewable sources (PakMinPlan, 2014). The current demand and supply gap of 5,000-8,000 MW and demand growing at 8 percent per year ensures guaranteed uptake of power produced by independent power producer projects at market competitive prices (BOI, 2014).

Pakistan has one of the world's largest lignite reserves in the Tharparkar district of Sindh, found in the early 1990s and estimated at more than 185 billion tonnes (PakTribune, 2010). Table 25-1 indicates Pakistan's recoverable coal reserves to be 2,070 million tonnes (Mmt). Total estimated resources are far more extensive and may offer greater recovery ultimately. The total in-ground resource is estimated to be 185,000 Mmt, of which about 2,000 Mmt are presently mineable and 3,400 Mmt are measured (PakGeoSurvey, 2014).

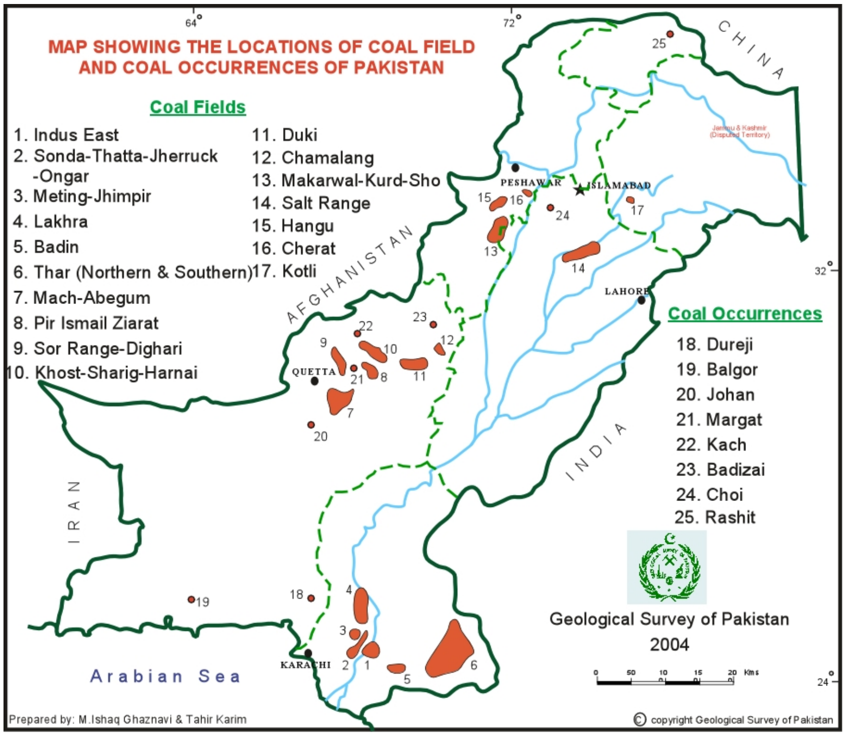
Table 25-1. Pakistan's Coal Reserves and Production

Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2011)	0	2,070	2,070	21 (0.2%)
Annual Coal Production (2012)	1.9	1.2	3.1	38 (0.04%)

Source: EIA (2014)

Pakistan is divided up into four provinces and four federal territories. Coal is found in all four provinces, but the bulk (around 98 percent) is in Sindh province, where the Thar coalfield is located (Figure 25-1).

Figure 25-1. Pakistan's Coal Fields



Source: PakGeoSurvey (2004)

25.1.2 STAKEHOLDERS

State-owned companies control the production and marketing of coal. The Mineral Department of the Ministry of Petroleum and Natural Resources is responsible for the exploration, planning, development, and operation of mining ventures that are controlled by the state-owned companies (USGS, 2014). The Government of Sindh and the Thar Coal Development Authority are other governmental bodies that claim ownership and/or control over the resources.

Key stakeholders involved in Pakistan's coal and the coal mine methane (CMM) development industries are outlined in Table 25-2.

Table 25-2. Key Stakeholders in Pakistan's CMM Industry

Stakeholder Category	Stakeholder	Role
Developer	▪ Cathay Oil & Gas Ltd.	Holds rights to CBM and groundwater in Sindh
	▪ M/s Rheinbraun Engineering	Mining feasibility studies
	▪ Lakhra Coal Development Authority (LCDC)	Project development
	▪ Pakistan Mineral Development Corporation (PMDC)	Project development
	▪ Deep Rock Drilling (pvt) Ltd.	Mining feasibility studies
Mining Companies	▪ Kathwai Coal Mines Pvt Ltd	Project hosts
	▪ Habibullah Mines Ltd.	
	▪ United Musakhel Mining Company (Pvt) Limited	

Table 25-2. Key Stakeholders in Pakistan's CMM Industry

Stakeholder Category	Stakeholder	Role
Universities and Research Centers	▪ Pakistan Institute of Engineering and Applied Sciences, Islamabad	Technical assistance
	▪ National University of Sciences & Technology Rawalpindi	
	▪ Ghulam Ishaq Khan Institute of Engineering, Swabi	
	▪ University of Eng. & Technology (UET), Lahore	
Energy Companies	▪ Habibullah Energy Limited (HEL)	Investment, energy production
	▪ Pak Energy (Pvt) Ltd	
	▪ Pakistan Electric Power Company (PEPCO)	
Investment Groups	▪ Al Abbas Group	Investment
Government Groups	▪ Ministry of Petroleum and Natural Resources	Licensing, exploration, production
	▪ Thar Coal Development Authority, Government of Sindh,	Licensing, exploration, production
	▪ Geological Survey of Pakistan	Technical assistance
	▪ Hydrocarbon Development Institute of Pakistan (HDIP)	Technical assistance

25.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

The contest between the national and provincial governments over the energy resources of Pakistan has stalled some development efforts. As part of a larger government plan to boost private sector ownership and involvement in industry and energy sectors, some government-created entities like the Lakhra Coal Development Authority (LCDC) have been transitioned to public-private entities. The goal is to encourage development and take advantage of market efficiencies, but these efforts have not been entirely successful. In 2007, the LCDC had 44 mines fully developed and capable of each producing 40 to 50 tonnes of coal per day, with another 39 mines under development (PakMinPet, 2007). After 17 years of operation, LCDC had developed less than 30 percent of the potential 149 mines in the Lakhra field and is able to meet only 60 percent of the coal requirements of the associated Lakhra power plant, which is often forced to operate below capacity (Siddiqui, 2008).

Additionally, American, Chinese, and German companies, among others, have been brought in to provide mining feasibility studies to encourage international investment, but questions over coal quality, infrastructure, and government support have caused many potential international investors to pull out of major projects (Haider, 2007; PakTribune, 2010).

Pakistan is still in the process of drafting a national coal policy. There have been repeated attempts to draft a policy since at least 2001, but they have not been successful as yet (Bhutta, 2010; Siddiqui, 2008). This lack of policy has hurt the development of the Thar deposits found in the 1990s and has impeded Pakistan's progress in developing mining technologies and attracting CMM investments (Chaudhry, 2007).

Table 25-3 lists some of the major coal mines in operation in Pakistan.

Table 25-3. Operating Coal Mines in Pakistan

Coal Field	Mine	Coal Rank	Mine Type	Operator
▪ Lakhra*	▪ Lakhra Collieries	Sub-bituminous to lignite	underground	PMDC
▪ Degari- Sor-Range*	▪ Degari Collieries	Sub-bituminous-A to high volatile B-bituminous	underground	PMDC
▪ Degari- Sor-Range*	▪ Sor- Range	Sub-bituminous-A to high volatile B-bituminous	underground	PMDC
▪ Shahrig- Khost- Harnai*	▪ Shahrig	Sub-bituminous-A to high volatile B-bituminous	underground	PMDC
▪ Lakhra Coal Field	▪ Multiple	Sub-bituminous to lignite	underground	LCDC

Sources: *PMDC (2014); **MBendi (2014)

25.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Pakistan, in operation or under development (GMI, 2014). Updates on future CMM projects in Pakistan can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

25.2.1 CMM Emissions from Operating Mines

Methane emissions in Pakistan totaled 66.5 million cubic meters (m^3) in 2000, but are projected to increase to 86.8 million m^3 by 2015, and then anticipated to further increase to 119 million m^3 by 2030 (see Table 25-4).

Table 25-4. Pakistan's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	66.5	105.0	79.1	86.8

Source: USEPA (2012)

25.2.2 CMM Emissions from Abandoned Coal Mines

No data about methane emissions from abandoned mines in Pakistan are available at this time.

25.2.3 CBM from Virgin Coal Seams

In 2007, Cathay Oil & Gas Ltd. (a Canada-based company) acquired sole rights to coal bed methane (CBM) and groundwater in Sindh, including the Thar coal field. The field has an estimated 1.0

trillion m^3 of CBM resource and up to 0.6 trillion m^3 of recoverable gas (USEPA, 2007). In 2013, Cathay obtained the go-ahead to explore and develop the CBM resources under the "Thar Coal Methane project" that aims to produce 0.14 trillion m^3 of methane gas over a 30-year period (Business Recorder, 2013).

25.3 Opportunities and Challenges to Greater CMM Recovery and Use

As reflected in Table 25-5, Pakistan is a signatory to both the UNFCCC and the Kyoto Protocol. Pakistan is a Non-Annex I Party.

Table 25-5. Pakistan's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	June 1, 1994
Kyoto Protocol	-	January 11, 2005

Source: UNFCCC (2014)

In 2013, Pakistan's Ministry of Climate Change in Islamabad launched its first National Climate Change Policy. The policy was approved in September 2012 and provides a framework for coping with the impacts of climate change through adaptation and mitigation measures. Promotion of renewable energy sources and efficient mass transport systems are in the lineup of policy measures and financing options for projects include the Green Climate Fund and formation of a National Climate Change Fund (Express Tribune, 2013).

25.3.1 Market and Infrastructure factors

Pakistan has experienced low domestic demand for coal resources, though this is beginning to change as domestic oil and natural gas suppliers reach production limits and as international energy prices increase. Despite this improving environment, conflicts between the various controlling interests within the Pakistani government have prevented a unified approach to coal resources and coal mining and thus to CMM/CBM utilization. Until there is a national coal policy and strong government interest in and focus on developing coal resources, there will not be a strong domestic market for development, nor strong international interest or confidence for investment.

Further, CMM and CBM infrastructure in Pakistan is practically non-existent currently; gas gathering, compression, and transmission infrastructure will be needed before any significant production is viable. Significant investment in coal mining infrastructure including basic resource survey and access to key supporting resources like water, roads, and electrical transmission lines will be needed before there is sufficient capability and potential for CMM/CBM development.

25.3.2 Regulatory Information

Pakistan is transitioning many of the minerals and natural gas entities from government ownership and control to private ownership or public-private ownership. This is part of a larger effort toward deregulation, reducing government debt burden, and taking advantage of the improved efficiency of market forces. The Privatization Commission (http://www.privatisation.gov.pk/) is responsible for the transition.

The Ministry of Petroleum and Natural Resources governs the activities and regulations for the coal mining industry and CMM/CBM industry. The ministry recently released a National Petroleum Policy (PakMinPet, 2009) and is drafting a National Coal Policy.

25.4 Profiles of Individual Mines

Individual mine profiles are unavailable.

25.5 References

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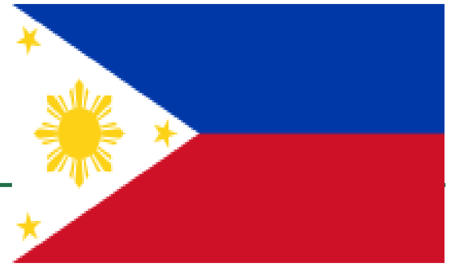

26 Philippines

26.1 Summary of Coal Industry

26.1.1 Role of Coal in the Republic of the Philippines

Currently, coal-fired thermal power plants remain the number one producer of electricity and accounted for a total of 5,568 megawatts (MW), or 33 percent, of the Republic of the Philippines' total installed power generating capacity in 2012 (PDOE, 2014a). The Philippines consumed 16.3 million tonnes (Mmt) of coal in 2012, around 75 percent of which was for power generation (EIA, 2014; Ocampo, 2012). The Philippines relies on imports to meet coal demand, importing 10.6 Mmt from Indonesia and 277 thousand tonnes from Vietnam in 2011 (Ocampo, 2012). The Philippine Energy Plan 2012-2030 (PEP) projects coal demand to increase by more than 70 percent between 2012 and 2030 (PDOE, 2014b).

The country's recoverable coal reserves, as shown in Table 26-1, are estimated at 315 Mmt, with most reserves as lignite. Total coal resources compiled by the Geothermal and Coal Resources Development Division (GCRDD) of the Department of Energy of the Philippines, are estimated at a minimum of 2,268.4 Mmt (USGS, 2006).

The Philippines produced 8.0 Mmt of coal in 2012, the highest annual production to date. Coal production is increasing rapidly, more than doubling between 2008 and 2012 (EIA, 2014). The PEP projects domestic coal production to continue to increase, reaching more than 11 Mmt in 2015 and more than 12.5 Mmt in 2020 (PDOE, 2014b).

Table 26-1. Philippines' 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)	41	275	315	41 (0.04%)
Annual Coal Production (2012)	8.0	0.0	8.0	29 (0.10%)

Source: EIA (2014)

The combined lignite and sub-bituminous coal reserves of the Philippines, including indicated and inferred reserves, are about 1,899.2 Mmt, which make up about 84 percent of the total coal reserves of the Philippines. The remaining reserves are composed of bituminous and semi-anthracite coal (USGS, 2006).

The Philippines has 19 coal districts. The largest total coal resource is estimated at 570 Mmt of sub-bituminous coal and is located in the Semirara coal district located on Semirara Island, which is located approximately 280 kilometers to the south of Manila and can be seen in Figure 26-1 below, just south of Mindoro (Ocampo, 2012). The northern part of Semirara Island is dominated by the Panian coalfield, the largest of three coalfields on the island. Other coalfields on Semirara include the East Panian, and Himalian coalfields (USGS, 2006). A fourth coalfield, the Unong coalfield, has been mined out. Other coal districts with large reserves include Cagayan-Isabella of northern Luzon and Sultan-Kudarat of Mindanao. Reserves and coal rank for all of the Philippines' coal districts are shown in Table 26-2 below.

Figure 26-1. Philippines' Coal Resources

Sources: Modified from Schwochow (1997); USGS (2006)

Table 26-2. Philippines' Coal Districts

Coal District	Coal Rank	Coal Reserves (million tonnes)
Samar-Leyte	Lignite	27.0
Cotabato	Sub-bituminous/Lignite	230.4
Quirino	Sub-bituminous/Lignite	0.7
Cagayan-Isabella	Sub-bituminous/Lignite	336.0
Sarangani	Sub-bituminous/Lignite	120.0
Sultan-Kudarat	Sub-bituminous/Lignite	300.3
Sorsogon	Sub-bituminous	1.0
Negros	Sub-bituminous	4.5
Davao	Sub-bituminous	100.0
Batan Island	Sub-bituminous	11.8
Masbate	Sub-bituminous	2.5
Quezon-Polilio	Sub-bituminous	6.0
Semirara	Sub-bituminous/Bituminous	570.0
Surigao	Sub-bituminous/Bituminous	209.0
Zamboanga-Sibugay (Malangas)	Sub-bituminous/Bituminous	45.0
Cebu	Sub-bituminous/Bituminous	165.0
Catanduanes	Bituminous/Anthracite	1.2
Bukidnon	Unknown	50.0
Maguindanao	Unknown	108.0

Sources: USGS (2006); Ocampo (2012)

26.1.2 STAKEHOLDERS

Table 26-3 identifies potential key stakeholders in the Philippines' coal mine methane (CMM) development.

Table 26-3. Key Stakeholders in the Philippines' CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ 3 Kings Sunrise Mining Corp. ▪ A Blackstone Energy Corp. ▪ Abacus Coal Exploration & Development Corp. ▪ Adlaon Energy Development Corp. ▪ Agusan Petroleum & Mineral Corp. ▪ Aragorn Coal Resources, Inc. ▪ ASK Mining & Energy Corp. ▪ Batan Coal Resources Corp. ▪ Benguet Corp. ▪ Bislig Ventures Construction & Development Corp. ▪ Blackgem Resources & Energy, Inc. ▪ Bonanza Energy Resources, Inc. ▪ Brixton Energy & Mining Corp. ▪ Calatrava Coal Corp. ▪ Cedaphil Mining Corp.	Project hosts

Table 26-3. Key Stakeholders in the Philippines' CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies (con't)	▪ Coal Mountain Ventures, Inc. ▪ Core8 Mining Corp. ▪ D.M. Consunji-Construction Equipment Resources, Inc. ▪ D.M. Wenceslao & Associates, Inc. ▪ Daguma Agro-Minerals, Inc. ▪ Dell Equipment & Construction Corp. ▪ E-Oil & Gas Company, Inc. ▪ Filsystems, Inc. ▪ First Asian Resources & Mining Corp. ▪ Forum Cebu Coal Corp. ▪ Great Wall Mining & Power Corp. ▪ Guidance Management Corp. ▪ Ibalong Resources & Development Corp. ▪ Il Rey'c Exploration & Mining Corp. ▪ Lebach Mining Corp. ▪ LIMA Coal Development Corp. ▪ Monte Oro Resources & Energy, Inc. ▪ MS-SK Coal Corp. ▪ Oriental Energy & Power Generation Corp. ▪ Philippine National Oil Company ▪ Rock Energy International Corp. ▪ Samaju Corp. ▪ SERI ▪ Semirara Mining Corp. ▪ SKI Energy Resources, Inc. ▪ Sultan Energy Philippines Corp. ▪ Titan Mining & Energy Corp. ▪ Visayas Multi-Minerals & Trading Corp.	Project hosts
Engineering, consultancy, and related services	▪ R.M.B. Earth Science Consultants Ltd.	Technical assistance
Universities, Research Establishments	▪ Philippine Council for Industry and Energy R & D ▪ Cebu Institute of Technology	Technical assistance
Regulatory Agencies and Government Groups	▪ Philippine Department of Energy ▪ Philippine National Oil Company ▪ Philippine Department of Environment and Natural Resources – Mines and Geosciences Bureau	Project identification and assessment support

Sources: PDOE (nd); PMEA (nd); TFL (2009); USGS (2006); Ocampo (2012)

26.1.3 Status of Coal and the Coal Mining Industry

The Philippines' largest coal producer is Semirara Mining Corp., which accounts for about 94 percent of domestic coal production (Ocampo, 2012). Additional resources are being mined in Cebu, Zamboanga Sibugay, Albay, Surigao del Norte, and Negros provinces as shown in Table 26-4.

Currently most of the coal mined in the Philippines is from the large surface mine at Semirara; however, the remainder is produced from small underground mines (Flores, 2014). The Integrated Little Baguio colliery is the Philippines' largest semi-mechanized underground mine and is located in Malangas, Zamboanga-Sibugay (PNOC-EC, 2012).

Table 26-4. Coal Production by Area 2011

Area	Production (million tonnes)	Percent of Total Production	Coal Operator
Semirara Island, Antique	7,190,363	94.47	▪ Semirara Mining Corporation
Zamboanga Sibugay	168,951	2.22	▪ PNOC-EC ▪ Filsystems ▪ Brixton Energy & Mining Corp.
Cebu	85,063	1.12	▪ Adlaon Development Corp. ▪ SERI ▪ Ibalong Resources Dev. Corp. ▪ Il Rey'c Exploration & Mining Corp.
Surigao del Sur	26,980	0.35	▪ Bislig Venture & Dev. Corp.
Albay	18,395	0.24	▪ Batan Coal Corp. ▪ Samaju Corp. ▪ Lima Coal Mining Corp. ▪ Ibalong Resources Dev. Corp.
Negros	2,060	0.03	▪ Calatrava Coal Miners' Cooperative
Small-scale Coal Mining	119,521	1.57	

Source: Ocampo (2012)

The Philippines consumes all domestically-produced coal and relies on imports to meet power generation, cement production, and industrial process demand (Ocampo, 2012). As of 2013, the country was operating 14 coal-fired power plants with combined capacity of 5,568 MW (PDOE, 2014c) as shown in Table 26-5.

Table 26-5. Coal-fired Power Plants as of 2013

Facility Name	Capacity (MW)		Number of Units	Location	Owner	Year Commissioned
	Installed	Dependable				
Pagbilao	764.0	764.0	2	Pagbilao, Quezon	TeaM Pagbilao	1996
Calaca	600.0	510.0	2	Calaca, Batangas	SEM Calaca Power Corp.	1984
Masinloc	630.0	630.0	2	Masinloc, Zambales	Masinloc-Power	1998
Sual	1,294.0	1,294.0	2	Sual, Pangasinan	TeaM Sual Corporation	1999
Quezon Power	511.0	460.0	1	Mauban, Quezon	Quezon Power Phils.	2000

Table 26-5. Coal-fired Power Plants as of 2013

Facility Name	Capacity (MW)		Number of Units	Location	Owner	Year Commissioned
	Installed	Dependable				
APEC	50.0	42.0	1	Mabalacat, Pampanga	Asia Pacific Energy Corp.	2006
UPPC	30.0	24.0	1	Calumpit, Bulacan	United Pulp & Paper Co., Inc.	1998
Mariveles Coal	651.6	495.0	2	Marveles, Bataan	GN Power Mariveles Coal Plant	2013
Mindanao Coal	232.0	210.0	2	Villanueva, Misamis	STEAG State Power Inc.	2006
PEDC Coal	164.0	164.0	2	Iloilo City, Panay	Panay Energy Development Corporation	2011
Toledo Power Corp.	88.8	60.0	4	Toledo City, Cebu	Global Business Power Corp.	1993
Cebu TPP (Salcon)	106.8	106.8	2	Naga, Cebu	Salcon Phils.	1981
CEDC Coal	246.0	246.0	3	Toledo City, Cebu	Cebu Energy Development Corporation	Testing and commissioning as of 2013
Korea Electric Power Corp. Coal	200.0	200.0	2	Naga, Cebu	KepCo-Salcon	2011
Total	**5,568.2**	**4,995.8**				

Source: PDOE (2014c)

There are also 10 cement plants operating on coal as well as six industrial plants, including smelting, and phosphate, alcohol, and rubber production (Ocampo, 2012).

26.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no CMM recovery projects in the Philippines.

A CMM project was planned by Semirara Mining Corp. which signed a memorandum of agreement in late 2009 with Endesa Carbono S.L. to implement a CMM extraction, flaring, and power generation project on Semirara Island (Gatdula, 2011); however, the project was abandoned. The proposed project would have captured methane released by the open pit mining operations through pre-mining drainage. The captured methane and the electricity generated were expected to reduce greenhouse gas emissions by an average of 385,478 tonnes of carbon dioxide equivalent per year (UNFCCC, 2011).

A 2008 report indicated that a preliminary evaluation of CMM in the Visayan and Zamboanga Basins suggests a potential for gas drainage development during mining (Flores et al, 2008).

26.2.1 CMM Emissions from Operating Mines

Table 26-6 summarizes the Philippines' CMM emissions.

Table 26-6. Philippines' CMM Emissions (million cubic meters)

Emission Category	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	14.2	30.2	26.5	29.0

Source: USEPA (2012)

The Philippines has a number of gassy coal mines, as indicated by a number of methane-related mine accidents. An explosion in the town of Imelda in Zamboanga Sibugay province caused the death of a worker and injured four others in December 2009. In 1995, a coal mine tunnel in Malangas was destroyed by a massive methane gas explosion, which killed more than 100 people (Mining-Technology.com, 2009).

26.2.2 CMM Emissions from Abandoned Mines

No information relating to recovery or use of CMM from abandoned mines was found.

26.2.3 CBM from Virgin Coal Seams

The United States Geological Survey (USGS) and the Philippines Department of Energy (PDOE) launched a collaboration to determine the methane gas content and adsorptive capacity of Philippine coal. The study entitled "Assessment of Philippine Coal Bed Methane" identified several coals, from lignite to semi-anthracite, in the country that possess large gas storage capacity. In Table 26-7 below, the results of the study are summarized. Total potential minimum coal bed methane (CBM) in-place resources in the Philippines are estimated at 16,416 million cubic meters (m^3).

Table 26-7. Philippines' Potential CBM In-Place Resources

Coal District Area	Coal Rank	Potential CBM In-Place Resources (million cubic meters)
Samar-Leyte	Lignite	183
Cotabato		1,037
Cagayan-Isabella		652 - 2,400
Negros	Sub-bituminous	5
Semirara		3,361
Surigao		1,120

Table 26-7. Philippines' Potential CBM In-Place Resources

Coal District Area	Coal Rank	Potential CBM In-Place Resources (million cubic meters)
Bataan Island	Bituminous	119
Catanduanes		36
Cebu		2,670 – 3,530
Zamboanga – Sibuguey (Malangas)	Semi-Anthracite	580 – 1,033

The potential minimum CBM in-place resources (in million m^3) estimated for Philippines coal districts based on ideal gas storage capacity (100 percent gas saturation).
Source: USGS (2006)

There are currently no CBM projects in the Philippines.

26.3 Opportunities and Challenges to Greater CMM Recovery and Use

The Philippines is a signatory to both the UNFCCC and the Kyoto Protocol (see Table 26-8). As a Non-Annex I Party to the Kyoto Protocol, it has no national emissions targets and was eligible to host mitigation projects under the Clean Development Mechanism (CDM). The Semirara CMM Project was stopped during validation as a CDM project.

Table 26-8. Philippines' Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	August 2, 1994
Kyoto Protocol	April 15, 1998	November 20, 2003

Source: UNFCCC (2014)

26.3.1 Market and Infrastructure Factors

As mentioned in section 26.1.1, the PEP projects coal demand to grow by 70 percent between 2012 and 2030. With the increase in power demand, coal mining is expected to remain a steady source for power plants. Additionally, natural gas demand is expected to grow in the Philippines, opening up opportunities for CMM and CBM. As of 2013, installed natural gas power generation capacity was 3,537 MW including 675 MW of gas turbine capacity, or a 20 percent share of overall generating capacity (PDOE, 2014c). In 2013, the Philippines produced 3.5 billion m^3 of natural gas, consuming 3.3 billion m^3 for power production and 75 million m^3 for industrial use, including the Pilipinas Shell Refinery (PDOE, 2014d). During 2013, an average of 19 compressed natural gas (CNG) buses were loaded daily.

Total natural gas demand for the year 2014 is projected to reach 3.8 billion m^3, reflecting a projected increase in consumption of 13 percent in the power generating sector, 24 percent in the industrial sector and 74 percent in the transport sector. The transportation sector will see large gains as additional buses are expected to be brought online in 2014, and bidding for equipment and civil works for two additional CNG stations was completed in late 2013 (PDOE, 2014e).

26.3.2 Regulatory Information

The Philippine Department of Energy (PDOE) is the primary regulatory entity involved with CMM development. The PDOE regulates mine safety and sets limits for methane concentration in mine workings and ventilation air (PDOE, 1981). In 2007, at the Association of Southeast Asian Nations Forum on Coal, the Philippines discussed modifying the contracts and licenses for CBM development under coal operating contracts instead of service petroleum contracts (ASEAN, 2007). No guidelines or circulars concerning CBM development are available from the PDOE.

26.4 Profiles of Individual Mines

26.4.1 Panian Mine, Semirara Mining Corporation

Semirara Mining Corporation (Semirara) is the largest coal producer in the Philippines and is engaged in surface mining of thermal coal from the Panian mine on Semirara Island, in Antique province. Semirara Island covers an area of 55 square kilometers (km) and is located 350 km south of Manila. Coal resources have been discovered at four separate sites on Semirara Island, namely Panian, Bobog, Himalian and Unong; however, Semirara operates one mine at the Panian site. Operations at Unong mine ceased in 2000 after 17 years of extraction. Coal produced at the Panian mine is sold domestically to power plants, cement plants, paper mills, textile dying plants, canneries, food factories, a sugar mill, and a fertilizer plant. In 2007, Semirara commenced export to China and is now selling coal to China, India, Japan, Taiwan, and Thailand. In 2010, remaining recoverable reserves at Panian mine were estimated at 42.41 million metric tonnes (Semirara, 2014).

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27 Poland

27.1 Summary of Coal Industry

27.1.1 Role of Coal in Poland

Poland ranks ninth globally in coal production and produced 143.5 million tonnes (Mmt) in 2012, accounting for 1.82 percent of global production (EIA, 2013). Hosting the second largest coal reserves in the European Union, coal provides for two-thirds of Poland's energy demand and more than 75 percent (inclusive of peat) of its primary energy production (EIA, 2013).

Table 27-1. Poland's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous and Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	4,178	1,287	5465	16 (0.615%)
Annual Coal Production (2012)	79.2	64.3	143.5	9 (1.82%)

Sources: EIA (2013)

The World Energy Council estimates similar proven Polish coal reserves for anthracite and bituminous in 2011 at 4, 178 Mmt, and reserves for lignite and sub-bituminous of 1, 287 Mmt (EIA, 2011). An in-country estimate from 2002 estimates reserves of 63,000 Mmt and 14,000 Mmt, for hard coal and lignite, respectively (Palarski, 2003).

As seen in Figure 27-1, Poland's hard coal reserves are located in three fields: the Upper and Lower Silesian Basins, and the Lublin Basin. The Upper Silesian Basin (USB) is currently the major coal producer, while the Lower Silesian Basin is completely abandoned, and only one mine is operational at the Lublin Basin. Lignite basins are located in central and western Poland, with four of them currently in production (WEC, 2014).

Figure 27-1. Poland's Major Coal Basins

Poland's Lignite Deposits

Location of Hard Coal Basins

Source: Volkmer, 2008

27.1.2 STAKEHOLDERS

Table 27-2 lists potential stakeholders in coal mine methane (CMM) development in Poland.

Table 27-2. Key Stakeholders in Poland's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ Kompania Weglowa, S.A. ▪ Katowki Holding Weglowy ▪ Jastrzebska Spolka Weglowa, S.A. Company (JSW) ▪ Independent Mines: Budryk, Bogdanka and Jaworzno ▪ Siltech	Project hosts
Regulatory Agencies	▪ Polish Geological Institute	Project identification and assessment support
Natural Gas Transmission & Distribution Companies	▪ Polish Oil and Gas Company or PGNiG (http://www.pgnig.pl/?s,main,language=EN), OGP GAZ-SYSTEM (http://en.gaz-system.pl/)	Gas distribution and storage
Government Groups	▪ Ministry of Natural Resources ▪ Ministry of Economy ▪ Central Mining Institute	Licensing

Table 27-2. Key Stakeholders in Poland's CMM Industry

Stakeholder Category	Stakeholder	Role
Other	▪ U.S. Trade and Development Agency ▪ Metanel S.A. ▪ World Bank ▪ U.S. Environmental Protection Agency, www.epa.gov/coalbed/networkcontacts.html ▪ European Investment Bank ▪ European Union's PHARE Program ▪ Institute for Ecology of Industrial Areas (IETU) ▪ Strata Mechanics ▪ LNG Silesia	Project identification and assessment support

27.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Coal is one of Poland's largest industries and employers, but inefficiencies resulted in large annual losses, spurring the government to reform the sector. In 1998, the government introduced a five-year (1998-2002) Hard Coal Sector Reform Program, which reduced employment from 248,000 to 140,000 by the end of 2002. In February 2003, the Polish government consolidated several failing coal firms to form Kompania Weglowa, which is now one of Europe's largest coal companies. Kompania Weglowa includes mines from five firms: Bytomska, Rudzka, Gliwicka, Nadwislanska, and Rybnicka. Table 27-3 illustrates Poland's declining mine statistics from 2004 to 2008. In November 2003, the government introduced a second program to further consolidate and reform Poland's coal sector – Program of Restructuring of the Hard Coal Mining Sector for 2003 to 2006 (World Bank, 2004). Poland received a World Bank loan of $100 million in 2004 to support the restructuring program, requiring a workforce reduction of 25,500 mining sector jobs from 2004 to 2006 and for voluntary closure of inefficient mines (World Bank, 2007).

The restructuring program also planned to privatize the country's coal industry by 2006. Privatization of Polish coal mines began with a sale of 45 percent of the Bogdanka mine to Management Bogdanka, a private company of investors. Other privatizations followed, with PricewaterhouseCoopers advising the Ministry of the Economy. Privatization of the coal industry was, however, halted by the Polish government in 2006. The World-Bank-supported restructuring program had been suspended by the Polish government in 2006 because the coal industry had become more profitable and only two mines had been closed through the project. The Polish government decided that any further mine closures would be handled by the mine companies and not by the Mine Restructuring Company (SRK). The loan balance was returned (World Bank, 2007).

The restructuring program has led to substantial changes in Poland's three major coal basins. Specifically, the Lower Silesian Coal Basin was closed leaving only the Upper Silesian Basin and the efficient Lublin Coal basin open for production and subsequent expansion. Post restructuring, the Polish coal industry has experienced "periods of profitability". However, market forces and increasing foreign coal imports have acted to threaten its domestic coal industry. Poland's goal of commercializing and privatizing the mining companies was completed by 2009 (Suwala, 2010).

Table 27-3. Poland's Coal Mines, 2004 versus 2008

Company	Number of Mines, 2004*	Number of Mines, 2008**
Kompania Weglowa (KW)	23 (51 Mmt/yr)	16
Katowki Holding Weglowy (KHW)	9 (19 Mmt/yr)	6
Jastrzebska Coking Coal Company (JSW)	5 (14 Mmt/yr)	6
Independent Mines: Bogdanka, Budryk, and Jaworzno	3 (11 Mmt/yr)	NA

Source: *World Bank (2004), **DOC (2008)

As per Poland's Central Mining Institute of Katowice, there were 33 coal mines in operation, with 29 of them classified as gassy, 20 of them employing degasification systems and 14 of them utilizing the drained methane as of 2008 (IEA, 2008).

27.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies three active CMM recovery projects in Poland, in addition to four proposed projects (GMI, 2014). Poland has extensive experience in CMM recovery and utilization as demonstrated by JSW's unique project at Pniowek mine that implements three onsite end uses: electricity, heating, and cooling. A Cogeneration Power-Cooling System supplies power to the central air conditioning system and was the first of its kind upon its launch (UNECE, 2009). In addition to JSW, Kompania Weglowa has implemented a power project using CMM at the Knurow-Szczyglowice mine and is planning for a VAM project at the Brzeszcze Mine.

27.2.1 CMM Emissions from Active Mines

In 2010, coal mining was the source of 22.6 percent of the country's overall methane emissions (USEPA, 2012), with total emissions equaling 2,364 million cubic meters (m^3). Table 27-4 summarizes Poland's CMM emissions by mining category. The data in this table may vary from the USEPA data presented in the Executive Summary due to differences in inventory methodology and rounding of digits.

Table 27-4. Poland's CMM Emissions (million cubic meters)

Emission Category	2000	2005	2010	2015 (projected)*
Underground coal mines – mining activities	690.26	600.71	446.87	
Underground coal mines – post-mining activities	49.38	45.43	35.08	
Surface coal mines-mining activities	1.08	1.11	1.02	
Solid Fuel Transformation	6.37	5.96	6.91	
Emission from coke oven gas subsystem	4.43	3.92	6.14	
Total emitted	**740.73**	**647.25**	**482.97**	**530.39**

Sources: UNFCCC (2013); *USEPA (2012)

As of 1997, about 300 million m³ was being drained from Polish coal mines annually, with 65 to 70 percent of drainage being used at the mine sites or sold to outside consumers, and the rest vented (Schwochow, 1997). Methane recovery, however, has declined over the years, mainly due to the closure of numerous mines. Of an estimated 870 million m³ of methane emissions in 2006, less than 30 percent was removed through degasification (IEA, 2008). In 2008, 269 million m³ was removed through degasification, with about 166 million m³ utilized and 103 million m³ released into the atmosphere (Skiba, 2009). In 2011, about 268.97 million m³ was removed through degasification systems, which comprised approximately 13 percent of methane emissions for 2011 (UNFCC, 2013). Skiba reports that 259.7 million m³ , or 31 percent of total methane emissions was captured by degasification systems in 2013, and drained gas volumes are expected to increase in 2014 Of this total, 187.8 million m³ was used in 2013 (Skiba, 2014).

A 2005 study by Kwarciński showed that in 2003, venting systems resulted in emissions equal to 3.8868 Gg CH_4/Mg of extracted coal. Methane capture systems resulted in 0.6651 Gg CH_4/Mg of extracted coal. The post-mining processes led to 0.2873 Gg CH_4/Mg of extracted coal, and production waste contributed 0.0194 Gg CH_4/Mg of extracted coal (KOBiZE, 2011).

Although the number of gassy mines has decreased in Poland by 48 percent from 1989 – 2005, absolute gassiness has dropped by only 19 percent over the period, indicating an increasing share of gassy coal mines in the country. This scenario represents an opportunity for CMM recovery and utilization projects (IEA, 2008). CMM capture is forecasted to increase to 320.5 million m³ by 2015, with an estimated utilization potential of 1068 GWh (Skiba, 2009).

Poland has an open, emerging market economy that should be conducive to CMM project implementation, and Polish mining authorities are supportive of CMM development initiatives (IRG, 2003). Actions similar to the World Bank's industry restructuring loan should also constitute positive factors favoring project development.

GMI awarded a grant in 2008 to the Central Mining Institute of Katowice, Poland to provide "Detailed Characteristics of the Ventilation Air Methane Emissions from Ten Gassy Underground Coal Mines in Poland," and another in 2009 to perform a "Pre-feasibility Study for Degasification and Methane Capture Before Mining at the Pawlowice I Coal Field.," A third grant was awarded to the Institute for Ecology of Industrial Areas in 2008 to perform an "Abandoned Mine Feasibility Study and Coal Mine Methane to Liquefied Natural Gas Assessment" at the Zory coal mine in the

Silesian region (M2M Agreements, 2008; M2M Agreements, 2009). Most recently, U.S. EPA initiated a pre-feasibility study to examine the use of in-mine horizontal wells to degasify seams in advance of mining, as well as for developing horizontal GOB wells.

The Ministry of Environment has launched a project to further investigate surface directional drilling in advance of mining as an effective degasification tool. If successful, then the volume and quality of CMM could increase providing additional gas for utilization (Skiba, 2014).

27.2.2 CMM Emissions from Abandoned Coal Mines

No data quantifying emissions from abandoned Polish mines are currently available, though the methane volume in abandoned coal mines in the USB was estimated in 2006 to range from 150 to 200 billion m^3 (Nagy, 2006).

27.2.3 CBM from Virgin Coal Seams

Estimated in-place coal seam gas resources in Poland are summarized in Table 27-5. One estimate of resources in actively mined and undeveloped coals in the USB yields 1,300 billion m^3 of coal bed methane (CBM) to a depth of 1,500 m. A different method used by the Polish Geological Institute yields a more conservative estimate of 350 billion m^3, of which 210 billion m^3 exists in virgin coal. Including the Lower Silesian and Lublin basins, total in-place CBM resources range from 425 to 1,450 billion m^3 (Schwochow, 1997).

Table 27-5. Poland's In-Place CBM Resources

Coal Basin	Gas Content		Gas in Place	
	m^3/Mg	m^3/t	billion m^3	Tcf
Upper Silesian, first estimate*				
Active mines to 1,000 m (3,280 ft)	—	—	370	13.1
Undeveloped coal to 1,000 m (3,280 ft)	—	—	340	12.0
Coal at 1,000–1,5000 m (3,280–4,920 ft)	—	—	590	20.8
Subtotal	≤ 22	≤ 20	1,300	45.9
Upper Silesian, second estimate†				
Coal to 1,500 m (4,920 ft)	≤ 20	≤ 18.1	350	12.4
Lower Silesian‡	≤ 30	≤ 27.2	25-50	0.9-1.8
Lublin‡	25	22.7	50-100	1.8-3.5
Total	**≤ 97**	**≤ 88**	**425-1,450**	**15-51**

Sources: *Hoffman and Weil (1993); †Surówka (1993); ‡Grzybek (1996), as presented in Schwochow (1997)

The USB first attracted CBM developers in early 1990s. Several CBM concessions were granted from 1991 – 1997, but none of these could establish commercial production of CBM. CBM production in Poland is contingent on the availability of highly specialized equipment, as well as expertise (Hadro, 2008).

27.3 Opportunities and Challenges to Greater CMM Recovery and Use

Poland has signed and ratified the UNFCCC and Kyoto Protocol, as indicated in Table 27-6. As an Annex 1 country, Poland is eligible to host Joint Implementation (JI) projects that can acquire revenue from the sale of carbon credits. In February 2008, the first JI project in Poland was initiated to capture and utilize CMM at the KWK Borynia Coal Mine (JI, 2008). Subsequent to the Borynia Mine project, Kompania Weglowa implemented a JI project in 2009 at the Knurow-Szczyglowice Mine in cooperation with Chugoko Electric Power of Japan to produce electricity from CMM.

Polish Licensing Authority
The Ministry of Natural Resources Ul. Wawelska 52/54 00-922 Warszawa Contact: Jacek Wroblewski Phone: 48 22 251503, 48 22 250001 int. 335 Fax: 48 22 251503, 48 22 253972 Email jwroble@mos.gov.pl Website http://www.mos.gov.pl/

Table 27-6. Poland's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 5, 1992	July 28, 1994
Kyoto Protocol	July 15, 1998	December 13, 2002

Source: UNFCCC (2014)

27.3.1 Market and Infrastructure Factors

Polish companies have been very innovative at utilizing CMM at mine sites in a variety of ways including heat, power, LNG, and coal drying. Poland is also working toward ventilation air methane (VAM) utilization and recovery through the use of advanced technologies and creating market conditions that can spur VAM project development. The Central Mining Institute of Katowice is researching VAM emissions from 10 gassy hard coal mines in Poland and their potential end use (Skiba, 2009) and Kompania Weglowa is exploring the use of VAM as well.

The transmission network of the Polish Oil and Gas Company (PGNiG) could also play a favorable role for CMM. It is extensive, with 17.9 thousand km of pipes covering almost all of Poland. PGNiG has two main gas transmission networks – one for low-methane gas and another for high-methane gas. The distribution networks include approximately 105 thousand km of gas pipelines that cover the urban areas of the country. PGNiG also has seven underground gas storage facilities (PGNiG, 2006). PGNiG is thus well-situated to make use of CMM projects.

27.3.2 Regulatory Information

The *Geological and Mining Law of February 4, 1994* regulates the ownership of natural resources, including the right to explore for and extract them. The *Energy Law* requires energy enterprises to supply and connect customers, meet demands, and initiate actions for reducing consumption. There are 27 licenses for exploration fields reported in the USB and 68 licenses for coal mines.

Poland is currently providing support for methane use by promoting the use of Combined Heat and Power (CHP) systems through the "CHP Certificates" mechanism and is also providing excise tax exemptions for electricity generation (Skiba, 2009).

27.4 Profiles of Individual Mines

Detailed profiles of gassy Polish mines are available through the GMI website at https://www.globalmethane.org/partners/poland.aspx.

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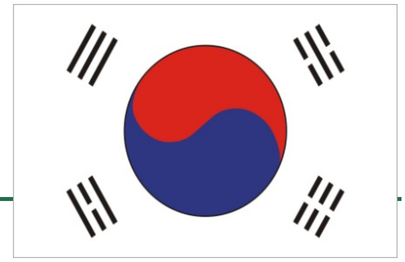


28.1 Summary of Coal Industry

28.1.1 The Role of Coal in Korea

The Republic of Korea (Korea) relies on imports for 97 percent of its energy needs because of its severely limited domestic resources (EIA, 2014a). Coal supplies about 28 percent of the country's total energy, amounting to an estimated coal consumption of 125 million tonnes (Mmt) in 2012 (EIA, 2014a). However, only about 2.1 Mmt of anthracite coal was produced domestically in 2012, as shown in Table 28-1 (EIA, 2014b; USGS, 2013). Rising coal consumption and a negligible production level have caused the country to rely heavily on imports over the past several years, making Korea the fourth-largest importer of coal in the world, mainly from Australia, Indonesia, and Russia (EIA, 2014a). Indigenous coal reserves were estimated at 126 Mmt in 2011 (EIA, 2014b).

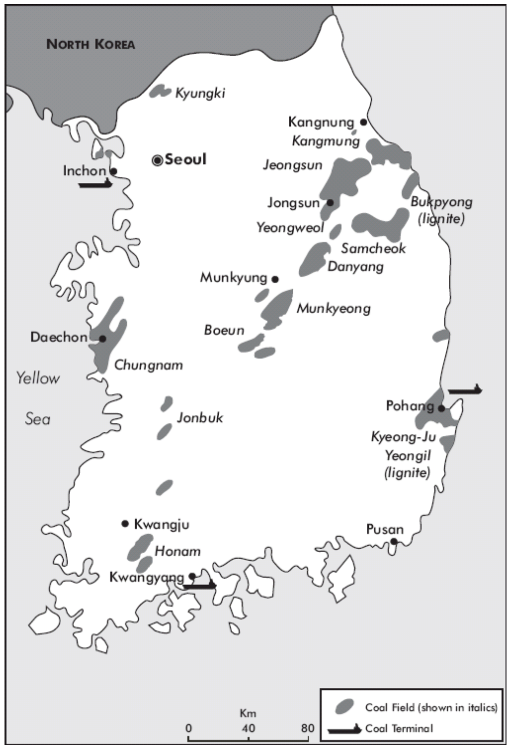
Table 28-1. Korea's Coal Reserves and Production

Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2011)	0	126	126	57 (0.01%)
Annual Coal Production (2012)	2.1	0	2.1	42 (0.03%)

Source: EIA (2014b)

Figure 28-1 illustrates the locations of coal basins and mines in Korea. As seen, Korea's coal is concentrated in four of its nine provinces: North and South Chungcheong, Gangwon (location of Samcheok, the largest coalfield in Korea), and to a small extent in South Jeolla (NationMaster, nd).

Figure 28-1. Korea's Coal Fields and Major Coal Terminals



Source: IEA (2002)

28.1.2 STAKEHOLDERS

Table 28-2 lists potential stakeholders in the development of Korea's coal mine methane (CMM) industry.

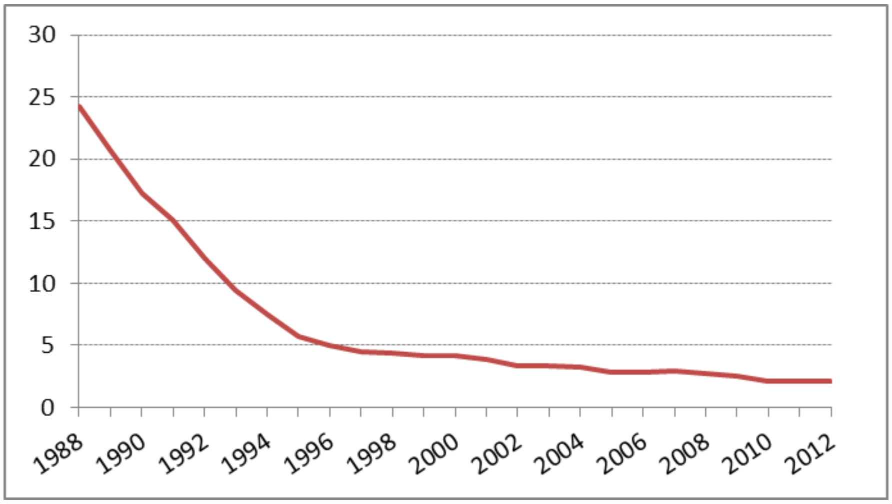
Table 28-2. Key Stakeholders in the Republic of Korea's CMM Industry

Stakeholder Category	Stakeholder	Role
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Mining Companies and CBM Developers	▪ Korea Resources Corporation ▪ Korean Coal Corporation ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project hosts/promoters
Universities, Research Establishments	▪ Korea Institute of Energy Research ▪ Korea Electrotechnology Research Institute ▪ Korea Institute of Science and Technology ▪ Korea Institute of Geoscience and Mineral Resources ▪ Korea Electric Power Research Institute	Technical assistance
Government Groups	▪ Ministry of Education, Science, and Technology ▪ Ministry of Knowledge Economy ▪ Global Green Growth Institute	Licensing, Monitoring and Control
Other	▪ Korea Energy Management Corporation ▪ Korea Energy Economics Institute	Policy

28.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

As seen in Figure 28-2, Korean coal production has declined drastically in the last 25 years, with many coal mines closing. Coal production has declined 91 percent from its peak in the late 1980s (EIA, 2014b). Currently, Korea produces only anthracite, importing all its bituminous requirements.

Figure 28-2. Korea's Coal Production (million tonnes)



Source: EIA (2014b)

Korea has five anthracite coal mines, three of which are operated by the state-owned Korea Coal Corporation (KCC). The company is also examining production opportunities abroad and developing a mine in the Uvs province of Mongolia. This represents a significant decrease from the 347 mines in operation in 1988, a result of the government's policy of rationalizing domestic coal production. Production of coal in Korea is subsidized by the government and the cost of production is higher than the cost of imports. Nevertheless, the government intends to stabilize supply and demand for anthracite coal, maintaining a minimum annual production volume, given that it is the nation's only natural energy resource (IEA, 2012).

According to the Korean government's green growth policy (see page XX) and the G-20 initiative to abolish fossil fuel subsidies, the government has gradually reduced subsidies in the coal sector. They will come to an end in 2020. The main subsidy was for the production of coal and its use in the form of charcoal briquettes by low-income households. The subsidy covers subsidies for briquette manufacturers, industrial accident insurance premiums, and school expenses for children of mine workers.

Coal consumption in Korea increased by 55 percent between 2005 and 2012, driven primarily by growing demand from the electric power sector, which accounts for 62 percent of the country's coal consumption (EIA, 2014a). Although the share of liquefied natural gas (LNG) in power generation in Korea has increased rapidly, gas is a relatively expensive energy source for power generation. This gives coal a relative cost advantage over gas in the power generation sector. However, expected additions to the coal-fired power plant fleet are modest in the midterm and thus much of the growth in coal imports is expected to come from the industry sector, largely iron and steel production, which consumed approximately 12 percent of coal in 2010 (IEA, 2012).

28.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Korea, in operation or under development (GMI, 2014). Updates on future CMM projects in the Republic of Korea can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

28.2.1 CMM Emissions from Operating Mines

Methane emissions in Korea totaled 81.2 million cubic meters (m^3) in 2000, but are expected to decrease to 61.6 million m^3 by 2015, and then anticipated to increase again to 76.3 million m^3 by 2030 (see Table 28-3).

Table 28-3. Korea's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH4 Emitted	81.2	55.3	56.7	61.6

Source: USEPA (2012)

28.2.2 CMM Emissions from Abandoned Coal Mines

The number of operating coal mines has dwindled from 70 in 1993 to only 5 in 2012 (KEEI, 2009; KEEI, 2013). Although the potential for methane to be found in so many abandoned mines may likely be attractive, no specific data were found.

28.2.3 CBM from Virgin Coal Seams

No data were found for virgin coal seams.

28.3 Opportunities and Challenges to Greater CMM Recovery and Use

Rapid industrialization, growth in income and the resultant increase in cars on the road have led to serious environmental concerns for Korea, such as acid rain and a rise in greenhouse gas (GHG) emissions. After the Asian financial crisis of 1997-98, Korea began aligning itself with more secure and environmentally sound energy development. It established goals for promoting green development via its *National Vision for Environmental Policies in the 21st Century*.

Korea signed the Kyoto Protocol in September 1998 (see Table 28-4). Although Korea has no formal Kyoto commitment to cap its GHG emissions, it announced in 2009 to unilaterally cut its emissions 4 percent below 2005 levels by 2020, which is a 30 percent cut in emissions under a business as usual scenario.

Table 28-4. Korea's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	December 14, 1993
Kyoto Protocol	September 25, 1998	November 8, 2002

Source: UNFCCC (2014)

In 2010, Korea established the National Climate Change Adaptation Master Plan (Master Plan) based on the Framework Act on Low Carbon, Green Growth (Green Law) and set up a committee comprised of representatives from 13 ministries to implement the Master Plan successfully. Adaptation of Industry/Energy is one of the ten sectors outlined in the Master Plan, striving to create new business for adaptation, minimize damages in industry, and provide energy stability (KACCC, 2014). Korea's Ministry of Environment (MOE) has conducted a national GHG inventory in accordance with the Green Law since 2010. More than 450 Korean companies agreed upon the GHGs and energy reduction goal for 2012 in October 2011, and submitted the implementation plan using the National Greenhouse Gas Reporting System in December 2011 (MOE, 2014).

28.3.1 Market and Infrastructure Factors

Alternative energy sources are still not commercially competitive with conventional fossil fuel energy in Korea. The Korean government plays a central role in setting prices for the energy market. With the country's push toward sustainable development, the government is taking significant steps to improve market penetration of renewable energy (see "Regulatory Information"). The Ministry of Knowledge Economy (MKE) is also concerned with regulating economic policy, particularly in the industrial and energy sectors, and is involved in encouraging foreign investment in Korea.

Several organizations are vested in energy-related research and development (R&D) besides MKE, such as the Ministry of Education, Science and Technology. The Korea Institute of Energy Research and the Korea Electrotechnology Research Institute are two more major public institutes for energy technology research and are government funded. Other government-supported research institutes include the Korea Institute of Science and Technology (KIST) and the Korea Institute of Geoscience and Mineral Resources (KIGAM). KIST is the leading Korean institute for research in fundamental and applied science, which plays an essential role in developing energy-efficient industrial technologies. KIGAM seeks to boost sustainable development through advancement of science and technology by conducting geological surveys and disseminating research outcomes in fields such as mineral resources, geohazards, and climate change.

The Korea Energy Economics Institute (KEEI) is Korea's main energy policy research organization. KEEI conducts basic research on energy policy options. It provides energy information and statistics and produces energy balances; formulates policies for the government on reforms in the electricity and gas supply industries, energy efficiency, and demand management; produces energy supply and consumption forecasts; and is also involved in climate change studies. The Korea Energy Management Corporation (KEMCO) plays a key role in implementing R&D policy objectives for energy efficiency, energy conservation, and clean energy technologies.

No data are available on CMM operations in Korea. However, projects utilizing methane from landfills are well under way and may help in drawing parallel to CMM projects (NREL, 2006). The

MKE has partnered with the U.S. Environmental Protection Agency to form the Climate Change Technology Program to assist with implementing methane recovery and energy-efficient technologies in Korea. The plan involves government-supported project development and technology implementation through private sector collaboration between Korean and international firms. Korea has also been at the forefront of green growth initiatives, issuing *The National Strategy for Green Growth (2009-2050)* and the *Five-Year Plan (2009-2013)* to provide a comprehensive policy framework for green growth (OECD, 2014). In the long term, the National Strategy aims to promote eco-friendly new growth engines, enhance peoples' quality of life, and contribute to international efforts to fight climate change. The Five-Year Plan outlines government actions for National Strategy implementation and provides detailed tasks for ministries and local governments. Under the plan, the government will spend approximately 2 percent of annual GDP on green growth programs and projects, with initial investments geared towards infrastructure systems (OECD, 2014).

28.3.2 Regulatory Information

Although Korea initiated privatization of the natural gas companies, the Korea Gas Corporation (KOGAS) and several other state-owned enterprises in 1999, the State still retains a 27 percent direct equity share (EIA, 2014a). KOGAS was to be split into three competitive retail gas suppliers; however, the government decided to revise its plans.

Under Korea's constitution, the land and natural resources are protected by the state and the government plans for the best development and utilization of its resources. The State may grant licenses for temporary periods to private companies for tapping into the natural wealth (Constitution, nd).

The Korea Occupational Safety and Health Agency (KOSHA), which oversees the country's Industrial Safety and Health Act that provides occupational safety measures for both employers and employees, focuses on preventing workplace accidents, improving working environments, and preventing occupational diseases such as pneumoconiosis, common in workers engaged in "dust work" (KOSHA, 2014).

A renewable portfolio standard (RPS) for Korea became effective in 2012, with an anticipated increase in renewable power generation to 10 percent of total power generation by 2022, up from two percent in 2012 (EIA, 2014a). The RPS replaces previous feed-in tariff subsidizes for power generated from alternative sources. Korea's ongoing R&D tax credit program still applies to renewable energy technologies, and import duties are reduced by 50 percent for components and/or equipment procured for renewable energy facilities (KPMG, 2014).

CMM recovery is justifiably a key element of energy conservancy and is environmentally crucial. Therefore, although CMM projects have yet to develop in Korea and the government is pursuing other clean technologies (e.g., green growth), it is possible that the Korean government would contribute by providing incentives and tax breaks to encourage CMM use and ease its entry into the energy market.

28.4 Profiles of Individual Mines

Information on active mines in Korea is currently unavailable.

28.5 References

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29 Romania

29.1 Summary of Coal Industry

29.1.1 Role of Coal in Romania

Coal accounts for 29 percent of energy production in Romania (EIA, 2014). Romania's proven coal reserves are estimated at about 291 million tonnes (Mmt) and the country ranks 20th worldwide in coal production (see Table 29-1). More than 80 percent of Romanian lignite reserves can be mined profitably in opencast mines, while the remaining 20 percent require underground mining (Euracoal, 2014; WEC, 2000).

Table 29-1. Romania'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)	10.0	281.0	291.0	43 (0.033%)
Annual Coal Production (2012)	0.04	33.99	34.03	20 (0.43%)

Source: EIA (2014)

Figure 29-1 shows the distribution of lignite and hard coalfields in Romania. The coal deposits are grouped into four zones:

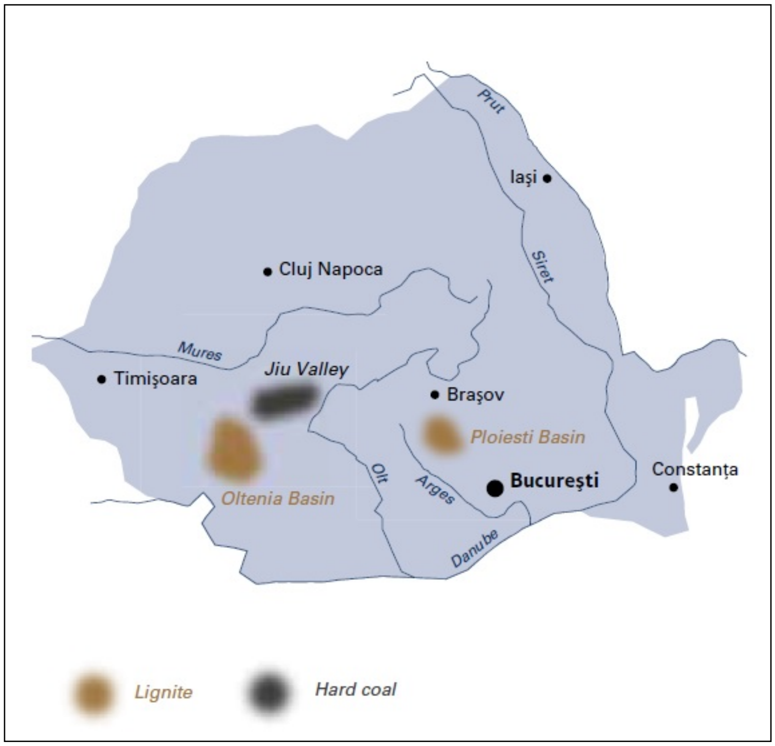
Zone I, mainly located in the Southern Carpathian Mountains, includes all the high-grade coal such as anthracite, pit coal (higher ranking than brown coal – bituminous and sub-bituminous), and brown coal (lignite) from the Petrosani, Anina and Tebea-Brad basins.

Zone II, located within the Pre-Carpathian creep, between the Olt and Valea Buzaului rivers, includes the lignite deposits of Campulung, Sotanga, Filipestii de Padure, and Ceptura. The coal basins of the Eastern Carpathian are also included within this zone: Baraolt-Virghis (lignite) and Comanesti-Bacau (brown coal). More than 90 percent of Romanian coal reserves are located within Zone II, namely in the mining basins of the Oltenia Region.

Zone III is located in the Sub-Carpathian creep of the Getic Plateau, between the river Olt and the Danube, including the lignite deposits of Rovinari, Motru, Jilt, Berbesti-Alunu, and Mehedinti.

Zone IV is located in the Panonian creep in the northwestern part of Transylvania and includes the brown coal and lignite deposits of Sarmasag, Voievozi, Surduc, and Borod.

Figure 29-1. Romania's Coalfields



Source: Euracoal (2014)

29.1.2 STAKEHOLDERS

Table 29-2 lists potential stakeholders in Romania's coal mine methane (CMM) industry.

Table 29-2. Key Stakeholders in Romania's CMM Industry

Stakeholder Category	Stakeholder	Role
Governmental Mining Companies	▪ National Company of Lignite OLTENIA, Târgu-Jiu ▪ National Hard Coal Company, Petrosani ▪ National Coal Company, Ploiesti	Project hosts
Other Mining Companies/License Holders	▪ Asociatia Mina Borod ▪ SC Complexul Energetic Craiova S.A.	Project hosts
Developers	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Regulatory Agencies and Government Groups	Ministry of Environment and Climate Change Ministry of Economy	Management of mineral resources, issue and enforce government policy

Source: USGS (2013)

29.1.3 Status of Coal and the Coal Mining Industry

Three national companies are active in the Romanian coal industry: National Company of Lignite OLTENIA, Târgu-Jiu; National Hard Coal Company, Petrosani; and National Coal Company, Ploiesti (USGS, 2013; WEC, 2000).

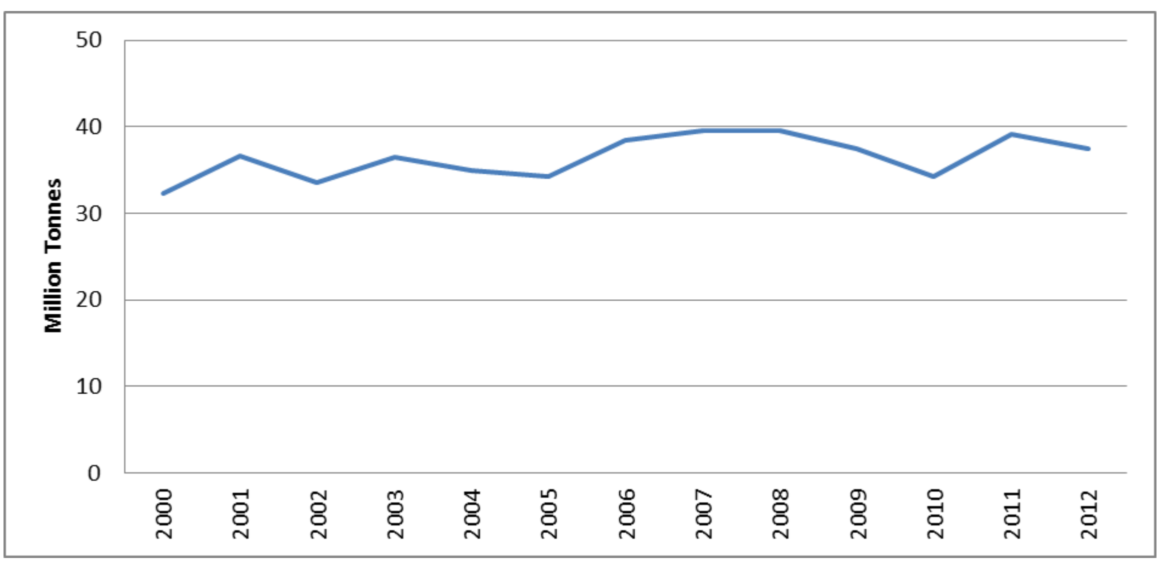
The National Company of Lignite OLTENIA (NCL), Târgu-Jiu has nine main fields (estimated annual capacities): Rovinari (8.0 Mmt/yr), Balteni (6.9 Mmt/yr), Udari (0.3 Mmt/yr), Matasari (7.6 Mmt/yr), Motru (6.6 Mmt/yr), Berbeşti (2.0 Mmt/yr), Bolboceşti (0.6 Mmt/yr), Zegujani (0.6 Mmt/yr), and Husnicioara (2.5 Mmt/yr). NCL has lignite reserves of around 820 Mmt and produces 34 Mmt of lignite annually (USGS, 2013; NCL, 2014).

The National Hard Coal Company (CNH), Petrosani operates seven coal mines: Lonea, Petrila, Livezeni, Vulcan, Paroseni, Uricani, and Lupeni. Three of the mines are considered uncompetitive and are expected to close – Petrila by the end of 2015 and Paroseni and Uricani by the end of 2017 (EUROPA, 2012). CNH has an estimated capacity of approximately 3.5 Mmt per year of bituminous coal (USGS, 2013).

National Coal Company (NCC), Ploiesti operates mainly in seven small opencast pits and one underground mine. The pits are located in the southeast, central, and northwest basins of the country near Campulung, Baraolt City, Sarmasag, Popesti Commune, Comanesti Commune, Filipestii de Padure Commune, Sotanga Commune, and the underground mine is in Borsec City. NCC has an estimated annual capacity of 3 Mmt of lignite (USGS, 2013).

Romania has suffered from declines in production, outdated infrastructure, and labor unrest; however, the Romanian government is hoping for a resurgence of the coal industry and for increased output from existing mines. The first sign of improvement came in 2000, as Romanian coal mine output improved over the previous year's total for the first time in several years. Since then, average production has risen but fluctuated, as shown in Figure 29-2.

Figure 29-2. Romania's Annual Coal Production



Source: EIA (2014)

29.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies two CMM recovery projects in Romania: an operating boiler fuel project at Lupeni Mine, an active surface mine in the Jui Valley coal basin, and a proposed combined heat and power (CHP) project at an unnamed abandoned mine in the Caras-Severin region (GMI, 2014). Updates on future CMM projects in Romania can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx

29.2.1 CMM Emissions from Operating Mines

Methane emissions in Romania totaled 187.0 million cubic meters (m^3) in 2000, but are expected to increase to 199.6 million m^3 by 2015, and then anticipated to further increase to 201.0 million m^3 by 2030 (see Table 29-3).

Table 29-3. Romania's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	187.0	174.4	191.2	199.6

Source: USEPA (2012)

All mines in the Jiu Valley have ventilations systems (UNECE, 2006), and the total amount of methane emissions from the valley is estimated at 49 million cubic meters per year from ventilation systems and another 4 million per year from other degasification systems (WEC, 2008).

As previously mentioned, Romania has one operating CMM utilization project at an active mine in the Jiu Valley Coal Basin. At the Lupeni mine, two on-site boilers are fueled by methane from the coal mine, generating a total of 35 MW of electric capacity and avoiding 478,800 metric tons of carbon equivalent per year (GMI, 2014). The project is summarized below in Table 29-4. Romania is seeking partners to develop other projects.

Table 29-4. Romania's CMM Utilization Projects

Site	Project Operator	Mine Type	First Year of Project Operation	Use of Methane	Output
Lupeni Mine	CNH Petrosani	Active	2008	Boiler Fuel	2 x 15 Gcal/hour

Source: GMI (2014)

29.2.2 CMM Emissions from Abandoned Coal Mines

The potential for CMM emission recovery from abandoned coal mines is unknown.

29.2.3 CBM from Virgin Coal Seams

Proposed efforts to explore and/or evaluate coal bed methane (CBM) production were abandoned in 2008; to date, the potential remain unknown.

29.3 Opportunities and Challenges to Greater CMM Recovery and Use

Romania ratified the Kyoto Protocol as an Annex 1 country and is eligible to host Joint Implementation projects that reduce greenhouse gas (GHG) emissions. Table 29-5 summarizes Romania's climate change commitment.

Table 29-5. Romania's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 5, 1992	June 8, 1994
Kyoto Protocol	January 5, 1999	March 19, 2001

Source: UNFCCC (2014)

Romania's *National Strategy on Climate Change (NSCC) 2005-5007* outlined the country's policies in meeting the international obligations of the Kyoto Protocol and its own national priorities (RMO, 2008a), while the National Action Plan on Climate Change outlined the implementation methodology for the NSCC (RMO, 2008b).

In recent years, Romania's climate change position is reflected in the overall position of the European Union of committing unilaterally to reduce, by 2020, the emissions of GHGs by 20 percent from the level recorded in 1990 (MFA, 2014). In this context, Romania's main objectives, alongside the EU Member States, are the adoption of a comprehensive global climate change agreement, subject to international law and applicable to all states after 2020, as well as increasing commitments to reduce GHG emissions in the near future, with the ultimate long-term aim to limit the average global temperature increase below 2° C (MFA, 2014).

29.3.1 Market and Infrastructure Factors

The natural gas transmission system is run by the state-owned company TRANSGAZ. Romania had previously increased imports of Russian gas due to depletion of domestic sources (Transgaz, 2002); however, more recently Romania is increasingly looking elsewhere to diversify it sources of gas to avoid supply interruptions or price pressures (Upstream, 2010). Both of these situations indicate favorability toward developing domestic alternative gas sources like CMM/CBM.

The Romanian government ended subsidies for lignite and metals mining in 2007, closed some unprofitable mines, and privatized profitable mines. Key remaining challenges include the continued closure of unprofitable mines, modernization of remaining mines, and reduction in employment/manpower (Euracoal, 2014). Another major obstacle against further CMM development, in the case of the Jiu Valley at least, has been the lack of investment (WEC, 2008). Additionally, the EU's position on state aid (subsidies) mandates three hard coal extraction units from the Jiu Valley—Petrila, Uricani and Paroseni—must be closed by 2018, which will result in job losses totaling 3,500 employees (Euracoal, 2014).

29.3.2 Regulatory Information

Romania instituted a national energy plan for 2007 through 2020 that includes the privatization of the energy sector. The law requires that all mining activities be based on licenses for either administration or specific concessions. All enterprises with ongoing mining exploitation and exploration activities must apply for licenses in areas where they are active, and as part of the restructuring process are required to relinquish all inactive areas to be reorganized and offered up to competitive Romanian and foreign investment. The former National Agency for Mineral Resources (NAMR), now Ministry of Environment and Climate Change, has been appointed as the controlling authority for coal extraction in Romania. This Ministry has the power, on behalf of the State, to manage the mineral resources of the country and to enforce the provisions of the exploration and utilization of mineral resources. The Ministry of Economy (formerly the Ministry of Industry and Trade) issues and enforces government policy in the mining field and administers and monitors public property in the field of mineral resources (WEC, 2000).

Romania entered the European Union (EU) in 2007 and has to meet energy production and other requirements of EU law. Romania's energy policy framework regulates the production of gas, coal, lignite, oil, and nuclear energy, as well as power plant modernization (Euracoal, 2014). Romania also passed a Renewable Energy Law (no. 220/2008) in 2008, in part to meet the EU regulatory requirements, promote investment, and meet the goals of the national energy plan (EBRD, 2009).

29.4 Profiles of Individual Mines

Some basic capacity numbers can be found in the 2011 Minerals Yearbook for Romania (USGS, 2013) and in a 2006 report on Jiu Valley Mine Potential (Lupu, 2006). Updates on future CMM projects in Romania can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

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30 Russia

30.1 Summary of Coal Industry

30.1.1 Role of Coal in Russia

Russia's coal industry became a principal sector of the country's economy at the end of the 1930s. By 1950, coal accounted for 59 percent of Russia's fuel balance. The discovery of huge oil and natural gas reserves in the 1960s along with the development of nuclear power, however, led to decreasing dependence on coal. As of 2009, 14.7 percent of Russia's total primary energy supply came from coal/peat (IEA, 2009). More than 40 percent of coal consumed in Russia is used for heat and power generation. Natural gas is the principal competitor with coal in these end uses.

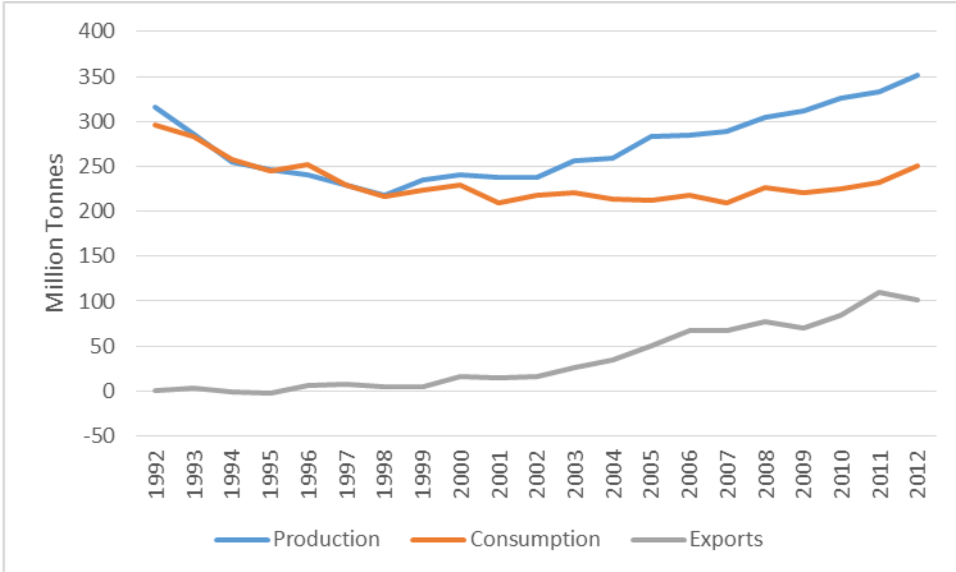
Russia is ranked sixth in global coal production with 2012 production of 354 million tonnes (Mmt) and has coal reserves of approximately 157 billion tonnes as of 2008, which is second worldwide only to the United States (see Table 30-1). Russia exported 136.7 Mmt of coal in 2012 (EIA, 2014a). The Russian Ministry of Energy estimates total coal exports will reach 140 Mmt in 2015, and further anticipated growth in exports will reach 170 Mmt by 2030 (World Coal, 2013). Figure 30-1 illustrates historical Russian coal production, consumption, and exports. Table 30-2 shows Russia's power generation by source.

Table 30-1. Russia's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank
Estimated Proved Coal Reserves (2011)	49,088	107,922	157,010	2 (17.6%)
Annual Coal Production (2012)	276.1	77.9	353.9	6 (4.5%)

Source: EIA (2014a)

Figure 30-1. Historical Russian Coal Production, Consumption, and Exports



Source: EIA (2013)

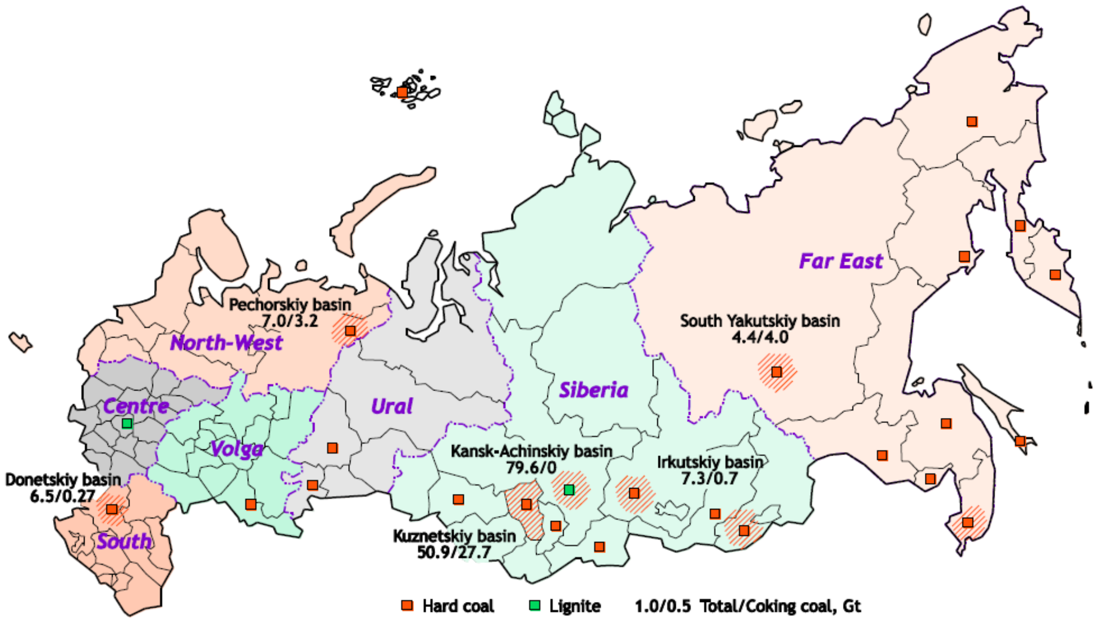
Table 30-2. Russia's Power Generation by Source, 2011

Power Source	Billion kWhr	%
Coal	164,348	15.6
Oil	27,362	2.6
Gas	519,202	49.4
Bio	35	0.0
Nuclear	172,941	16.4
Hydro	167,608	15.9
Geothermal	522	0.0
Solar PV	0	0.0
Solar Thermal	0	0.0
Wind	5	0.0
Total	**1,052,023**	**100**

Source: IEA (2011)

Russia's coal reserves are primarily concentrated in Siberia (80 percent), followed distantly by the Far East region (10 percent), as seen in Figure 30-2. The main coal-producing basins in Siberia are the Kuznetskiy and Kansko-Achinskiy, along with the South Yakutsly basin in the Far East region (IEA, 2009). Table 30-3 shows Russia's coal production by region.

Figure 30-2. Russia's Coal Reserves



Note: The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: IEA (2009)

Table 30-3. Russia's Coal Production by Region, 2012

Region	Million Tonnes
Kuzbass	198.9
East Siberia	48.2
Kansk Achinsk	40.7
Far East	32.4
Pechora	14.2
Yakutsk	12.2
Donbass (Rostov)	5.6
Moscow	0.3
Urals fields	0.1
Others	0.1
Total	**352.7**

Source: Eastern Bloc Energy (2012)

30.1.2 STAKEHOLDERS

Table 30-4 highlights a partial list of key stakeholders in coal mine methane (CMM) development in Russia.

Table 30-4. Key Stakeholders in Russia's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ Severstal-Resource ▪ Evraz Holding ▪ MDM ▪ Ural Mining and Metallurgical Company ▪ Sibirsky Delovoy Soyuz ▪ Sibuglemet ▪ Belon ▪ Mechel ▪ Siberian Coal Energy Company	Project hosts
Equipment Manufacturers	▪ Kyshtym Machine Works ▪ Druzhkov Machine Works ▪ Artemovsk Machine Works ▪ VENTPROM ▪ Yurga Machine Works	Power generation equipment supplier
Developers and Engineering/ Consultancy	▪ Uglemetan ▪ Green Gas International ▪ Additional stakeholders: ▪ http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification, planning, technical assistance and design work
Universities/Research Establishments	▪ Institute of Coal of SB RAS Mining Institute of the Ural Branch of the Russian Academy of Sciences ▪ National University of Science and Technology "MISIS"/Mining Institute ▪ Promgas ▪ VostNII ▪ Skochinsky Institute of Mining (SIM)	Technical assistance
Natural Gas Transmission & Distribution Companies	▪ Gazprom	Distribution and pipeline sales
Government Groups	▪ Federal Ministry of Natural Resources ▪ Russian Federation Ministry of Energy ▪ Russian Federal Mining and Industrial Inspectorate (RosTechNadzor) ▪ Regional administrations	▪ Licensing ▪ Project approval ▪ Safety standards for mines ▪ Regional environmental and safety rules and requirements

30.1.3 Status of Coal and the Coal Mining Industry

Between 1996 and 2001, Russia worked with the World Bank to restructure the country's coal industry, which is now privatized. As a result of the restructuring, nearly all of domestic coal production comes from independent producers (EIA, 2014b). The Russian Energy Strategy to 2030 released in November 2009 focuses attention on the goal to have the Russian economy become one based more on innovation as opposed to the export of energy resources. However, the energy strategy 2009 projects a 100 percent increase in coal exports from 2008 to 2020 (World Coal, 2013). It also projects an almost three-fold increase in domestic capacity of hard coal processing plants by 2020, reflecting an increase in the domestic use of coal for electricity production (IEA, 2009). Table 30-5 presents production statistics for Russian coal mining.

Table 30-5. Russia's Coal Mining Statistics (2012)

Type of Mine	Production (million tonnes)	Number of Mines
Underground (active) mines	99.6	91
Surface (active) mines	255.1	137
Total mines	**354.7**	**228**

Source: *Coal Age* (2013)

30.2 Overview of CMM Emissions and Development Potential

In 2009, 57 underground coal mines were considered either "Category 3" mines, with methane emissions of 10 to 15 cubic meters per ton (m^3/t) of coal mined, or "Super Hazardous" mines, with methane emissions greater than 15 m^3/t (IEA, 2009). Of these mines, approximately 25 deployed degasification systems in 2009. While underground mining represents 30 percent of Russia's total coal production, forecasts predict an increasing share of coal production from deeper underground mines, leading to increased methane emissions. The restructuring of Russia's coal mining industry over the 1990s resulted in the closure of 188 uneconomic mines. Many of these mines were among the gassiest, and this thereby led to a considerable drop in Russia's methane emissions at operating mines (IEA, 2009).

30.2.1 CMM Emissions from Operating Mines

CMM in Russia is primarily located in three coal basins: Kuzbass, Pechora, and Donetsk (also known as Donbass, the majority of which is situated in Ukraine). According to UNFCC's National Inventory Submissions of greenhouse gases (GHGs), CMM from underground coal mines in Russia totaled 2.02 billion m^3 in 2011 (UNFCC, 2013). The Kuzbass accounts for approximately 65 percent of CMM emissions and the Pechora Basin accounts for 19 percent of CMM emissions (Tailakov, 2012).

Methane emissions from all Russian coal mines are summarized in Table 30-6. The Kuzbass had 47 active mines in 2003 (Tailakov, 2003) and their methane emissions are quantified in Table 30-7 (Tailakov, 2012). The data in these tables may vary from the USEPA data presented in the Executive Summary due to differences in inventory methodology and rounding of digits. Figure 30-3 shows the historical emissions based on reporting to the UNFCCC.

Table 30-6. Russia's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	2,942.8	3,183.8	3,424.9	3,575.5

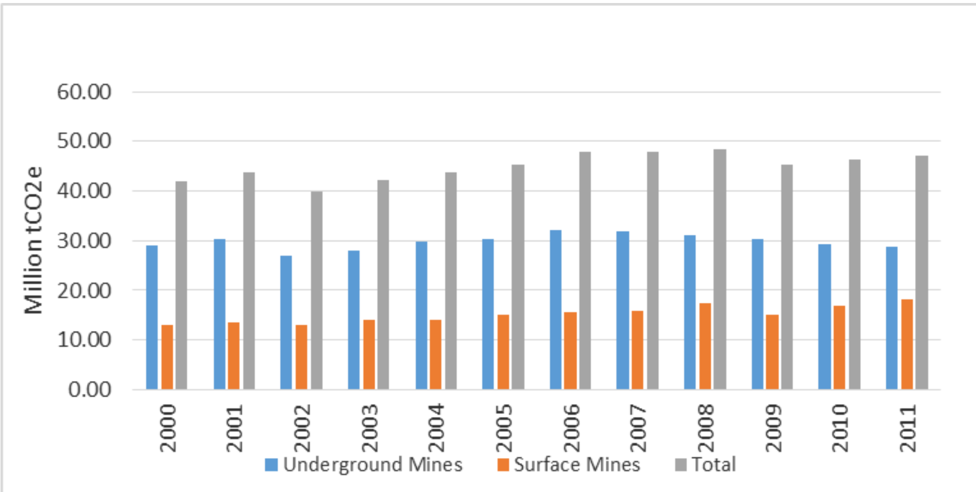
Source: USEPA (2012)

Table 30-7. Kuzbass CMM Emissions (million cubic meters)

Emission Category	2007	2008	2009	2010	2011
Coal Mines Ventilation and Gas Suction Systems	1,520	1,530	1,550	1,550	1,600

Source: Tailakov (2012)

Figure 30-3. Estimated Historical Methane Emissions from Russia's Underground and Surface Coal Mines



Source: UNFCC (2014)

Methane drainage was first initiated in the Kuzbass in 1951 and in the Pechora basin in 1956 (at the Severnaya, Komsomolsksya, Vorkutinskaya, and Zapolyarnaya mines). Degasification, however, reached its peak in 1990 when many of these mines had to shut down due to financial losses. The mines in the Pechora basin vented 289.8 million m^3 of methane in 1998 (RRR, 2001). In 2000, vented methane in the Pechora basin decreased to 42.05 million m^3 (Uglemetan, 2005). The wide disparity between the ventilation emissions was the result of mine closures between 1998 and 2000. In 1998, the seven Pechora basin mines had an average degasification efficiency of about 0.5. By 2000, three of the mines in the basin were closed and only Severnaya, Komsomolsksya, Vorkutinskaya, and Zapolyarnaya mines have continued mining operations. The average degasification efficiency of those mines is significantly higher, accounting for degasification efficiency of 0.7 on average, resulting in more drainage and less ventilation emissions in 2000.

In recent years, the rate of methane recovery from CMM drainage has been roughly 27-30 percent on average, with only 25 percent of active mines utilizing degasification system as of 2009. Drained CMM from mines that have degasification systems in the Pechorskiy and Kuznetskiy basins has methane concentrations of 25-60 percent. CMM at the higher end of this range can be supplied to fuel industrial boilers to generate steam or hot water, if suitable sites are located close to the coal mines. This is the most common application in Russia (IEA, 2009). As of 2008, total methane drained from mines in the Kuzbaas and Pechora basins was estimated to be 320 million m^3. Being drained primarily for the purpose of safety, the recovered methane has typically been of poor concentration (less than 25 percent). Currently, methane drained from the Vorkuta mines in the Pechora basin is being used for boiler fuel (40 million m^3 in 2006) (IEA, 2009).

Siberian Coal Energy Company (SUEK), which, in 2009, developed several CMM recovery and utilization projects at up to five coal mines and submitted the projects for registration under the UNFCCC Joint Implementation. According to the project's Monitoring Report, the CMM reductions equated to 98,887 $MTCO_2e$ from 2009 to 2011 (SUEK, 2011). Another mining group, Yuzhkuzbassugol United Coal Company, a division of the EVRAZ steel and mining group, is the eighth largest underground coal producer in Russia, producing approximately 11 million tons in 2012. Two of Yuzhkuzbassugol's eight coal mines operating in the Kuzbass—Alardinskaya and Uskovskaya coal mines—operate within the Kemerovo Oblast about 200 km apart, and both mine high-grade thermal and coking coal from carboniferous strata and are highly gassy.

The following summarizes select CMM-related activities completed and/or underway in Russia:

- CMM project potential was studied by the not-for-profit organization Uglemetan and by ICF Consulting Ltd. Their joint involvement resulted in a United Nations Development Program/Global Environment Facility project titled "Russian Federation - Removing Barriers for CMM Recovery & Utilization," which started in 2003 and ended in December 2010. The project financing amounted to 8.3 million USD. The project sought to mitigate GHG emissions by removing barriers to implementing and financing CMM recovery and utilization projects in Russia. Its initial focus was on the Kuzbass region, with replication potential expected in other coal-producing areas in Russia and elsewhere (Uglemetan, 2010).
- Plans for a CMM project at active and abandoned underground mines in Prokopyevsk, Kuzbass were initiated in 2010 and continue to date are in development. The recovered methane is intended for use in boilers for heat generation. The potential methane reduction is estimated to be 2.0 million m^3 or 29,346 Mmt CO_2e (GMI, 2010).
- A pre-feasibility study was conducted for two of Yuzhkuzbassugol's eight coal mines operating in the Kuzbass—Alardinskaya and Uskovskaya coal mines in 2012 and 2013. This study is now available from GMI, both in English (http://www.epa.gov/cmop/docs/Yuzhkuzbassugol-Mines-PFS-Jan2014-ENG.pdf) and Russian (http://www.epa.gov/cmop/docs/Yuzhkuzbassugol-Mines-PFS-Jan2014-RUS.pdf).

30.2.2 CMM Emissions from Abandoned Coal Mines

There are 43 abandoned mines in the Kuzbass, 39 of which are monitored for methane concentrations. Methane is registered at 32 mines, 14 of which have dangerous levels of methane gas and 5 with methane concentrations that could be explosive (Uglemetan, 2005).

30.2.3 CBM from Virgin Coal Seams

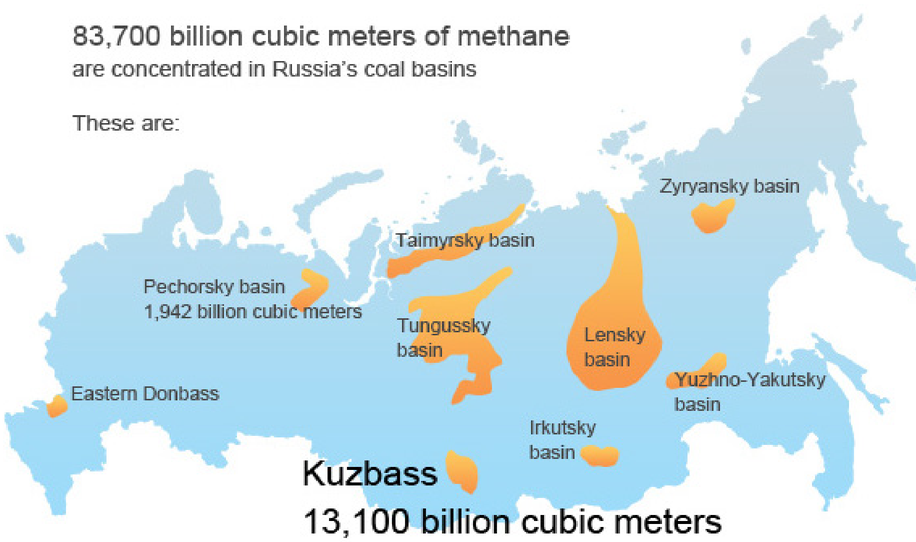
Russia is estimated to have significant CBM resources – more than 80 trillion m^3 in coal seams, with the Kuzbass basin providing possibly one of the largest CBM resource development opportunities in the world. Gazprom estimates more than 13 trillion m^3 of CBM in Kuzbass (see Figure 30-4), accessible at 1,800 – 2,000 m depth (Gazprom, 2014). Another source estimates Kuzbass CBM resources to be 94 billion m^3 in active degasification areas and 120 billion m^3 in areas where degasification is expected to be conducted in the future, for a total of 214 billion m^3 (M2M Workshop – Russia, 2005). The Pechora basin's CBM resource is estimated at 2.26 to 3.40 trillion m^3, but the area's harsh climate may limit exploitation of this resource. Overall, CBM resource is estimated at 48 trillion m^3. The breakdown for individual basins is provided in Table 30-8 (M2M Symposium – USA, 2006). It is estimated that if appropriate technology is deployed and if an economic environment favorable for CBM is created, Russian CBM production could increase to up to 2 billion m³ per year (M2M Workshop – Russia, 2005).

Table 30-8. Estimate of CBM Resources

Basin	CBM Resources (trillion cubic meters)
Kuzbass	13.085
Pechora	1.942
Eastern Donbass	0.097
South Yakutia	0.92
Ziryank	0.099
Tunguska	20.0
Lensk	6.0
Taymir	5.5
Total Resources	**47.643**

Source: M2M Symposium – USA (2006)

Figure 30-4. CBM Distribution in the Kuzbass Basin in Russia



Source: Gazprom (2014)

The following activities are advancing CBM development in Russia:

- Between 2008 and 2009, Gazprom initiated a pilot operation at eight exploratory wells in Taldinskoye field in the Kuzbaas basin and by 2010, the recovered CBM was being supplied to gas filling stations. In 2011, the daily gas production from the Taldinskaya area totaled 20 thousand cubic meters, and Gazprom aims to reach 4.0 billion m³ of CBM production from expanded operations by 2021. Two CBM-fired reciprocating-engine power plants have also been commissioned at the Taldinskoye field, which make it possible to supply electricity to the Taldinsky coal strip mine. In February 2012, the Central Commission for Hydrocarbon Fields Development under the Federal Subsurface Use Agency approved the Development Plan by Gazprom Promgaz for the pilot commercial development of the southeastern part of the Taldinskoye CBM field (Gazprom, 2014).

- In early 2005, the Rosnauka (Federal Agency for Science and Innovation or FASI), a federal agency in the Ministry of Science and Higher Education, began an effort to accelerate CBM/CMM development projects to improve mine safety and reduce GHG emissions. This activity involved improving stimulation techniques to enhance methane desorption and drainage, improving methane production and utilization technologies, organizing a scientific and educational center for CBM/CMM development and coordinating same with foreign experts, and developing a CBM/CMM business plan (M2M Workshop – Beijing, 2006). FASI was disbanded as an independent agency in March 2010, but its operations were rolled back into the Ministry (ERAWATCH, 2013). One of FASI's projects, which started in 2007, is a joint operation with private industry (Siberian Coal Energy Company) and implemented by the IPKON RAN research institute. The project will develop operating procedures for CMM recovery for use in gassy mines. The procedures will conform to the Kyoto Protocol, increase productivity of coal seams with high gas content, and use CMM to generate electricity, heat and emission reductions for carbon trading (IEA, 2009). The project is on-going and will be used as a model for future projects.
- Uglemetan works actively to promote the development of CBM recovery in Russia by providing information and assistance to interested companies and government agencies. The non-profit organization was formed in 2002 expressly for this purpose. Under a 2011 GMI grant, Uglemetan has embarked on a project aimed at improving the measurement of ventilation air methane (VAM) emissions in the Kuznetsk Coal Basin (Kuzbass) that will lead to the use of VAM as a potential clean fuel for energy production. A forthcoming pre-feasibility study will include definition of fuel gathering and delivery equipment plus utilization equipment, along with energy delivery systems. The focus of this work will be to perform an economic analysis showing the internal rate of return and net present value of the technology option applied for a real mine situation.

30.3 Opportunities and Challenges to Greater CMM Recovery and Use

The collapse of Soviet-era industry saw Russia's GHG emissions drop nearly 40 percent from 1990 to 1998 (Yale, 2011). Russia ratified the Kyoto Protocol in 2004, and accepted a GHG emission reduction target of 15 – 25 percent by 2020, with 1990 as its baseline emissions (UNFCCC, 2010). Russia is also a participant in Joint Implementation (JI) projects under Kyoto, the first of which— an energy-efficient power plant near Moscow—was approved in 2010.

Table 30-9. Russia's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	December 28, 1994
Kyoto Protocol	March 11, 1999	November 18, 2004

Source: UNFCCC (2014)

Russia saw a major shift in its climate policy in 2009, when the government released its "Climate Doctrine" recognizing the anthropogenic nature of climate change and announcing long-term emission reduction targets at least 50 percent below 1990 levels by 2050 (Yale, 2011). A 2009 government report was also the first to acknowledge the economic benefits from climate change mitigation, (e.g., avoided floods, wildfires, permafrost melt) outweigh potential climate change-induced gains (e.g., Arctic Shelf access, increased agricultural productivity). In 2011, then Prime Minister Putin adopted the "Comprehensive Implementation Plan of the Climate Doctrine by 2020," which included adaptation and mitigation measures, as well as efforts on education and long-term GHG scenarios. Though the Russian government continues to voice support for climate change mitigation, many of these promises have yet to be translated into effective domestic laws and policies.

30.3.1 Market and Infrastructure Factors

Table 30-10 lists total consumption by potential CMM markets in Kuzbass. According to a 2009 report, CMM recovery and utilization is a huge economic opportunity in Russia and estimates 130 million USD in revenue if all of its 1.9 billion m^3 CMM were to be recovered and used (based on 2008 regulated wholesale natural gas prices in Russia) (IEA, 2009). However, safety concerns would remain the principal driver for CMM projects.

Table 30-10. Total Consumption by Potential CMM Markets

Market	Electrical Power (million kilowatt hours)	Thermal Power	Natural Gas
All sectors*	21,343	31,113	3,010
Industry	18,387	23,940	2,971
Fuel industry	4,385	5,570	N/A

Source: *Tailakov (2004)

Russia has many barriers to expanded CMM/CBM development. First, CMM and CBM must compete with large, in-country proven gas resources with low-cost production capacity. Second, state regulations keep the large gas supply at a low sale price, making it difficult for a CMM project to achieve financial viability. Further, power generation projects are not usually financially viable due to historically low power prices. Moreover, technological challenges continue from the extraction of CBM economically from saturated, low-permeability coal seams.

However, there are many positive aspects that favor CMM development in Russia. Mining and geological conditions are similar to those in Australia, Canada, and the United States. Further, expected CBM production rates are promising and natural gas infrastructure and markets exist within 20 to 100 km of high-priority CBM/CMM production areas (M2M Workshop – Russia, 2005). Also, domestic power prices have doubled over the past 10 years and now appear to be in line with global power prices. The power price in 2013 was expected to be $89/MWhr with inflation or $62/MWhr without inflation (i.e., prices are trending upward). Russia is also working toward establishing a favorable legislative climate for CMM development (see below).

30.3.2 Regulatory Information

The institutional oversight of CMM recovery and use in Russia is managed at the federal and regional levels. However, no one institution at either the federal or regional level is directly charged with addressing the issue of CMM utilization. This lack of coordination or management within government is a key challenge to the enhanced recovery and use of CMM in Russia. Regional authorities (part of regional administrations) monitor activities of coal companies and issue licenses for subsoil use (IEA, 2009).

CBM, like any other mineral resource in Russia, is owned by the state. A license is required for methane extraction. There are three types of licenses: exploration license, production license, and combined license. The license is applied for at the Territorial Authority representing the Federal Ministry of Natural Resources, which publishes a tender announcement. The tender is held with a minimum starting price determined by the Federal Agency and it typically takes about a year to obtain a license. As for CMM, licensing for ownership and use currently lacks clarity, which hinders investments from third parties looking to utilize the recovered gas. Licensing processes for CMM activities are also unclear. While an additional license is not required for CMM recovered from and used within the mine, new mineral extraction licenses are needed if the recovered CMM is sold to another party or used for heat and power generation which is sold to another party (IEA, 2009).

Russia offers significant opportunity for foreign investment in CMM projects because of its large CMM resources and a significant market for clean energy. Although rules and regulations on foreign investment in Russia are complex, the investment climate is improving (Tailakov, 2005). CMM projects are expected to be pursued through Production Sharing Agreements (PSAs), which provide exemptions from all federal taxes with the exception of certain payments for subsoil use, a modified profits tax, VAT and excise on domestic purchases, and unified social tax during the period of PSA validity (Uglemetan, 2004). Methane extraction from virgin seams and sale is taxed at 7 percent and is subject to a single license fee. There are no royalties if methane is used for the mine's onsite needs. Uglemetan, as an organization devoted to the promotion of CMM and CBM development projects, provides investors with the latest information on the current investment climate in Russia.

Russian mines are subject to safety regulations but lack the resources to ensure their enforcement. A "Guide for Safe Operation of CMM Energy Units" has been prepared by the local mine safety institute in Kuzbass to provide guidelines to coal mines for the safe installation of CMM recovery and utilization systems. According to the regulations, drained gas must have a minimum methane concentration of 30 percent to ensure that it is not within the explosive range. In addition, the regulations cover various aspects of flame safety (e.g., using flame arresters).

Russia's recent regulatory and energy market developments are poised to stimulate CMM utilization on a larger scale. Initiatives such as a government decision on gradual price increases for natural gas for industrial and residential users, liberalization of the electricity market, and renewable energy targets inclusive of CMM, will facilitate the creation of a market where CMM could become competitive with other energy sources. The Decree on Main State Policy Areas to Increase the Energy Supply from Renewable Power Generation by 2020, passed in January 2009, has specifically incentivized CMM recovery and use by setting targets for increased share of renewable energy—inclusive of CMM—in the electric power supply. More supporting regulations and clarity are needed, though, to further leverage this legislation for CMM development (IEA, 2009).

30.4 Profiles of Individual Mines

Alardinskaya Mine, Kuzbass

Total no. of coal seams: 38, two of which are mined

Thickness of mined seams: Average – 7.6 m; Range 5.3 – 10.0 m

Overburden: Thickness – 700 m ; No. of seams – #6 and #3a

Coal reserves: 160.9 million tonnes

Coal quality and rank:	Ash (%): 16 - 19	Sulfur (%): 0.04 - 0.40
	Heating Value (kcal/kg): 8,600	Volatile Matter (%): NA
	Moisture (%): NA	Rank: high volatile bituminous

Yubileynaya Mine, Kuzbass

Total no. of coal seams: Six, one of which is currently mined

Thickness of mined seams: Average – 2.67 m; Range 1.85 – 3.55 m

Overburden: Thickness – 300 m ; No. of seams – #50

Coal reserves: NA million tonnes

Coal quality and rank:	Ash (%): 6.9	Sulfur (%): 0.54
	Heating Value (kcal/kg): 8,223	Volatile Matter (%): 37.1
	Moisture (%): 5.5	Rank: high volatile bituminous

Source: USEPA (2013)

Although mining and methane emissions and recovery data is outdated, geologic profiles on more coal mines are available in "Reducing Methane Emissions from Coal Mines in Russia: A Handbook for Expanding Coalbed Methane Recovery and Use in the Kuznetsk Coal Basin" at http://www.epa.gov/cmop/docs/int005.pdf (USEPA, 1996).

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31 South Africa

31.1 Summary of Coal Industry

31.1.1 Role of Coal in South Africa

South Africa is the world's seventh largest coal producer and dominates the African coal industry, producing 259 million tonnes (Mmt) of coal in 2012 (EIA, 2013). It is the seventh largest coal exporter in the world (EIA, 2013), and responsible for about 97 percent of all coal production in Africa (EIA, 2013). South Africa's coal resources are estimated at 115 billion tonnes, based on a survey conducted in 1987 (DME, 2010a). As seen in Table 31-1, its reserves are estimated at about 30.1 billion tonnes which consist almost entirely of hard coals (i.e., anthracite and bituminous) (EIA, 2013).

Table 31-1. South Africa's Coal Reserves and Production

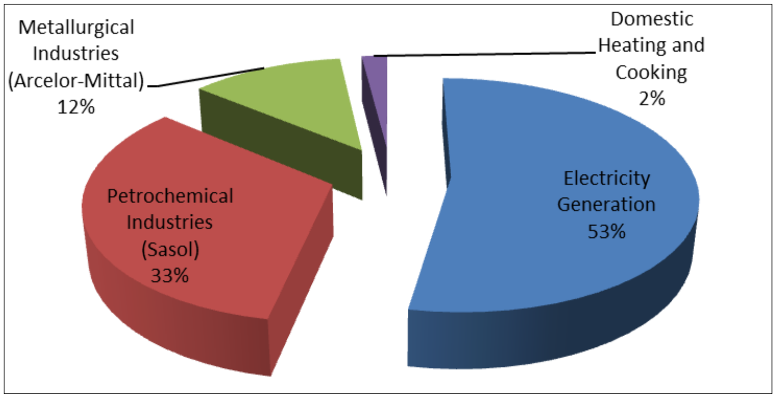
Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	30,156	0	30,156	10 (3.39%)
Annual Coal Production (2012)	259	0	259	7 (3.29%)

Source: EIA (2013)

Coal is the primary fuel produced and consumed in South Africa, accounting for 69.4 percent of total primary energy supply in 2011 (IEA, 2013). Three quarters of its production is consumed internally and one quarter is exported to the European Union and East Asia (EIA, 2014). Internal consumption is primarily for electric power generation (about 53 percent of locally sold coal in 2013). The second most important use is conversion to synthetic liquid petrol and diesel fuels (33 percent). The metallurgical industries consumed 12 percent of South Africa's domestic coal consumption and 2 percent was used for domestic heating and cooking coal (Figure 31-1) (ESK, 2014).

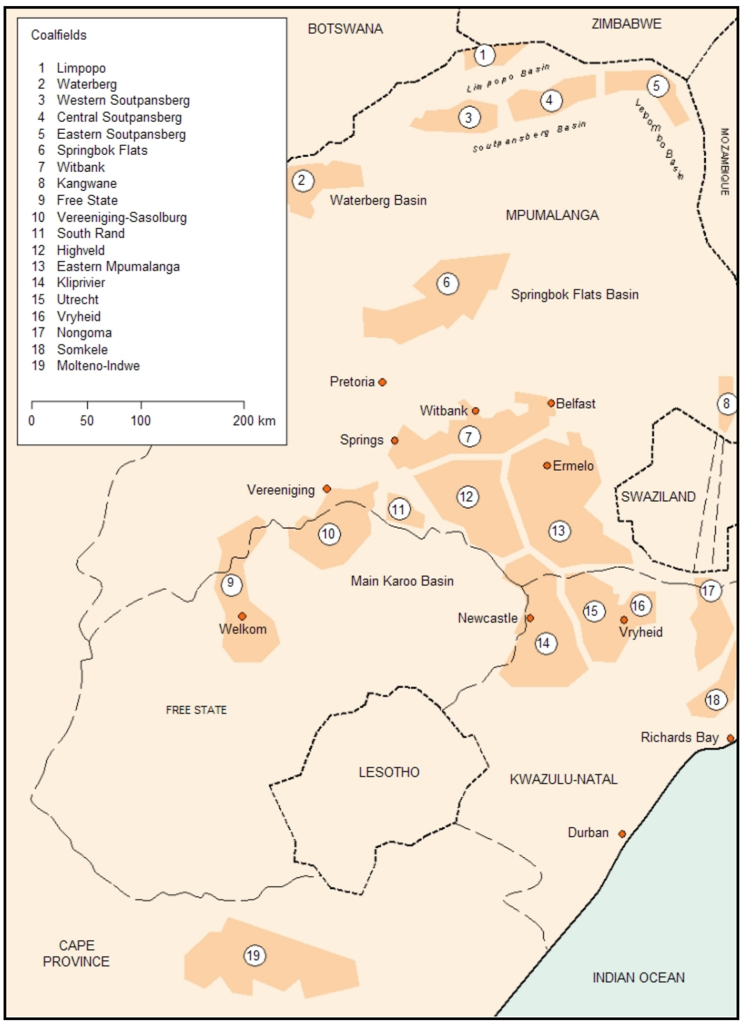
Figure 31-2 illustrates the distribution of coal deposits in the country. Seventy percent of South Africa's recoverable coal reserves lie in the Highveld, Waterberg, and Witbank fields. The great bulk of the coal reserves are concentrated in 19 Karoo (Permian) coalfields in the Mpumalanga region of the country and underlay an area of about 115,000 square miles (EIA, 2007).

Figure 31-1. South Africa's Domestic Coal Consumption by Sector



Source: ESK (2014)

Figure 31-2. South Africa's Coal Basins

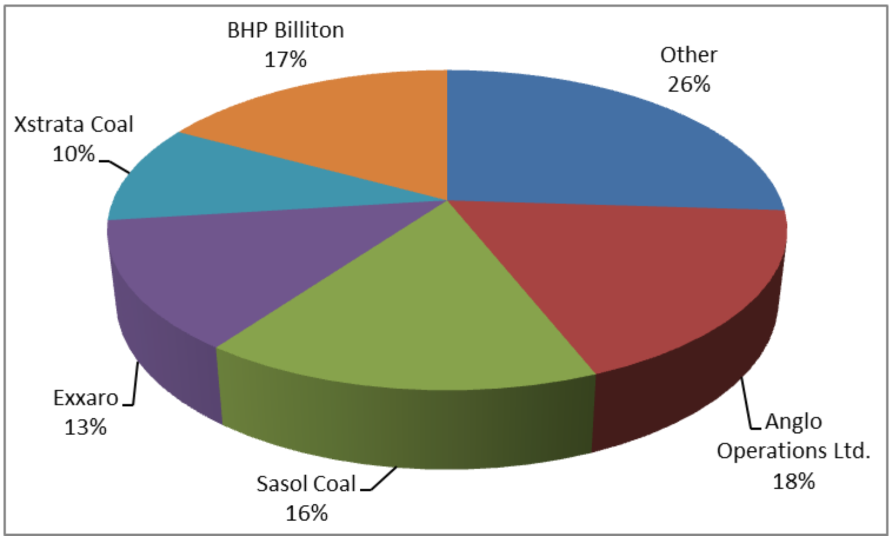


Source: Walker (2000)

South Africa's production of bituminous coal increased by 6.54 Mmt (2.5 percent) and exports increased by 5.5 Mmt (8.0 percent) from 2011 to 2012. In 2012, South African coal was mainly exported to India (30 percent) and, in order of decreasing percentage, was exported to Europe (19 percent), China (17 percent), Other Asia and Oceania (14 percent), Middle East (10 percent), Africa (7 percent), South America and Caribbean (2 percent), and North America (1 percent) (EIA, 2014). Revenue from export sales increased from 2007 to 2012 by 46.8 percent and total revenue from the sale of coal increased by 45.9 percent (DMR, 2013).

In 2012, 74 percent of the saleable coal production was supplied by mines controlled by the five largest mining groups, including Anglo Coal, BHP Billiton, Exxaro, Sasol and Xstrata as shown in Figure 31-3 (CM, 2013).

Figure 31-3. 2012 Saleable Coal Production by Mining Company



Source: CM (2013)

31.1.2 STAKEHOLDERS

The coal mine methane (CMM) industry has significant potential to develop as deeper, gassier seams are targeted for mining. Table 31-2 lists potential stakeholders in CMM development in South Africa.

Table 31-2. Key Stakeholders in South Africa's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ BHP Billiton ▪ Anglo Coal ▪ Continental Coal ▪ SASOL ▪ Exxaro Coal	Project host
Government Groups	▪ Department of Minerals and Energy	Licensing

Table 31-2. Key Stakeholders in South Africa's CMM Industry

Stakeholder Category	Stakeholder	Role
Developers and Consultancy	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification, planning and technical assistance
Organizations	▪ Chamber of Mines of South Africa ▪ South African Mining Development Association	
Universities, Research Establishments	▪ See Table 31-6	

Source: DME (2010a, 2010b)

31.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

There are about 90 operating coal mines as per recent statistics for coal mining in South Africa (see Table 31-3). Forty operations are surface mines, 18 combine surface and underground mining operations, and 35 are solely underground mining operations (DME, 2009). About 51 percent of South Africa's coal production is from underground mines and about 49 percent is from surface mines (GCIS, 2013).

Table 31-3. South Africa's Recent Production and Mine Statistics

Type of mine	Production (million tonnes)	Number of mines
Underground	NA	35 (2008)
Opencast / Surface	NA	40 (2008)
Combined Opencast and Underground	NA	18 (2008)
Total production	**239.3 (2003)**	**93 (2008)**

Source: DME (2009)

The coal mining industry is operated by private companies. Increasingly these companies are consolidating and multinational coal mining companies are joining large domestic companies. Forty-two companies currently operate coal mines in South Africa (DME, 2009), although five companies—namely Anglo Coal, BHP Billiton, Exxaro (Kumba Resources and Eyesiswe), SASOL Mining and Xstrata Coal—are responsible for about 74 percent of the country's saleable coal production (CM, 2013). A majority of production (70 percent) is concentrated in 11 mines (GCIS, 2013).

Asset sales have been conducted to achieve government-set targets for black ownership under South Africa's black economic empowerment program (BEE). For example, South Africa's procurement policies for ESKOM, the parastatal electric utility, grant preferences to companies owned by previously disadvantaged communities. In November 2000, Anglo Coal and Ingwe sold assets for $222 million to the black empowerment group Eyesizwe Coal, creating what was at the time, South Africa's fourth largest coal mining company. Subsequent deals included the splitting of Kumba resources and the formation of Exxaro Resources, which contains assets from both Kumba and Eyesizwe (DME, 2008b). Exxaro is now the largest black mining firm and the fourth largest coal producer in South Africa (DME, 2006).

Future new coal developments are expected to be located mainly in the northern provinces of Limpopo and Mpumalanga. Anglo and Sasol began operation of the Kriel South coalfield, Mpumalanga province in 2005 which produces about 5.0 Mmt/year (Anglo, 2005). Coal of Africa (COA, 2009) is progressing with plans for two mines in the Limpopo province, which—at full capacity—will produce a total of 10 Mmt/year (combined investment $755 million). ESKOM estimates that 40 new mines will be necessary over the next decade to produce enough coal to fuel future electricity demand (SAinfo, 2009).

Two new coal power stations with capacities of 4,800 MW each are under construction. The Medupi power station is located near Lephalale in Limpopo and the Kusile power station in Mpumalanga.

The percentage of operating mines considered “gassy” is very low. It is estimated that in the shallower fields, methane loss could have approached 80 percent of initial gas content in the coalification process (UNFCCC, 2000). However, newer underground mines that may be developed in deeper zones are likely to be gassier.

31.2 Overview of CMM Emissions and Development Potential

In the mid-1990s, South Africa was ranked as one of the world’s top five CMM emitters attributable to its high coal production and estimates placed the gas content of South Africa’s coals on a par with Australia’s. Since then, it has been shown that these original estimates were overstated. In 2010, its rank in worldwide CMM emissions dropped to ninth with estimated emissions of approximately 8.2 million tonnes of carbon dioxide equivalent ($MmtCO_2e$) (EPA, 2012).

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies one CMM recovery project in South Africa (GMI, 2014). The recovery project is a flaring project at Anglo American Thermal Coal’s New Denmark colliery near Standerton. The operation involves the incorporation of two enclosed Swiss-designed mobile flares into the mine's methane drainage system. A small diesel blower delivers the methane to four flaring nozzles where the gas is mixed with air to a concentration that enables it to be safely burnt. The process can be monitored remotely via the flare’s solar-powered communication system. The project reportedly cost $1.2 million and the project developers are pursuing carbon credits under the Clean Development Mechanism (Creamer, 2010a).

31.2.1 CMM Emissions from Operating Mines

A national greenhouse gas (GHG) inventory for South Africa was initially prepared for the years 1990-1994 for South Africa’s First National Communication Report to the UNFCCC, published in 2000. Work is currently underway by the Climate Change Division of the Department of Environmental Affairs and Tourism (DEAT) to design a process and approach for preparation of an updated inventory (DEAT, 2010).

In the energy sector, fugitive emissions contributed 323 gigagrams (Gg) or 475 million cubic meters (Mcm) of methane in 1990 and 327 Gg (481 Mcm) in 1994, which represents about 16 percent of the total methane emissions. In 1990, methane emissions from coal mining contributed almost 100 percent of the fugitive emissions and 97 percent in 1994 when emissions from natural gas processing were included in the total. Of the coal mining fugitive emissions, 88 percent were from underground mines (UNFCCC, 2000). Methane emissions for South Africa are summarized in Table 31-4.

Table 31-4. South Africa's CMM Emissions (million cubic meters)

Emission Category	2000	2005	2010	2015 (projected)
Total CH_4 emitted	518	562	551	583

Source: USEPA (2012)

A detailed industry-funded study, *Coal Tech 2020*, was conducted in 2004, to more accurately assess South Africa's CMM emissions. This study, conducted by the Council for Scientific and Industrial Research (CSIR), measured ventilation air methane concentrations from most major mines (USEPA, 2004a). The final report is only available to CoalTech members, but a summary of its principal results by study participants Alan Cooke and Philip Lloyd provides key insights as to South Africa's likely CMM emissions levels. An excerpt from their findings is provided below in Figure 31-4.

Figure 31-4. *Coal Tech 2020* Summary Results

During the course of this work most of the production shafts on underground mines have been sampled repeatedly. In total there were 243 measurements of methane in the return air from 27 different shafts. As we have seen, a wide scatter was observed, but taken as a whole the results give us some measure of the quantities involved. For each shaft the average methane concentration was multiplied by the known ventilation rate, which gave a contribution to the total methane emission of 40.8 Gg CH_4/a (with an error of ±30.2 Gg).

Seam gas contents had been determined for about 72% of the coal production. Assuming 50% was lost underground, and contributed to the methane in the return air, and that the mines for which data were missing were represented by the mines for which there was data, then the total lost after leaving underground mines was about 28.6 Gg CH_4/a (with an error of about 24 Gg).

Thus the best present estimate of the release of methane from South African coalmines is:

- 40.8 Gg CH_4/a in ventilation air from underground mines;
- 28.6 Gg CH_4/a from coal after it has left the mine; and
- <3 Gg CH_4/a from surface mining operations,

or approximately 72 Gg/a.

However, there are very large errors associated with these estimates. The source of these errors is largely the physical processes responsible for the release of much of the methane from South African coalmines, particularly the sporadic release of free methane. This causes huge fluctuations in the measurable concentrations of methane in the return air. To improve the estimates will require effectively continuous measurements over several weeks on each shaft. Further errors arise from the considerable variation in the seam gas content of the coal, and it will require repeated measurements of the residual gas in coal coming from underground in each mine before these errors can be reduced significantly.

Source: Excerpted from Lloyd and Cook (2004)

The coal seams of the main Karoo coalfields being relatively shallow are generally not regarded as being very gassy. Accordingly, little attention has been paid to CMM recovery and end-use. There are, however, several individual examples of gassy mines in South Africa. The most noted example is the Majuba Colliery, which experienced higher than expected levels of methane in the mine workings. Gas desorption tests showed that the coal contains up to 300 cubic feet per ton. In the early 1990s, several in-mine horizontal wells were drilled to degasify the coal in advance of mining. The mine operators were contemplating various CMM drainage and end-use scenarios, but the mine was eventually closed due to other reasons (USEPA, 2004b).

Some South African mines have been known to drain methane prior to mining through surface holes and the feasibility of recovering this methane for use in local heating has been widely investigated (UNFCCC, 2000).

31.2.2 CMM Emissions from Abandoned Mines

South Africa has a number of abandoned coal mines; the number of operating mines having declined by about one half between 1986 and 2004 (Limpitlaw and Aken, 2005). No data quantifying emissions from abandoned mines in South Africa were found. However, the percentage of gassy mines is thought to be low as most of the gassy areas of South Africa's coal resources have not yet been developed. It does not appear that any company is currently extracting methane resources from abandoned mines. Key barriers are legal and regulatory constraints; many companies are concerned that once they have received a mine closure certificate, further work in and around the mine could expose them to legal liabilities.

31.2.3 CBM from Virgin Coal Seams

The country's coal bed methane (CBM) resource is estimated to be 0.14 to 0.28 trillion m^3. Currently, there is no commercial CBM production reported for South Africa; however, there is significant discussion about possible future projects, and several pilot wells have been installed and are undergoing testing. Moreover, adoption of CBM/CMM technologies could become increasingly likely as additional mines are expected to open in gassy coal fields.

The most promising areas for CBM are where the deeper, thicker, and gassier coal resources are found. The Waterberg Basin in the northwest Mpumalanga region of the country and the southwest portion of the Highveld coalfield near Paardekop-Amersfoort are deeper (> 1,000 feet) and gassier (4-10 m^3/tonne at 1000-1200 ft) and appear to have the best potential for CBM development (ARI, 1992).

Anglo Coal has been conducting a CBM exploration program in the Waterberg Basin for the past 15 years. As part of this program, a series of core wells were drilled and tested and a five-well pilot production project was installed. Barriers to project progress include its remote location, delays in rights conversions, lack of prior experience among government authorities, and lack of incentives (DME, 2006; Merwe, 2007). Other CBM licenses are held by Badimo, NT Energy Africa, Molopo/Highland Energy, and numerous smaller companies, but little work has been done to date.

While there is only one active CMM recovery and end-use activity in South Africa, there are several reports, from the gold mining sector, of companies utilizing methane coming from gold mine shafts. For example, at the Harmony Gold Mine in the Free State province, the kitchen stoves and bath houses were fueled by captured mine methane for over 20 years (USEPA, 2004b). The Beatrix Gold

Mine, also in the Free State province, has applied for a methane capture project under the Clean Development Mechanism of the Kyoto Protocol (Le Roux, 2007). Methane emanates from faults and fissures intersected during normal mining operations and a pipeline drainage system is currently being installed to capture the methane at source underground and transport it to the surface where the gas will be flared (Creamer, 2010b). The mine estimates that for an initial outlay of $5.5 million, $27 million in carbon credits will be earned over 7 years through flaring alone, with resultant emission reductions estimated to be 2.6 $MmtCO_2e$. Plans are also in place to begin construction of a methane-fueled, 5-MW power plant in 2011.

31.3 Opportunities and Challenges to Greater CMM Recovery and Use

As reflected in Table 31-5, South Africa is a signatory to both the UNFCCC and the Kyoto Protocol. As a non-Annex 1 country, South Africa is eligible to host Clean Development Mechanism projects that reduce GHG emissions. Carbon credits could be available if South Africa reduces total emissions below 1990 levels (USEPA, 1998).

Table 31-5. South Africa's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 15, 1993	August 8, 1997
Kyoto Protocol	---	July 31, 2002 (Accession)

Source: UNFCCC (2014)

31.3.1 Market and Infrastructure Factors

Significant R&D organizations exist in South Africa to assist in the assessment of CMM emissions, recovery potential, and technology. Coaltech 2020 is an industry-led consortium of coal mine research and technology organizations (see Table 31-6).

Table 31-6. Coaltech 2020 Consortium Members

Names of Companies/Organizations	
Anglo Coal	Kumba Resources
CSIR Mining Technology	National Union of Mineworkers (NUM)
Department of Minerals and Energy (DME)	National Research Foundation (NRF)
Department of Trade and Industry (DTI-THRIP)	Sasol Coal
Xstrata (producer)	The Chamber of Mines of South Africa
Eskom (state utility)	University of Pretoria
Eyesizwe	University of Witwatersrand*

*Note: The University of Witwatersrand has for more than a decade conducted research on coal seam gas content, gas emission rates, permeability, and other coal properties (Schwochow, 1997).

The potential end uses for CMM in South Africa include electric power generation, boiler fuel, transportation fuel, and petrochemical feedstocks. CMM could offset or reduce growing requirements for gas imports to meet increasing gas demand. It could also provide an effective fuel substitute for coal and firewood.

Where mines are shallow and less gassy, collected CMM could be used for local heating purposes, but infrastructure would be required. In new areas, where virgin seams are deeper and gassier, CBM development could precede mining. Higher gas volumes from CBM and subsequent CMM in commercial quantities would require infrastructure investments for development of deeper mines, installation of gas collection technologies, and construction of gas pipelines to move the methane to markets.

Evidence of the gas potential in South African coals has evolved from a long record of gas-related mine explosions. Mines experience problems with gas and dust explosions and fires because the coals are hard and highly prone to sparking, as are the sandstone roof rocks. The proportion of mine deaths related to explosions increased from 3 percent in 1955 to 21 percent in 1993 (Schwochow, 1997).

31.3.2 Regulatory Information

In South Africa, CBM is defined by law as a unique mineral, so rights to its exploration and development can be separate from those of coal in the same seam. Under the latest Minerals Act, all mineral rights are vested with the government. Companies that held mineral rights under old orders, however, can apply for an extension to retain those rights. Technically, development licenses are required by law after commercially successful exploration, but many mines currently operate under exploration licenses. Licensing requirements and applications are available for review on the Department of Minerals and Energy's Web site (www.dme.gov.za).

Electricity, petroleum pipelines, and piped gas including CBM are regulated by the independent National Energy Regulator of South Africa (NERSA), which, among other things, issues licenses for construction and operation of gas transmission, storage, distribution, liquefaction, and re-gasification facilities (Gas Act, 2001). The piped gas industry is regulated by the Gas Act as amended by the National Energy Regulatory Act, which was brought into operation in 2005. Prior to 2005, the gas industry was not regulated and companies had to negotiate a regulatory agreement with the South African Government. The Piped-Gas Regulations Act came into effect in 2007. The Act is continuously reviewed by NERSA with the aim of suggesting possible amendments to the Minister of Minerals and Energy should these be deemed necessary (NERSA, 2009).

31.4 Profiles of Individual Mines

A comprehensive inventory of coal mines and coal production in South Africa can be found on the DME web site (DME, 2010c). Detailed spreadsheets of mines and contact information are also available online at http://www.dme.gov.za. Profiles for individual mines are not available.

31.5 References

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32 Spain

32.1 Summary of Coal Industry

32.1.1 Role of Coal in Spain

Spain has experienced significant industrialization since the 1970s, spurred on by its European Union (EU) membership in 1986. These factors have contributed to a 100 percent increase in energy demand since the mid-1970s. Spain is Europe's fifth largest energy consumer and has virtually no domestic production of liquid fuels or natural gas, so it depends upon imports for the bulk of its energy needs (EIA, 2014a). Coal represented more than 12 percent of the nation's primary energy supply in 2012 (EURACOAL, 2013).

Coal is Spain's most plentiful indigenous energy source, with reserves estimated at 530 million tonnes (Mmt). In 2012, Spain produced 6.15 Mmt of coal, while consuming 28.7Mmt, relying on imports for the balance (EIA, 2014b). Table 32-1 summarizes Spain's coal reserves and production.

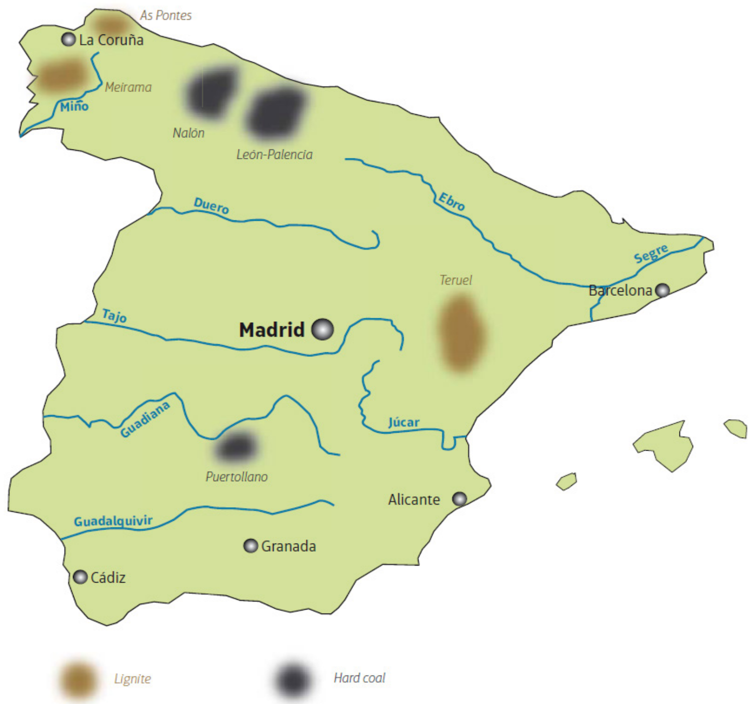
Table 32-1. Spain's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	200	330	530	33 (0.06%)
Annual Coal Production (2012)	6.15	0.0	6.15	32 (0.08%)

Source: EIA (2014b)

Spain's hard coal mining occurs primarily in northwestern Spain in Asturias, Castilla-León, Aragón, and León-Palencia, and also in the southern areas of Ciudad Real and Cordoba. The important opencast operations are located in Aragón, Ciudad Real, and at the border between Asturias and León. Teruel has the largest sub-bituminous coal reserves in the country, while most of the lignite is located in Galicia (see Figure 32-1). In recent years, high extraction costs have led to the gradual closure of mines, including the lignite mines in Galicia (EURACOAL, 2013).

Figure 32-1. Spain's Coal Fields



Source: EURACOAL (2013)

32.1.2 STAKEHOLDERS

Table 32-2 lists Spain's key stakeholders in the development of coal mine methane (CMM) industry.

Table 32-2. Key Stakeholders in Spain's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	HUNOSA (Huelleras del Norte S.A.) Endesa, S.A. UMINSA (Unión Minera del Norte S.A.)	Project host
Developers	See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities/Research Establishments	Geological and Mining Institute of Spain (Instituto Geologico y Minero de Espagne)	Technical assistance
Government Groups	Ministry of Industry, Energy, and Tourism – Directorate of Energy Policy and Mines	Regulatory

32.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Government-owned companies produce most of the coal in Spain. One of the main public companies is Hulleras del Norte, S.A. (abbreviated as HUNOSA), which is 100 percent owned by the government through the Sociedad Estatal de Participaciones Industriales (SEPI) holding company.

HUNOSA, the major producer of hard coal in the central Asturian basin, was founded in 1967 to direct most of Spain's coal mining, and it gradually took over the larger coal companies. There are a few remaining private companies, however, the largest of which is Unión Minera del Norte S.A. (UMINSA) that resulted from a merger of 15 independent companies (OECD, nd). Endesa, the leading lignite producer, is also the largest power generating and distributing company in Spain, with nearly 40,000 megawatts (MW) of installed generating capacity (Endesa, 2014).

Similar to other EU members, Spain's coal industry has struggled to remain competitive vis-à-vis imported coal and other energy sources. More than 60 percent of Spain's hard coal is mined in opencast mines, making indigenous hard coal competitive compared with imported coal (EURACOAL, 2013). The National Energy Plan (Plan Energético Nacional or PEN), the basic statement of official energy policy first formulated in 1978, was aimed at a rationalization of energy consumption and a reduction in Spain's dependence on imported energy. In line with the energy rationalization policies set by PEN, the government sought to increase the efficiency of the coal mining sector by closing down high-cost mines and by providing financial aid for the industry's modernization. To encourage the cement and other industries to convert from oil to coal, the government allowed them to import duty-free coal. The government also made efforts to substitute the use of oil for coal in urban areas.

Up until the 2008 economic recession, Spain was slowly phasing out its coal production subsidies in accordance with EU requirements. However, coal production and consumption increased in 2011 after the Spanish government introduced domestic coal production subsidies and gave preferential wholesale power market access to coal-powered generators in an attempt to reduce the country's imported coal dependence. This caused electricity producers to move away from renewable energy sources and back to coal. CARBUNION, the Spanish coal producers' federation, sought to maintain competitive indigenous coal production but in 2012, the government reduced mining subsidies by more than 80 percent, from 300 million Euros to 55 million Euros during 2011-2013. According to Spain's *Framework Plan for Coal Mines and Mining Communities 2013-2018*, coal production subsidies will end after 2018 (EIA, 2014a). The 2013-18 coal plan also aims to reduce coal production to 5.9 Mmt by 2018.

32.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies no projects in Spain, in operation or development (GMI, 2014). Updates on future CMM projects in Spain can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx.

32.2.1 CMM Emissions from Operating Mines

According to USEPA, methane emissions in Spain totaled 86.1 million cubic meters (m^3) in 2000, but are expected to decrease by nearly half to 44.1 million m^3 by 2015, and then anticipated to decrease slightly more to 42.7 million m^3 by 2030. Table 32-3 summarizes Spain's CMM emissions.

Table 32-3. Spain's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	86.1	64.4	46.2	44.1

Source: USEPA (2012)

32.2.2 CMM Emissions from Abandoned Coal Mines

At least 100 underground coal mines have been abandoned since 1970, but emissions from none of them are being exploited (Martinez, 2004).

32.2.3 CBM from Virgin Coal Seams

A "Spanish National Inventory of Coalbed Methane (CBM) Resources" was initiated in 2002 (Martinez, 2004). Although none of the CMM or abandoned mine methane emissions are being exploited in any coal basin, either in active or abandoned mines, future projects may emerge.

32.3 Opportunities and Challenges to Greater CMM Recovery and Use

As reflected in Table 32-4, Spain ratified the Kyoto Protocol as an Annex 1 country. The country's Kyoto emission reduction target is no more than 15 percent of its baseline emissions. As an Annex 1 country, Spain is eligible to host Joint Implementation (JI) projects but to date, its three JI efforts are focused on nitrous oxide abatement from nitric acid plants.

Table 32-4. Spain's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 13, 1992	December 21, 1993
Kyoto Protocol	April 29, 1998	May 31, 2002

Source: UNFCCC (2014)

The Spanish Strategy of Climate Change and Clean Energy (EECCEL), adopted in 2007 and running through 2020, defines actions to fight climate change while achieving cleaner energy and is based on the "Spanish Strategy for the fulfillment of the objectives under the Kyoto Protocol" framework approved by Spain's National Climate Council in 2004 (Magrama, 2007). However, the 2007 Strategy was primarily based on promotion of renewable electricity generation via a feed-in tariff scheme (e.g., subsidies) that has been mostly abandoned, so it is unclear how effective the climate policy might be until the current situation is resolved (Ecologic Institute – eclareon , 2014).

32.3.1 Market and Infrastructure Factors

The 2008 economic crisis was particularly harsh in Spain, and the government was forced to introduce austerity measures (i.e., deep subsidy cuts) that directly impacted the coal industry. There are now coal mines operating without these subsidies, which represent a newly competitive mining industry in Spain. In September 2013, the Spanish government sought review of the EU's directive on state aid to facilitate the closure of uncompetitive coal mines to allow those facilities that have achieved competitiveness to continue coal production beyond 2018 without having to repay past state aid (EURACOAL, 2013).

Spain's high levels and costs of gas imports ensure a significant market for any domestically produced natural gas that can compete on a cost basis with LNG imports and other high cost gas imports. Possible end uses for CMM in Spain include electric power generation and support for mine operations.

32.3.2 Regulatory Information

Mineral resources (including gas) are owned by the state and licensed for production by quasi-private enterprises and private operators.

Current subsidies for coal production are being phased out, and there are no current subsidies known for coal bed methane or CMM production.

32.4 Profiles of Individual Mines

No individual mine profiles are available at this time for Spain.

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33 Turkey

33.1 Summary of Coal Industry

33.1.1 Role of Coal in Turkey

Coal accounts for just over half of Turkey's total primary energy production from domestic resources, but it is not clear what role coal will play in Turkey's future energy makeup. Coal production and consumption has risen dramatically over the past few years, but so has the country's natural gas use as Turkey is emerging as a major energy transport hub connecting central Asia and Europe (EIA, 2009). The amount of natural gas in Turkey's total energy consumption increased to 32 percent from 6 percent between 1990 and 2010. This consumption is reflected in the share of electricity generated from gas between 1990 and 2010, which rose to 49 percent from 18 percent over the time period (MEU, 2013).

In 2010, coal represented about 53 percent of Turkey's primary energy production from domestic resources, with low-quality lignite comprising 48 percent and hard coal 5 percent. The role of domestic coal is projected to increase in Turkey's primary energy supply, but due to increasing total energy consumption, dependency on foreign energy imports has increased to 70 percent in 2010 from 52 percent in 1990 (MEU, 2013). As of 2012, Turkey produced 69.51 million tonnes (Mmt) of coal and imported 31.77 Mmt of mostly hard coal for thermal power plants, steel production, and domestic heating, mainly from Russia, Colombia, the United States, and South Africa (EURACOAL, 2014; EIA, 2014).

Table 33-1 summarizes Turkey's proved coal reserves and production.

Table 33-1. Turkey's Coal Reserves and Production

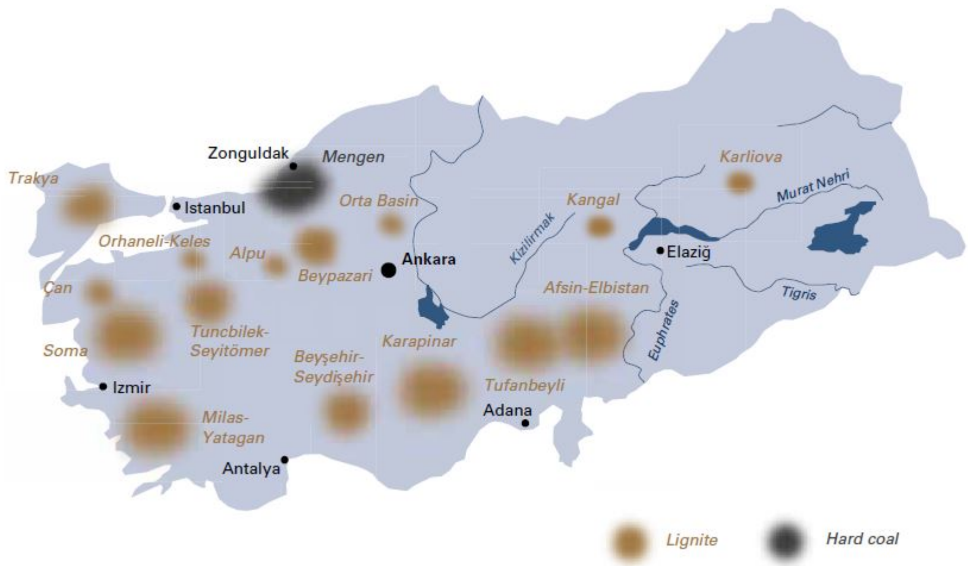
Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	322	8,380	8,702	(13, 0.98%)
Annual Coal Production (2012)	3.56	65.95	69.51	(12, 0.88%)

Source: EIA (2013)

Figure 33-1 shows locations of coalfields in Turkey. Lignite deposits are widespread throughout the country. BP's Statistical review of World Energy (2013) provides a somewhat lower estimate coal reserves with estimated lignite, hard coal and total coal resources of 1,645, 479.9, and 2,125.53 Mmt, respectively. In-country estimates completed by the Turkish Ministry of Energy and Natural Resources (MENR) increased total lignite reserves from 8.3 to 14.1 billion tonnes based on exploratory work completed by the Mineral Research and Exploration (MTA) in 2014.

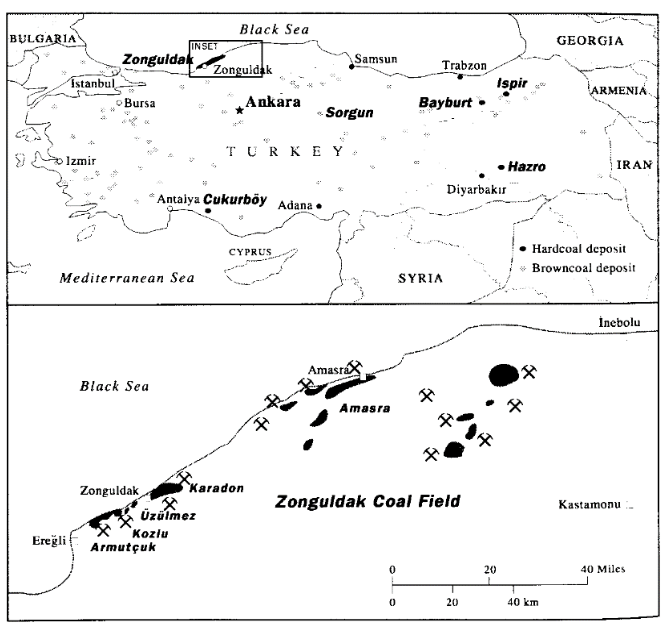
Most of Turkey's reserves are considered by MENR as economically mineable, though about half of the reserves have a low heating value that ranges between 1,000 and 1,500 kcal/kg. Approximately 46 percent of Turkey's lignite is in the Afsin-Elbistan Basin (MENR, 2014). Turkey's hard coal deposits are mostly located in the western part of the country, in the Zonguldak Basin (see Figure 33-2). MENR estimated hard coal resources in the basin at 1,316 billion tonnes; of which, 514 Mmt are considered reserves.

Figure 33-1. Turkey's Coal Fields



Source: EURACOAL (2014)

Figure 33-2. Turkey's Zonguldak Coal Basin



Source: Schwochow (1997)

33.1.2 STAKEHOLDERS

The government-run companies, Turkish Coal Enterprise and Turkish Hard Coal Enterprise, are the main coal companies. Table 33-2 lists all potential stakeholders in Turkey's coal mine methane (CMM) industry.

Table 33-2. Key Stakeholders in Turkey's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ Turkish Hard Coal Enterprise, TTK (Türk Taşkömürü işletmeleri) ▪ Turkish Coal Enterprise (TKI) ▪ HEMA Energi	Project host
Government Groups	▪ Ministry of Energy and Natural Resources ▪ Organization of Aegean Lignite ▪ Turkey Hard Coal Authority ▪ Representation of Turkish Coal Enterprises	Preparation and implementation of mining and energy policies, plans and programs
Developers, Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance, project opportunity identification and planning

33.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

The Turkish government has complete ownership over the country's coal resources and these rights are administered by two government-owned corporations, Turkish Coal Enterprises (TKI) and Turkish Hard Coal Enterprises (TTK). In recent years, TKI and TTK have leased out coal reserves to private companies and several private mines are in operation. TKI was established in 1957 to operate the coal mines of Turkey and it is the major brown coal producer in the country, operating 30 opencast and nine deep mines, which produced a total of 33 Mmt of low quality lignite in 2009. In addition to TKI, Elektrik Üretim A.Ş. (EÜAŞ) and the private sector produced 36 and 7 Mmt, respectively (EURACOAL, 2010). TTK was established in 1983 to operate hard coal mines in the Zonguldak basin and is operating five deep mines that produced approximately 2.8 Mmt in 2010 (EURACOAL, 2010). This enterprise carries out the exploration, production, and marketing of domestic hard coal (TTK, 2010; EURACOAL, 2010). The private sector accounts for only about 8 percent of coal production, but about 35 percent of coal production reported by the state enterprises is mined by private companies under subcontract (EURACOAL, 2010).

Turkey has both active surface and underground mines. However, about 90 percent of the country's lignite production comes from surface mines (MBendi, 2010). More specific details about mines, reserves, and location of Turkey's coal can be found on an interactive Google Map developed by the MENR (MENR, 2010).

33.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies one project currently underway for the optimization of degasification systems to reduce methane emissions from Turkish coal mines (GMI, 2014). U.S. EPA's Coalbed Methane Outreach Program

(CMOP) has funded two pre-feasibility studies for CMM development in the Zonguldak region, awarded Virginia Tech a grant to study CMM and CBM potential in the country, and is currently working on a project at the HEMA Energi Mine in Amasra, Turkey, that is focused on mine pre-drainage and CMM utilization.

33.2.1 CMM Emissions from Operating Mines

CMM emissions from operating mines in Turkey are shown in Table 33-3.

Table 33-3. Turkey's CMM Emissions (million cubic meters)

Emissions	2000*	2005*	2010**	2015 (projected)†
Underground Mines	41.24	37.40	41.99	
Post-Underground Mines	NA	NA	6.00	
Surface Mines	71.96	66.40	80.85	
Post-Surface Mines	NA	NA	6.74	
Total emitted (= total liberated – recovered & used)	**113.20**	**103.80**	**135.58**	**127.68**

Sources: *UNFCCC (2010 [converted from Gg and rounded to the hundredths]); **UNFCCC (2013); †USEPA (2012)

33.2.2 CMM Emissions from Abandoned Mines

No information was found on CMM emissions from abandoned mines in Turkey.

33.2.3 CBM from Virgin Coal Seams

Coal bed methane (CBM) from the Zonguldak hard coal region could play a very significant role in Turkey's energy economy. The CBM in-place resources in two districts of the Zonguldak hard coal region are presently estimated to be at least 3 trillion cubic meters (Mustafa and Balat, 2004). In 2012, the U.S. Trade and Development Agency funded a CBM feasibility study in support of HEMA's CBM program in the Zonguldak coal region. HEMA has drilled a series of wells throughout their license area and intends to initiate full-scale development in late 2014.

33.3 Opportunities and Challenges to Greater CMM Recovery and Use

As indicated in Table 33-4, Turkey has acceded to the UNFCCC.

Table 33-4. Turkey's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	---	February 24, 2004 (Accession)
Kyoto Protocol	---	---

Source: UNFCCC (2014)

33.3.1 MARKET AND INFRASTRUCTURE FACTORS

In May 2001, Turkey enacted a new Natural Gas Law. Prior to this law, most of the natural gas market and infrastructure was dominated by the Petroleum Pipeline Corporation (a.k.a., BOTAS, a state-owned company). The new gas law requires that the natural gas transmission, storage, and distribution networks be open to competition and monopolistic elements be unbundled. BOTAS still owns the majority of the transmission infrastructure and most of the market, but distribution, storage, and import is open to competition. BOTAS has begun transferring ownership of its import contracts to private entities to comply with its mandated 20 percent of total market share. Revisions to the Natural Gas Law are being debated to improve the privatization effort and to further reduce dominance of BOTAS (MONDAQ, 2010).

Although Turkey has moved toward liberalizing its coal industry and no rules ban private sector involvement, no foreign companies have made investments (Kayıkçı, 2010). Seeking to increase its domestic electricity generation, Turkey is looking to expand its domestic lignite production instead of relying on external natural gas resources. With potential for thermal power generation, Turkey has opened up six of its lignite fields to the private sector under a royalty model (MBendi, 2010).

Turkey has several international natural gas lines that bring the resource into the country, which may make Turkey a major player in energy transit (EIA, 2009).

33.3.2 REGULATORY INFORMATION

The Ministry of Energy and Natural Resources is the main body of the Turkish mining and energy sector, responsible for the preparation and implementation of mining and energy policies, plans and programs, in coordination with its dependent and related institutions, and other public and private entities. The Ministry's duties related to the mining sector mainly include organizing and controlling the mining license for production of in-country natural resources, in order to contribute to the economy.

There have been several updates to laws regulating mining in recent years. They have, however, been struck down in court, and licenses and permits are still regulated from one law dating back to 1985 and two others from 2005. Three licenses relating to mining exist: a prospecting license, an operation license, and an operation permit (Kayıkçı, 2010).

33.4 Profiles of Individual Mines

No information profiling individual Turkish coal mines was found. Updates on future CMM projects in Turkey can be found at https://www.globalmethane.org/partners/turkey.aspx

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34 Ukraine

34.1 Summary of Coal Industry

34.1.1 Role of Coal in Ukraine

Ukraine produced approximately 1 percent of total world coal production in 2012 (see Table 34-1) producing 64,362 million tonnes (Mmt) of saleable hard coal according to the U.S. Energy Administration, making it the fourteenth largest producer of coal in the world (EIA, 2014a). BP ranked Ukraine as eleventh in production in their 2013 survey report with total raw coal production of 88.2 Mmt in 2012, a 4 percent increase over 2011 and a 20 percent increase over 2009 (BP, 2013). Statistics for 2013 have been released by the Ministry of Energy and Coal Industry of Ukraine, According to the Ministry, raw coal production totaled 83.7 Mmt in 2013 (Yashchenko, 2014).

Table 34-1. Ukraine's Coal Reserves and Production

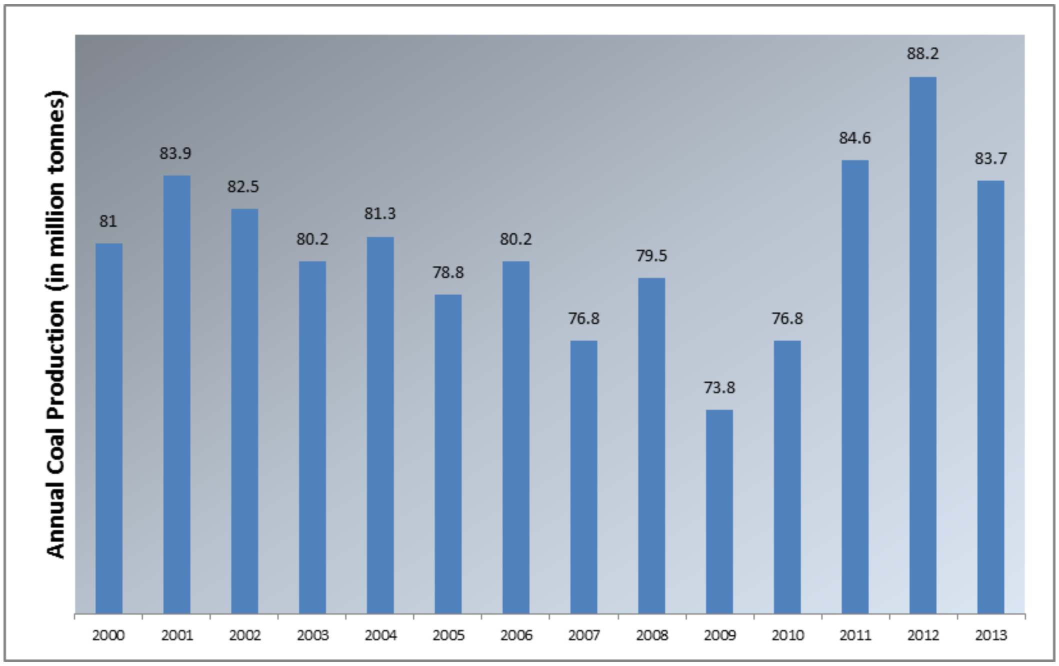
Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	15,351	18,522	33,873	7 (3.8%)
Total Primary Coal Production (2012)	64.4	0	64.4	14 (0.8%)

Source: EIA (2014a)

All of Ukraine's production is hard coal, according to IEA and EIA. 2007 was the last year lower rank brown coals were produced in Ukraine and even then only a small volume of lignite was produced—0.2 Mmt comprising only 0.3 percent of total coal production (IEA, 2013). As reflected in Table 34-1, Ukraine's total coal reserves as of 2012 were 33.9 billion tonnes, of which about 15.4 billion tonnes were hard coals and 18.5 billion tonnes were soft coals (sub-bituminous and lignite) (BP, 2013). Euracoal, the European Association for Coal and Lignite, estimates that Ukraine's total coal resources are 54 billion tonnes with economically recoverable reserves of 34 billion tonnes (Euracoal, 2013). Coal in 330 seams has been explored to a depth of 1,800 meters, with 130 seams exceeding 0.45 meters in thickness. Only 10 seams are suitable for development with the remainder being too deep or too thin to mine (M2M Workshop – Ukraine, 2005).

Coal production in Ukraine declined significantly from 1990 to 1996, falling by over 50 percent from 164.9 Mmt in 1990 to 70.5 Mmt in 1996. Coal production has since stabilized at an approximate average of 80 Mmt per year of raw coal production (BP, 2013). In 2013, Ukraine produced 83.7 Mmt of coal with 59.6 Mmt coming from private mines and the remaining 24.1 Mmt coming from state-owned mines (Yashchenko, 2014). In addition to licensed mines, unregulated coal mining is also reported to be occurring in Ukraine with reports estimating that illegal mining may produce up to 10 percent of Ukraine's coal (Cragg, 2013; Golovnev, 2013).

Figure 34-1. Ukraine's Historical Raw Coal Production Volumes, 2000-2012

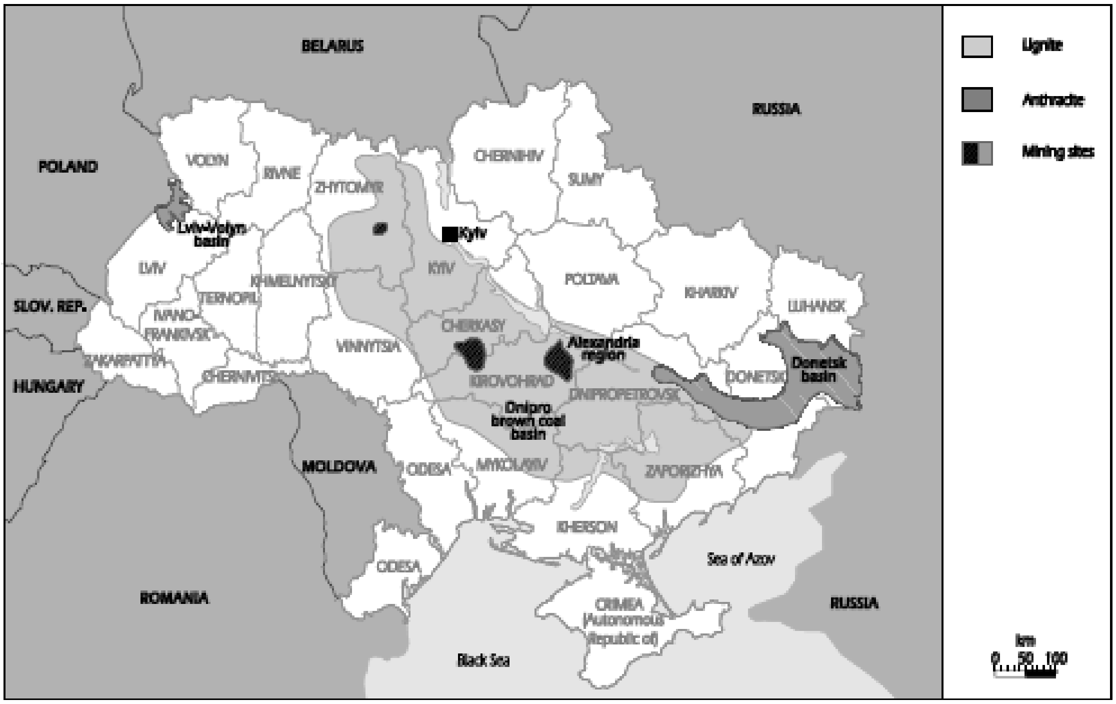


Sources: BP (2013); Yashchenko (2014)

Ukraine remains critically reliant on coal as one of its primary resources for electric power generation along with nuclear power (EIA, 2014b). In 2012, coal supplied 36 percent of Ukraine's total energy supply (BP, 2013). Ukraine is not among the world's major coal exporters because of a lack of progress on deregulation, along with underinvestment in coal production leading to high coal production costs. Despite its sizeable resources Ukraine is a net importer of coal and in 2012 imported a net 6.963 Mmt (EIA, 2014a). In 2012, 46 percent of the country's rated generating capacity was in thermal sources (coal, oil, and gas-fired), compared to nuclear at 48 percent and hydroelectric at 6.0 percent (EIA, 2014a). Thermal production's role steadily decreased between 2003 and 2005 from 50 percent to 45 percent as nuclear generation capacity increased; however, nuclear and thermal generation have been roughly equal since 2006 (EPA, 2014a).

Coal is produced in two major basins in Ukraine, the Donetsk Basin (60,000 km^2) in southeastern Ukraine (and western Russia), and the Lviv-Volyn basin (7,500 km^2) in western Ukraine, which continues into Poland (Sachsenhofera, 2002; M2M – Ukraine, 2005). The Donetsk Basin is commonly referred to as "the Donbass" and holds approximately 95 percent of Ukraine's proved coal reserves (Euracoal, 2013). The Donbass can be further subdivided between the Donetsk (45.6 percent), Lugansk (34.2 percent), and Dnipropetrovsk (15.3 percent) regions (Figure 34-2).

Figure 34-2. Ukraine's Coal Fields



Source: IEA (2012)

34.1.2 STAKEHOLDERS

Potential stakeholders in coal mine methane (CMM) development in Ukraine are listed in Table 34-2.

Table 34-2. Key Stakeholders in Ukraine's CMM Industry

Stakeholder Category	Stakeholder	Roles
Coal associations	▪ Makeyevugol Coal Association (http://www.makeevugol.donbass.com/) ▪ Donetsksteel ▪ DTEK (SCM Holdings) ▪ Komsomolets Donbassa Mine ▪ DTEK Pavlogradugol (10 mines) ▪ Dobropolyeugol (5 mines) ▪ Rovenkianthracite (6 mines) ▪ Sverdlovanthracite (5 mines) Mine ▪ ALC Mine Bilozerska (1 mine) ▪ State Enterprise Coal Company Krasnolimanskaya Mine ▪ Luganskugol ▪ Pervomayskugol ▪ Oktyabrugol ▪ Private Joint Stock Company "Mine named after AF Zasyadko ▪ METINVEST Holdings (http://www.metinvestholding.com/en) ▪ Krasnodonugol (5 mines)	Project hosts

Table 34-2. Key Stakeholders in Ukraine's CMM Industry

Stakeholder Category	Stakeholder	Roles
Coal associations (con't)	▪ Coal Energy SA (http://www.coalenergy.com.ua/en/) ▪ Svyato-Pokrovskaya mine ▪ Svyatitelya Vasiliya Velikogo mine ▪ Svyato-Serafimovskaya mine ▪ Svyato-Andreevskaya ▪ Prepodobnogo Sergiya Radonezhskogo mine ▪ Chapaeva mine, ▪ 1 Maya mine ▪ Ternopolskaya mine ▪ Svyato-Nikolayevskaya mine ▪ Udacha mine ▪ Rassypnianskii Krutoi mine sectors ▪ Donetsk Coal & Energy http://www.ivcdu.dn.ua/ ▪ Donugol (http://www.donugol.ru/) ▪ Dobropolyengol ▪ Dobropolye ▪ Krasnoarmeyskugol	Project hosts
Equipment manufacturers	▪ Caterpillar, USA ▪ Zeppelin Ukraine (Ukrainian division of Caterpillar) ▪ GE Jenbacher (Austria) ▪ Biothermica (Canada) – VAM ▪ Hofstetter (Switzerland) – flares ▪ MEGTEC Systems ▪ Durr	Power generation equipment supplier
Developers	▪ ATEC ▪ Carbon TF ▪ Eco-Alliance ▪ EcoMetan ▪ EnergoImpex ▪ EuroGas (Lviv-Volyn Basin) ▪ Green Gas International ▪ Green Way 2020 ▪ HEL East Ltd ▪ Pro2 Anlagentechnik GmbH ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning
Engineering, consultancy, and related services	▪ Advanced Resources International Inc. (USA) ▪ DMT GmbH ▪ Raven Ridge Resources ▪ REI Drilling (USA) ▪ Ruby Canyon Engineering ▪ Schluberger (global) ▪ Weatherford International (global) ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Government Groups	▪ Ministry of Energy and Coal Industry of Ukraine ▪ Donetsk Regional State Administration (DRSA) ▪ State Service of Mining Supervision and Industrial Safety of Ukraine	Project approval
Universities, Research Establishments	▪ Donetsk Coal Research Institute ▪ Ukrainian Natural Gas Research Institute ▪ Dnipropetrovsk Mining University of Ukraine ▪ National Academy of Sciences	Technical assistance

34.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Ukraine experienced a steep decline in coal production from 165 million raw tonnes per annum (Mta) in 1990 to 70.5 Mta in 1996. Production stabilized after 1996, fluctuating between 70 and 80 Mta, although 2012 production increased to 88.2 Mt (BP, 2013), and the Ministry of Energy and Coal Industry of Ukraine reports that raw coal production totaled 83.7 million metric tonnes in 2013 (Yashchenko, 2014). Almost two-thirds of the production is steam coal and the remainder is coking coal (IEA, 2013). The increase in coal production is due to the closure of uneconomic mines that came about from the Ukraine mine closure plan in 1997 and the privatization of formerly state-owned mines. Privatization has led to significant investment in the privatized mines and a broader move to market standards where transactions occur with creditworthy customers and payments are more regular. With reserves sufficient to last for over 350 years at current production levels, the coal mining industry should remain stable for the foreseeable future.

Private companies operated 70 percent of Ukraine coal production capacity at the end of 2013 (Yashchenko, 2014). By year end 2013, there were 143 coal mines operating in Ukraine, a decrease of 12 from 2012. Data on ownership is not available for 2013, but in 2012 there were 45 privately owned mines in Ukraine, up from 29 in 2010. The number of state-owned mines declined from 127 in 2010 to 110 in 2012 (Yashchenko, 2013). These changes are in line with the Energy Strategy of Ukraine, which plans for further decrease of state ownership of coal mines (Yashchenko, 2013). The Cabinet of Ministers approved privatization of 66 coal mines between 2012 and 2014, including noted coal associations such as Makeevugol and Luganskugol (MECI, 2012).

Most of the mines in Ukraine are underground mines (Table 34-3) producing bituminous coal. Anthracite accounts for 11 percent of coal production (IEA, 2013). Ninety-five percent of the active mines in 2012 were in the Donetsk basin, while the remaining five percent were found in the Lviv-Volyn basin (MECI, 2012; Yashchenko, 2013).

Table 34-3. Ukraine – Number of Coal Mines by Type

Type of mine	Raw Coal Production (million tonnes)	Number of mines
Underground (active) mines – total (2013)	83.7	143
Surface (active) mines – total (2012)	0.02	3

Sources: PEER (2005); Yashchenko (2014); UNFCCC (2014a)

Today, active Ukrainian underground coal mines have an average mining depth of more than 700m and one out of six mines are at a depth of greater than 1,000m (IEA, 2012). The deepest mine is 1,332m, and some preparatory work is being undertaken at a depth of 1,386m (Euracoal, 2013). Average seam thickness is 1.2m. Approximately 90 percent of mines release significant amounts of methane. About 60 percent of mines are reported to have possible coal dust outbursts, while 22 percent of mines are susceptible to possible coal spontaneous combustion (IEA, 2012).

In 2013, 133 out of 143 mines or 93 percent of operating mines were considered gassy, and these mines produced 70 percent of Ukraine's coal in 2013. Thirty of the mines have absolute methane emissions between 0.5 and 12 cubic meters per minute (m^3/m) and the other 103 have emissions greater than 12 m^3/m (Yashchenko, 2014). At some mines, the natural gas content can exceed 35 cubic meters per tonne of dry ash-free coal (PEER, 2002).

34.2 Overview of CMM Emissions and Development

The Global Methane Initiative (GMI) International CMM Projects Database identifies 31 CMM projects in Ukraine, involving 13 active, underground mines and one surface mine in the Donbass, and three active underground mines, one abandoned mine and one active surface mine in the Lugansk basin. The methane is used for boiler fuel in 11 of these projects, for combined heat and power in eight, flaring in seven, and for industrial use, power generation, pipeline injection, heating/cooling and vehicle fuel and flaring in the remaining five projects (GMI, 2014a). GMI's 2010 Projects Database lists a further eight projects that were publicized through posters at the 2007 and 2010 GMI Expos at https://www.globalmethane.org/activities/indexact2.aspx?sector=coal# (GMI, 2014b).

Ukraine has registered more CMM projects under the Joint Implementation (JI) mechanism of the Kyoto Protocol than any other country. Ukraine also has a very good track record with respect to generating Emission Reduction Units (ERUs) under the JI. Thirteen of the 16 projects in the pipeline have been registered with the remaining three still in the determination stage. Of the 13 registered projects, 12 have been issued ERUs, an extremely high success rate compared with other countries. Total ERUs issued through 2012 equal 23 million tonnes carbon dioxide equivalent (MmtCO_2e) (UNEP RISØ Center, 2014).

One of the latest CMM degasification and utilization projects at the Sukhodolska-Vostochnaya coal mine in Krasnodon was announced by Green Gas International in February, 2010. The mine currently operates at depths up to 1,000 meters and the project plans to enhance the gas drainage system to provide a steady source of methane for heat and power production for use at the mine. (Green Gas, 2010). In January 2014, GGI and Krasnodonugol announced they were entering the next phase of the project to generate heat and power. In addition, DTEK has announced plans to develop a 3 MW power project at the Komsomolets Donbassa mine where it has already used CMM in two flares and also uses CMM in boilers for hot water and steam in winter.

34.2.1 CMM Emissions from Operating Mines

Ukraine is considered to be the world's fourth largest emitter of methane emissions from coal mining activities (USEPA, 2012), even though emissions have been significantly reduced by mine closures and reduced coal production (see Table 34-4). The data in this table may vary from the USEPA data presented in the Executive Summary due to differences in inventory methodology and rounding.

Table 34-4. Ukraine's CMM Emissions (million cubic meters)

Emission Category	2000	2005	2010	2015 (projected)
Underground mining - active	1692.55	1315.73	1191.32	
Underground - post-mining	156.32	135.45	133.89	
Surface mining - active	1.42	0.41	.01	
Surface - post-mining	0.20	0.06	0.00	
Abandoned Mines	7.86	4.65	2.80	
Total Emissions	1850.49	1451.65	1325.21	2096.06*
Additional Recovered and Flared	70.36	55.02	127.61	

Sources: UNFCCC (2014a); *USEPA (2012)

In August 2005, the U.S. Trade and Development Agency (USTDA) awarded a $585,570 grant to the Donetsk Regional State Administration to conduct a feasibility study on commercial development of coal bed methane (CBM) and CMM in the Donbass region. The project aimed to increase the domestic supply of natural gas, increase mine safety, and improve local environmental quality. The analysis focused on developing the best technical and economic approach for methane drainage at mines, evaluating the technical and economic merits of producing CMM, and assessing the most likely markets and infrastructure required to utilize CMM and CBM (USTDA, 2005). The study focused on two mines, Bazhanov and South Donbass No.3, which were found to have average CMM emissions of 9.9 and 8.8 million m^3 per year respectively. Economic analysis suggests these emissions are sufficient to power on-site electricity generators with capacities of 1.7MW and 3.3 MW. The Bazhanov mine already utilizes 5.5 million m^3 per year of drained methane in onsite boilers for heating purposes (USTDA, 2008). The two mines were publicized in posters at the 2010 GMI Expo. The projects are currently searching for further financial and technical assistance to move their CMM projects to the development stage (GMI, 2014b).

The U.S. EPA supported two recent pre-feasibility studies in Ukraine:

- **Komsomolets Donbassa Mine** – The pre-feasibility study projects gas production from surface pre-mine drainage and gob vent boreholes, analyzes end-use options and assess the feasibility of various combinations of gas drainage and utilization technologies. The study concludes that gob vent boreholes combined with power generation can be economic at the mine.
- **Zhdanovskaya Mine** – There is large potential to reduce methane emissions at Zhdanovskaya Mine. The study identified two main, technically-viable options for the optimal utilization of CMM at the mine: (1) electricity generation by installing a gas-engine generator to produce power for mine use or export to the public grid; and (2) on-site heat generation from existing mine boilers which presently consume coal, but can be switched to use CMM.

34.2.2 CMM Emissions from Abandoned Coal Mines

Hundreds of mines have been closed and abandoned in Ukraine since the inception of its coal industry. Between 1990 and 2013, 143 underground mines were abandoned or were in the process of closure in a major effort by the state to increase mine efficiency, improve mine safety, and achieve mine profitability (UNFCCC, 2007; Yashchenko, 2013 & 2014). The mine closure rate has declined in recent years, as the government attempts to bolster national coal production with technical upgrades at coal mines rather than closure, while also investigating opening some previously closed mines (Euracoal, 2008). Due to high groundwater levels, it has been reported by experts in Ukraine that all abandoned mines flood limiting their capacity to be sources of AMM projects. Pumping flood water out of the mine has been considered but it is extremely energy and cost intensive. There may also be environmental concerns with discharge of mine water onto surface soils or surface water bodies. The Government of Ukraine has established a state-owned company responsible for closing mines and managing the abandoned mines. The company is called Ukruglerestrukturizatsia (UDKR). The Donetsk Regional State Administration and UDKR have expressed interest in developing policies and procedures to prepare operating mines for future AMM activity upon closure.

34.2.3 CBM from Virgin Coal Seams

Ukraine's CBM resource is approximately 1.7 trillion cubic meters (ARI, 1992; Thomas, 2002). The USTDA grant awarded to the Donetsk Regional State Administration in 2005 aimed to assess the most likely markets and infrastructure required to utilize virgin CBM (USTDA, 2005). The study looked at the feasibility of drilling CBM wells in the areas surrounding the Bazahnov and South Donbass No. 3 mines. Multiple seams of coal are present in a section 500-900 m deep and with gas contents ranging from 15-20 m^3 per tonne. Markets for potential produced gas include direct pipeline sales and compressed natural gas (CNG) projects (USTDA, 2008).

EuroGas Inc. was the first foreign company to drill for CBM in 1998, but has had no commercial success. In 2008, they formed a joint venture with one of Ukraine's largest industrial holding groups, to explore and develop CBM leases in east and west Ukraine, although this project is still in the planning stages (EuroGas, 2010).

Ukraine has very limited R&D resources available for pursuing CMM or CBM research, namely lack of technology for and experience in applying hydro-fracturing to stimulate CBM production. A more favorable investment climate along with clarity on CBM ownership issues are needed before more foreign companies are likely to commit to CBM projects in Ukraine.

34.3 Opportunities and Challenges to Greater CMM Recovery and Use

Ukraine has signed and ratified both the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (see Table 34-5). As an Annex I country, Ukraine is eligible to host Joint Implementation (JI) projects. Emission Reduction Units (ERUs) are the commodity generated by JI projects and one ERU is equivalent to one tonne of CO_2. ERU's are recognized offsets in the European Emissions Trading Scheme. The Kyoto Protocol ended on 31 December 2013, and there is no successor agreement; however, the EU ETS continues to operate. To be eligible to be traded in the EU ETS, ERUs must have been generated prior to 1 January 2013, and issued by the UNFCCC's Clean Development Mechanism Executive Board before 31 March 2015.

Table 34-5. Ukraine's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 11, 1992	May 13, 1997
Kyoto Protocol	March 15, 1999	April 12, 2004

Source: UNFCCC (2014b)

Per the Kyoto Protocol, Ukraine must stabilize greenhouse gas emissions at the 1990 level of 55.4 $MmtCO_2e$. Emission reductions since 1990 due largely to coal mine closures have resulted in current estimated emissions of 17.1 $MmtCO_2e$ (UNFCCC, 2014a).

As of 2013, degasification is performed at 37 coal mines in Ukraine that account for 41 percent of the country's total coal production. Of the 37 mines degassing, 20 are private mines with annual production of 28.6 Mmt or about one-third of total coal production. The remaining 17 are state-owned mines generating 10 Mta. The number of mines using degasification was steady between

2010 and 2012 at 41 to 42 mines but declined in 2013 to 37 mines. The decrease was due to a large decrease in the number of state-owned mines using methane degasification, while privately owned mines employing degasification has actually been growing since 2010 (Yashchenko, 2014).

Coal mines are prohibited from using CMM if the CH_4 content is below 25 percent, which was the case at 20 of the mines in 2012. The other 15 mines had CH_4 concentrations above 25 percent in their drainage systems, but only five of those have concentrations above 35 percent (Yashchenko, 2013).

In 2013, Ukraine mines recovered 370 Mm^3 in their degasification systems, the same amount as produced by degasification systems in 2012. The Ministry of Energy and Coal Industry reports utilization of 34 percent of the drained gas in 2013, a decrease from 43 percent in 2012. The Government's goal is to increase methane drainage to 450 Mm^3 annually while doubling utilization to 250 Mm^3 per year (Yashchenko, 2014).

34.3.1 Market and Infrastructure Factors

In Ukraine, mineral resources and mines are owned by the state. Existing mines are operated under licenses. While methane in coal is owned by the state, it is assigned to companies, mines, and individuals. CBM/CMM development is subject to the approval of the Ministry of Energy and Coal Industry (M2M Workshop – Ukraine, 2005).

Most CMM that is not flared is currently used for basic applications such as boiler firing and mine air heating, and combined heat and power. There remains significant potential for CMM to fuel additional power generation in gas or dual-fuel power plants, to supplement supplies for other residential, commercial, and industrial uses, or to be converted into transportation fuel. In 2011, Ukraine imported 77 percent of its natural gas requirements (EIA, 2014a) and so the potential markets for CMM in Ukraine are significant, especially as prices for natural gas increase. The principal barrier to expanding the use of CMM is poor market access, including the lack of modern infrastructure to gather and transport methane produced by CMM processes to internal end use markets and to existing international pipelines that serve foreign markets, mainly Western Europe.

34.3.2 Regulatory Information

The state owns all subsurface resources including coal and gas resources. Private mines lease the minerals from the State. Forty-five operating coal mines have been privatized, which represent roughly 71 percent of Ukraine's annual coal production (Yashchenko, 2013 and 2014). Major private mining companies include DTEK, METINVEST, Donetsk Steel, and Coal Energy SA. The remaining mines are state owned and are referred to as Joint Stock Holding Companies (Triplett, 2006).

The Government of Ukraine prepared the *Updated Energy Strategy of Ukraine to 2030* in 2012, addressing reform of the coal industry. Target growth is to reach 130 Mta of production by 2030, a 53 percent increase over 2012 levels.

State programs to advance CMM production, have previously relied mainly on private investment. Government support has taken the form of various tax incentives to attract investment in coal regions and exempting foreign-manufactured materials and equipment used in CMM development from Ukraine's value added tax.

On 22 February 2006, the Ukrainian Cabinet officially approved a set of JI procedures formally outlining the Federal Government's procedures for consideration, approval, and implementation for domestic companies such as coal mines to carry out JI projects under Article 6 of the Kyoto Protocol; several projects have already been submitted under these guidelines.

More recently, Ukraine has undertaken several important policy steps to promote CMM capture and use.

In 2009, Ukraine's Parliament passed the Law on Gas (Methane) from Coal Beds. The law defines CMM as a fuel resource and clarifies ownership issues, making it easier for third parties to obtain licenses to use vented CMM . The law also does not allow new mines to begin operating unless they brought concentrations of methane down to acceptable levels. In addition, it clarifies that CMM owners can sell their gas into the natural gas transmission system when the gas meets system requirements. Finally, the law attempts to support investments projects by offering state guarantees for protecting investments that aim to improve degasification, providing customs and tax incentives to businesses engaged in CMM recovery and CMM-based production, granting state support and guarantees to the producers and suppliers of energy from CMM.

Certain gas emissions, including methane and carbon dioxide, are controlled as a result of the Law of Ukraine on Protecting the Natural Environment and the Law of Ukraine on Air Protection. Ukraine has regulated emissions and pollutants by charging an ecological tax since 2009 in which each company has to turn in ecological tax forms quarterly and pay for their emissions (Roshchanka and Evans, 2014). The cost of methane emissions is 81.08 Ukraine Hryvnia (UAH)/tonne, or $9.9/tonne, while the cost of carbon dioxide emissions is 54.05 UAH/tonne, or $6.6/tonne (Government of Ukraine, 2010).

In June 2009, Ukrainian President Viktor Yushchenko signed important coal mine legislation that includes a tax exemption for Ukrainian CMM projects. Starting in 2010 and continuing through January 2020, profits from the production and use of CMM earned by Ukrainian enterprises will no longer be subject to taxation (the basic charge rate is 16 percent). However, in 2012, the Ukrainian Parliament amended the tax code, requiring mines to pay subsoil use tax for methane utilization. This made CMM projects less feasible. For example, DTEK had to suspend its CMM-fired cogeneration projects.

Due to the coal industry's large role in the economy, not only as an indigenous source of energy but also for employment, the Government of Ukraine offers significant subsidizes to state-owned coal enterprises. According to IEA, subsidies in 2009 totaled USD 1.7 billion (IEA, 2012). Private mines do not receive direct subsidies but may receive other preferential treatment such as favorable loan terms, low tariffs, or other attractive options.

34.4 Profiles of Individual Mines

Twenty-nine mines have been identified as primary opportunities for CBM/CMM development in Ukraine. These mines have been profiled in great detail by the Partnership for Energy and Environmental Reform in its *Handbook on Opportunities for Production and Investment in the Donetsk Basin* (PEER, 2001).

Table 34-6 gives more up to date details of one of the profiled mines. Other profiles are available at the following sources:

- Updated profiles are available on the GMI website, under "Projects" (GMI, 2014b). https://www.globalmethane.org/activities/indexact2.aspx?sector=coal#

The pre-feasibility studies of the:

- Komsomolets Donbassa mine http://epa.gov/coalbed/docs/KDMineUkraine_preFeasibilityStudy2013.pdf
- Zhdanovska mine http://epa.gov/coalbed/docs/Ukraine_PreFS_CMM_Zhdanovskaya%20Mine_July%202013.pdf
- The Project Design Documents available on the UNFCCC website for the projects listed in Table 34-7.
- The USEPA Publication *Addressing Barriers to CMM Project Development in Ukraine: Four Coal Mine Profiles* http://epa.gov/coalbed/docs/ukraine_cmm_profiles_may2010.pdf.
- U.S. Trade & Development Agency. Feasibility Study for the South Donbass #3 and Bazhanov Mines. *Coal Mine Methane and Coalbed Methane in the Donetsk Region, Ukraine*. http://www.ustda.gov/library/reports/ukr_200581025a.pdf

Table 34-6. Profile of Yuzhno-Donbasskaya #3

Yuzhno-Donbasskaya #3 Mine			
Mine Status	Active	**Mine Owner**	Donetskya Vulgina Energetichna Kompanya
Mining Method	Longwall	**Parent Company**	State
Depth of Seams	585-940 m	**Location**	Vugledar, Donetsk
No. of Seams	2 – C_{11} & C_{10}	**2008 VAM Volume**	30.32. Million m^3
Seam Thickness	1.5-1.7 m	**2008 Drained CH_4 Volume**	2.9 Mm^3
2008 Coal Production	1.2 million tonnes	**2008 Utilized CH_4 Volume**	0

	1997	**1998**	**1999**	**2000**	**2001**	**2002**
Coal Production (thousand tonnes/yr)	1019	1053	1224	1273	1569	1510
Methane (million m^3/yr)						
Emitted from ventilation systems	15.56	23.70	15.27	12.31	31.23	49.66
Liberated from drainage systems	2.58	1.00	2.89	2.9*	2.9*	2.9*
Total Methane Emissions	18.14	24.70	18.16	15.21	34.13	52.56
	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Coal Production (thousand tonnes/yr)	1289	1190	1266	1200*	1200*	1200*
Methane (million m^3/yr)						
Emitted from ventilation systems	46.97	53.75	47.97	35.00	32.90	30.32
Liberated from drainage systems	2.9*	2.9*	2.9*	2.9*	2.9*	2.9*
Total Methane Emissions	49.87	56.65	50.87	37.90	35.80	33.12

* Estimated
Source: GMI (2014b)

Table 34-7. List of Ukraine Joint Implementation Projects

Name of Project
▪ Utilization of CMM at the Coal Mine named after A.F. Zasyadko
▪ CMM utilization on the coal mine Shcheglovskaya-Glubokaya of the State Holding Joint-Stock Company GOAO Shakhtoupravlenye Donbass
▪ CMM utilization on the Coal Mine № 22 "Kommunarskaya" of the State Holding Joint-Stock Company GOAO Shakhtoupravlenye Donbass
▪ CMM utilization on the Joint Stock Company named Komsomolets Donbassa Coal Mine of DTEK (Donbasskaya Toplivnaya Energeticheskaya Kompanya)
▪ CMM utilization on the Joint Stock Company "Coal Company Krasnoarmeyskaya Zapadnaya № 1 Mine"
▪ CMM utilization for heat generation and flaring – Pivdennodonbaska No 3
▪ Utilization of CMM at the Coal Mine Sukhodilska-Skhidna
▪ CMM Capture and Utilization at Samsonivska-Zakhidna Mine
▪ Abandoned CMM Utilization at NPK-Kontakt Ltd.
▪ Utilization of CMM at the Coal Mine Named After M. P. Barakov of JSC Krasnodoncoal
▪ Power Generation from the CMM at the Sukhodolskaya – Vostochnaya Mine
▪ Utilization of CMM at the SE Makiyivvuhillya
▪ CMM utilization on the coal mine Molodogvardeyskaya of the Joint Stock Company Krasnodonugol
▪ Nykanor-Nova Coalmine Methane Utilization Project
▪ CMM capture and utilization at Holodnaya Balka mine in Donetsk Oblast
▪ CMM utilization on the coal mine Molodogvardeyskaya of the Joint Stock Company Krasnodonugol
▪ Nykanor-Nova Coalmine Methane Utilization Project
▪ CMM capture and utilization at Holodnaya Balka mine in Donetsk Oblast

Source: UNEP RISØE Center (2014)

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35 United Kingdom

35.1 Summary of Coal Industry

35.1.1 Role of Coal in the United Kingdom

Coal use in the United Kingdom (UK) has fallen by about one quarter in recent years due to a combination of relatively low natural gas prices and higher carbon dioxide (CO_2) emission allowance prices (EURACOAL, 2014). Coal still accounts for 19.9 percent of the UK's total energy needs (DECC, 2014a). The bulk of coal use goes toward power generation, supplying approximately 36 percent of UK's power needs (EIA, 2014a). UK is the seventh largest coal importer worldwide (WCI, 2014). Its primary importer is Russia, with Colombia and the United States contributing significant portions (EIA, 2014a).

Coal production in the UK has declined steadily and dramatically since the early 1990s, falling to its record low of 16.3 million tonnes (Mmt) in 2012, while holding proved reserves of 228 Mmt (Table 35-1; EIA, 2014b). Coal is located in a number of regions in the UK, as shown in Table 35-2 and Figure 35-1. A more detailed map is provided by the Confederation of UK Coal Producers (UKCoalPro, nda).

Table 35-1. United Kingdom'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)	228	0	228	45 (0.03%)
Annual Coal Production (2012)	16.3	0	16.3	24 (0.2%)

Source: EIA (2014b)

Table 35-2. United Kingdom's Coal Fields

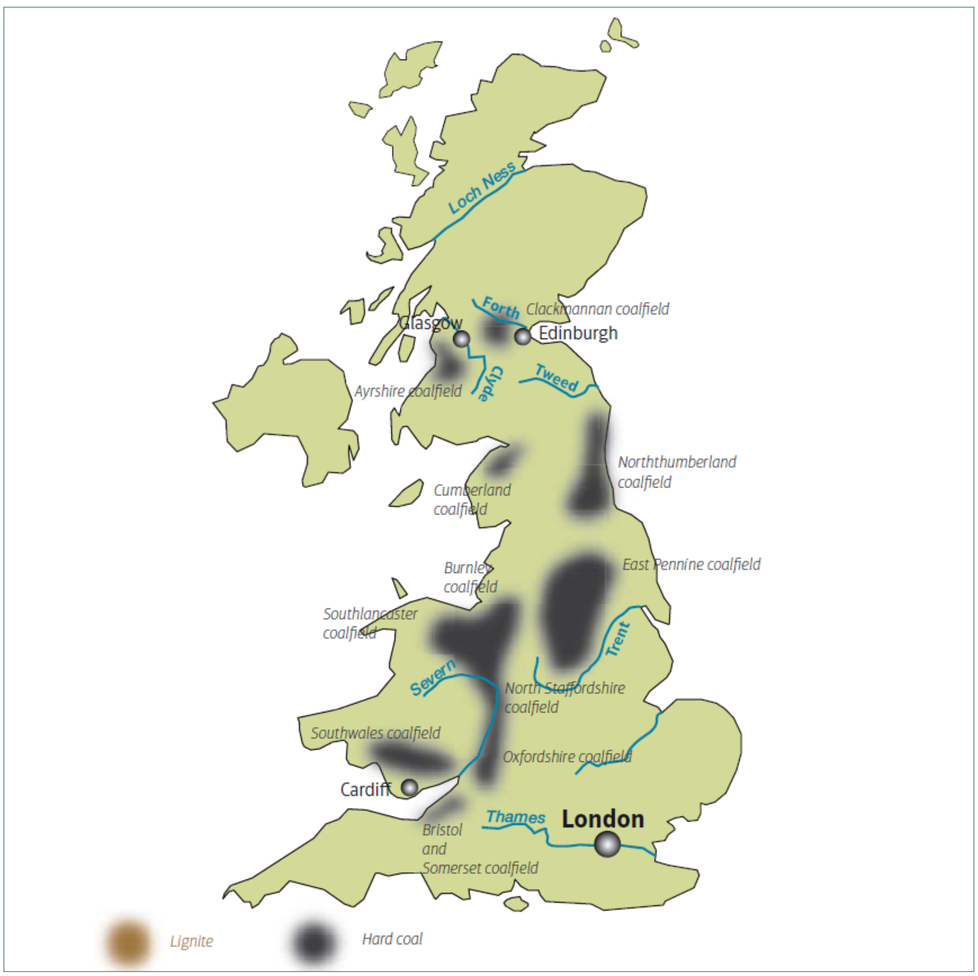
Basin / Location	Coal Field	
Midland Valley, Southern Scotland	▪ Fife ▪ Central ▪ Lothians ▪ Firth of Forth	▪ Ayrshire ▪ Douglas ▪ Sanquhar ▪ Machrihanish
Northern England, between the Southern Uplands and Craven	▪ Canonbie ▪ Cumberland ▪ Northwest Northumberland ▪ Midgeholme	▪ Northeastern (Durham) ▪ Ballycastle ▪ Ingleton
East Pennine Basin Central England, north of the Wales	▪ Nottinghamshire ▪ Yorkshire	▪ East Lincolnshire ▪ Scarborough

Table 35-2. United Kingdom's Coal Fields

Basin / Location	Coal Field	
West Pennine Basin Central England, north of the Wales	▪ Lancashire ▪ Chester Plains ▪ Anglesey ▪ North and South Staffordshire ▪ South Derbyshire ▪ Leicestershire ▪ Warwickshire	▪ Shropshire ▪ Cannock ▪ Coalbrookdale ▪ Wyre Forest ▪ Osfordshire ▪ Flintshire ▪ Denbighshire
Southern England, between the Wales-London-Brabant Massif and Variscan Tectonic Front	▪ Pembrokeshire	
Southern England, between the Wales	▪ South Wales ▪ Forest of Dean ▪ Bristol	▪ Somerset (Nailsea and Avonmouth), ▪ Berkshire ▪ Kent

Source: Schwochow (1997)

Figure 35-1. United Kingdom's Coal Fields



Source: EURACOAL (2014)

35.1.2 STAKEHOLDERS

Table 35-3 identifies potential key stakeholders in the UK's coal mine methane (CMM) development industry.

Table 35-3. Key Stakeholders in the United Kingdom's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ ATH Resources Limited ▪ Celtic Energy ▪ Energybuild ▪ Goitre Tower Anthracite ▪ H J Banks & Company Limited ▪ H R M Resources Limited ▪ Hall Construction Services Ltd ▪ Hargreaves Services ▪ J D Flack & Sons Ltd ▪ Land Engineering Services Ltd ▪ Maltby Colliery Ltd ▪ Powerfuel Plc ▪ Recycoal Ltd ▪ Scottish Coal Company Ltd ▪ Scottish Resources Group ▪ The Kier Group - Kier Mining ▪ The Miller Group - Miller Argent (South Wales) Limited ▪ UK Coal Production Limited	Project hosts
Equipment manufacturers	▪ MAN B&W Diesel ▪ Hamworthy Combustion Engineering ▪ ALSTOM Power UK ▪ Peter Brotherhood ▪ EDECO Petroleum Services	Methane treatment and utilization equipment
Developers	▪ Abmec ▪ Alkane Energy plc ▪ Arevon Energy Ltd ▪ Clarke Energy Ltd. ▪ Coalbed Methane Ltd. ▪ Coastal Oil and Gas Ltd. ▪ Db Schenker ▪ DEUTZ UK Ltd. ▪ Edinburgh Oil & Gas plc ▪ Energy Developments (UK) Ltd. ▪ Evergreen Resources UK Ltd. ▪ Federation Of Independent Mines ▪ First Energy Ltd. ▪ GeoMet UK Ltd. ▪ Harworth Power Generation Ltd. ▪ HEL-East Ltd ▪ Mines Rescue Service Ltd ▪ Octagon Energy Ltd. ▪ R J Blasting (Scotland) Ltd ▪ Renewable Power Systems ▪ Rolls-Royce Power Ventures Ltd. ▪ Scottish and Southern Energy plc	Project opportunity identification and planning

Table 35-3. Key Stakeholders in the United Kingdom's CMM Industry

Stakeholder Category	Stakeholder	Role
	▪ Terex Distribution Ltd ▪ The Solid Fuel Association ▪ UK Coal Mining Ltd. ▪ UK Gas Ltd. ▪ Warwick Energy Ltd. ▪ Workington Gas & Light Ltd. ▪ See http://www.epa.gov/coalbed/networkcontacts.html	
Engineering, consultancy, and related services	▪ ACA Howe International Ltd. ▪ AEA Technology Environment ▪ Cadogan Consultants Ltd. ▪ Celtic Energy Ltd. ▪ EDECO Petroleum Services Ltd. ▪ Farley Engineering Ltd. ▪ HEL-East Ltd ▪ International Mining Consultants ▪ Knight Energy Services Ltd. ▪ PR Marriott Drilling Ltd. ▪ Pipeline Services Ltd. ▪ Reeves Wireline Services Ltd. ▪ Schlumberger Oilfield Services Ltd. ▪ Scientific Analysis Ltd. ▪ StrataGas plc ▪ Wardell Armstrong ▪ WS Atkins Consultants Ltd. ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Universities, Research Establishments	▪ British Geological Survey ▪ Cranfield University ▪ Imperial College of Science, Technology, and Medicine (ICSTM) ▪ Loughborough University ▪ University of Cardiff ▪ University of Nottingham	Technical assistance
Regulatory Agencies and other Government Groups	▪ UK Coal Authority ▪ UK Department for Business, Innovation and Skills (BIS) ▪ Department of Energy and Climate Change	Regulation of methane rights
Other	▪ European CO_2 Network ▪ CoalPro, Confederation of UK Coal Producers ▪ The Association of Coal Mine Methane Operators (ACMMO) (defunct)	

Source: UKCoalPro (ndb); BERR/DTI (2001a); UK Nat Stats (nd)

There have been several pilot drilling schemes in the UK during the last few years but as of October 2010 there is only limited commercial production of coal bed methane (CBM) and this is being used to generate electricity rather than feeding the national gas distribution network. However, companies are now utilizing directional drilling techniques from the oil industry to try and make the exploitation of CBM a viable prospect in the UK (Coal Authority, 2014). Table 35-4 lists current licenses or agreements for CBM sites.

Table 35-4. United Kingdom's Current CBM Licenses/Agreements

Licensee	Name	Authority
Alkane Energy UK Ltd.	Glasshoughton Methane	Wakefield
	Old Mill Lane Industrial Estate	Nottinghamshire
	PPG Industries Site	Wigan
	Rexam Glassworks Site	Barnsley
Coal Bed Methane Ltd.	Arns Farm Development	Clackmannanshire
	River Forth Valley	Fife
Evergreen Resources (UK) Ltd.	Bersham (South Dee)	Wrexham
	Cronton	Knowsley
	Halewood	Knowsley
	Knowle Basin	Solihul
	Mersey Sealand	Cheshire
	Mersey Sealand Supplemental	Flintshire
	North Ouse	York
	Rhuddlan No. 1 Borehole	Denbighshire
	South Dee	Wrexham
	South Staffs	Staffordshire
	Vale of Clwyd	Denbighshire
	West Lancs	Cheshire
Nexen	Doe Green	NA
	Potteries	NA
Octagon (CBM) Ltd.	Old Boston	St. Helens
	Taff Merthyr – Penallta Project	Caerphilly

35.1.3 Status of Coal and the Coal Mining Industry

Coal production in the UK is declining because of falling consumption, relatively cheap natural gas that competes with coal for power generation, and a surge of low-cost imports (EIA, 2014a). UK's production shrunk roughly 40 percent over the last decade (DECC, 2013a).

Table 35-5. UK's Recent Coal Mine Statistics (2012)

Type of Mine	Coal Production (million tonnes)	Number of Mines
Underground (active) mines - total	6.2 (2012)	10
Surface (active) mines - total	10.1 (2012)	34

Source: (DECC, 2013b)

The UK coal mining industry is private, but subsidized by the government's Coal Investment Aid program that was launched in June 2003. As of 2006, UK's Department of Energy and Climate Change (DECC) reported that £162 million had been paid out to 26 different organizations (DECC, 2006).

Tables 35-6 and 35-7 provide information on major operating coal mines in the UK as of 2012.

Table 35-6. UK's Major Underground Mines in Production as of 2012

Licensee	Site Name	Location
Ayle Colliery Company Ltd	Ayle Colliery	Northumberland
Eckington Colliery Partnerships	Eckington Colliery	Derbyshire
Grimebridge Colliery Company Ltd	Hill Top Colliery	Lancashire
Maltby Colliery Ltd	Maltby Colliery	Rotherham
Hatfield Colliery Ltd	Hatfield Colliery	Doncaster
Ray Ashly, Richard Daniels and Neil Jones	Monument Colliery	Gloucestershire
UK Coal Operations Ltd	Daw Mill Colliery	Warwickshire
	Kellingley Colliery	North Yorkshire
	Thoresby Colliery	Nottinghamshire
Unity Mine Ltd	Unity Mine	Neath Port Talbot

Source: DECC (2013b)

Table 35-7. UK's Surface Mines in Production as of 2012

Licensee	Site Name	Location
Aardvark TMC Ltd	Glenmuckloch	Dumfries & Galloway
(trading as ATH Resources)	Glenmuckloch Samsiston Area	Dumfries & Galloway
	Laigh Glenmuir Site	East Ayrshire
	Muir Dean	Fife
	Netherton	East Ayrshire
Benhar Developments Ltd	Mossband Farm Quarry	North Lanarkshire
Bryn Bach Coal Ltd	Glan Lash	Carmarthenshire
Celtic Energy Ltd	East Pit	Neath Port Talbot
	Nant Helen	Powys
	Selar	Neath Port Talbot
Energybuild Ltd	Nant-y-Mynydd Site	Neath Port Talbot
H J Banks & Company Ltd	Brenkley Lane	Newcastle upon Tyne
	Shotton	Northumberland
Hall Construction Services Ltd	Earlseat	Fife
	Wilsontown	South Lanarkshire
Kier Minerals Ltd	Greenburn Project	East Ayrshire
Land Engineering Services Ltd	Comrie Colliery Site	Fife
Miller Argent (South Wales) Ltd	Ffos-y-Fran Land Reclamation Scheme	Merthyr Tydfil
Newcastle Science Central LLP	Science Central	Newcastle upon Tyne
The Scottish Coal Company Ltd	Blair House	Fife
	Broken Cross	South Lanarkshire
	Dalfad	East Ayrshire
	Dunstonhill	East Ayrshire
	House of Water	East Ayrshire
	Mainshill	South Lanarkshire
	Spireslack Complex (Airdsgreen)	East Ayrshire
	St Ninians	Fife

Table 35-7. UK's Surface Mines in Production as of 2012

Licensee	Site Name	Location
Tower Regeneration Ltd	Tower Colliery Surface Mining Site	Rhondaa Cyon Taff
UK Coal Mining Ltd	Butterwell Disposal Point	Northumberland
	Huntington Lane	Telford & Wrekin
	Lodge House	Derbyshire
	Minorca	Leicestershire
	Park Wall North	Durham
	Potland Burn	Northumberland

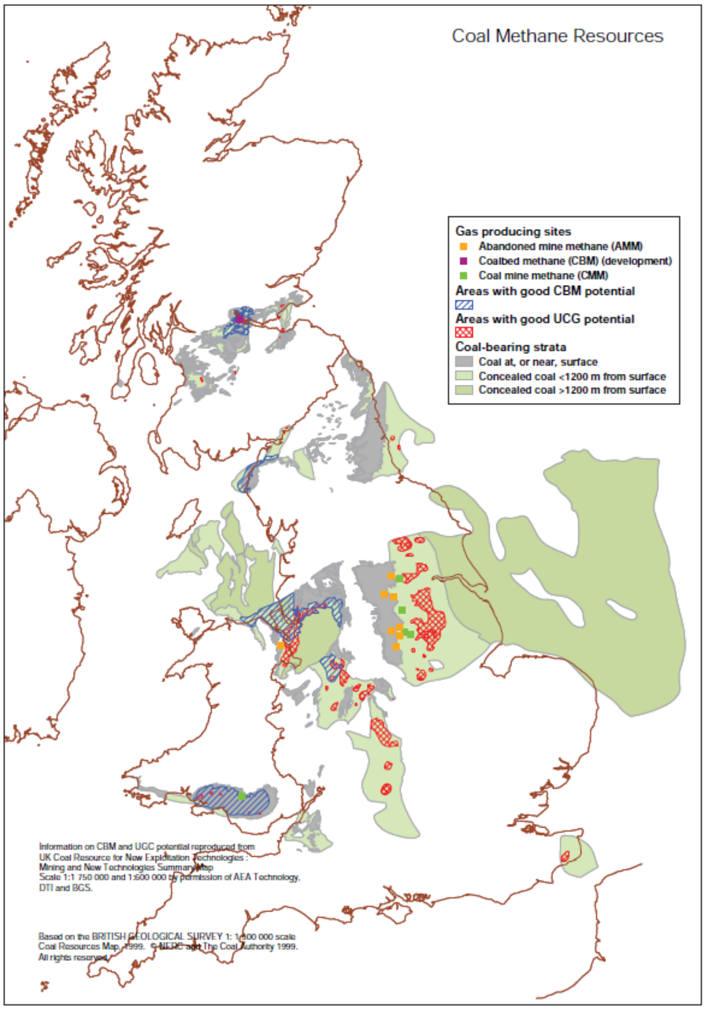
Source: DECC (2013b)

35.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (GMI) International CMM Projects Database currently identifies 46 projects in the United Kingdom (GMI, 2014). Of these 46, 23 are in place in abandoned mines, another 23 are located at active underground mines, and the remaining project is in place at an active surface mine. Of the 46 projects, 26 are for power generation, nine involve flaring, five use methane for boiler fuel, two involve heating and cooling, two are for industrial use, and two destroy ventilation air methane VAM). Updates on future CMM projects in the UK can be found at https://www.globalmethane.org/coal-mines/cmm/index.aspx. There are no active CMM flaring projects or VAM projects operating – all were decommissioned as there are no incentives in the UK for CMM or VAM destruction following the end of the UK ETS in 2005.

Figure 35-2 depicts coal methane reserves in the UK.

Figure 35-2. United Kingdom's Coal Methane Resources



Source: BGS (2006)

35.2.1 CMM Emissions from Operating Mines

Methane emissions in the United Kingdom were estimated at 489.5 million cubic meters (m^3) in 2000, but are expected to decrease by nearly two-thirds to 183.5 million m^3 by 2015, and then anticipated to decrease slightly more to 176.5 million m^3 by 2030 (see Table 35-8). As permeability is low, mines always use post drainage methods for extraction of CMM, resulting in CMM quality in the range of 25 to 60 percent methane.

Table 35-8. United Kingdom's CMM Emissions (million cubic meters)

Emissions	2000	2005	2010	2015 (projected)
Total CH_4 Emitted	489.5	285.7	191.2	183.5

Source: USEPA (2012)

35.2.2 CMM Emissions from Abandoned Coal Mines

There are more than 900 former deep mines in the UK, which offer differing degrees of potential for exploitation of methane. Projects can be developed using the existing mine shafts, where these remain open, or by drilling from the surface into the abandoned workings (Coal Authority, 2014). In 2012, the country produced and consumed 703 GWh of CMM, down from 775 GWh in 2009 (DECC, 2013c). It is estimated that 31,000 tonnes of methane have been recovered and used annually from abandoned mines (BERR/DTI, 2004b). Table 35-9 identifies abandoned mine methane (AMM) projects in the UK.

Table 35-9. United Kingdom's AMM Projects

Stakeholder	**Site**	**Extracted Methane Flow** (liter per second)	**Project Operating Dates**	**Use of Methane** (type)	**Electric Generation** (MW)	**Global Warming Potential Avoided** (tonnes CO_2e)
Alkane Energy Plc.	Bevercotes, North Nottinghamshire	N/A	2006-present	N/A	4.05	138,155
Alkane Energy Plc.	Whitwell, North Derbyshire	N/A	2006-present	N/A	1.35	46,052
Alkane Energy Plc.	Warsop, North Nottinghamshire	N/A	2006-present	N/A	1.35	46,052
Alkane Energy Plc.	Wheldale, West Yorkshire	[e]409	[a]2001-present	Electric generation	4.5 ([b]10.3) ([e]5.8)	153,054 ([e]184,000)
Alkane Energy Plc.	Mansfield, North Nottinghamshire	N/A	pre-2006-present	N/A	3.7	126,216
Alkane Energy Plc.	Sherwood, North Nottinghamshire	N/A	pre-2006-present	N/A	0.66	20,467
[e]Green Gas Power Ltd.	Silverdale, North Staffordshire	200	1999-	Burner tip use and electric generation via pipeline	[d]9	90,000
[e]Green Park Energy	Hickleton, South Yorkshire	250	[a]2000-	Electric generation	3.6 ([b]5.4)	112,500
[c]Green Park Energy	Grimethorpe Brodsworth Frickley Bentley Houghton Main	N/A	N/A	N/A	4MWe per site	N/A
[e]Warwick Energy	Annersley Bentinck, Nottinghamshire	140	[a]2000-	Electric generation	2.0 ([b]10.5)	63,000

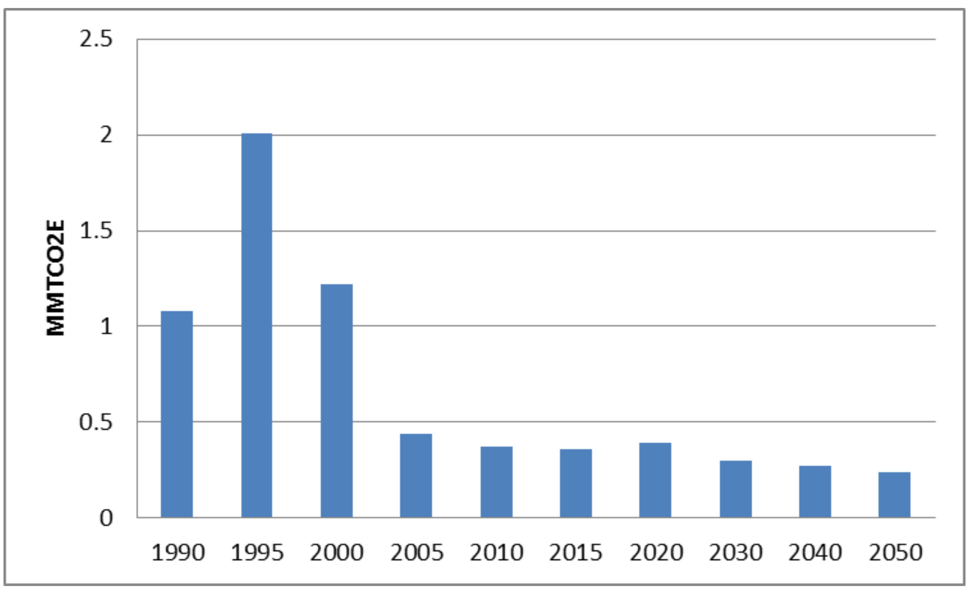
Table 35-9. United Kingdom's AMM Projects

Stakeholder	Site	Extracted Methane Flow (liter per second)	Project Operating Dates	Use of Methane (type)	Electric Generation (MW)	Global Warming Potential Avoided (tonnes CO_2e)
Likely Inactive						
[e]Alkane Energy Plc.	Markham, North Derbyshire	51	[a]1999-	Via pipeline to boilers	[d]6 ([b]3)	23,000
[d]Alkane Energy Plc.	Steetley, North Nottinghamshire	NA	[a]1999-	[d]Electric generation	[d]3	NA
[e]Alkane Energy Plc.	Shirebrook, North Derbyshire	372	[a]2000-	Electric generation	5.3 ([b]9.5)	167,400
[e]Alkane Energy Plc.	Monk Bretton, West Yorkshire	33	N/A	Burner tip use	[b]2 ([c]5)	14,900

Sources cover entire row unless otherwise noted: a) Alkane (2003); b) BERR/DTI (2004a); c) Coal Authority (2008); d) BERR/DTI (2001b); e) BERR/DTI (2004b)

Figure 35-3 shows net emissions from current and future abandoned mines through 2050.

Figure 35-3. Abandoned Mine Net Emissions



Source: DECC (2011)

35.2.3 CBM FROM VIRGIN COAL SEAMS

There is a very substantial technical resource of virgin CBM in the UK totaling 2.45 trillion m³. This would give the UK a 24-year supply under 2008 consumption levels. A 2001 estimate suggested that only 30 billion m³ would be economically recoverable (BERR/DTI, 2001b). However, given that the natural gas price in the UK was roughly $2.80 per million Btu in 2001 and the current EU average price has risen to nearly $10 per million Btu, the economic viability for CBM recovery would be far more favorable now (YCharts, 2014). Recent technological advancements associated with hydraulic fracturing would also likely further expand recoverable reserves. The highest gas contents of more than 20 m^3 per metric ton can be found in South Wales and is the focus of most commercial interest (ACMMO, nd).

It is worth noting U.K. coal seams are generally of low permeability; therefore, hydraulic fracking and directional drilling techniques are likely to be necessary to recover commercial volumes.

35.3 Opportunities and Challenges to Greater CMM Recovery and Use

The UK is a signatory to both the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (Table 35-10). As an Annex I Party to the Kyoto Protocol, its emissions target is 20 percent below 1990 levels by 2020.

Table 35-10. UK's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	December 8, 1993
Kyoto Protocol	April 29, 1998	May 31, 2002

Source: UNFCCC (2014)

The first and second phases (2005-8 and 2008-12, respectively) of the European Union Emissions Trading Scheme (EU ETS) did not include methane emissions (EC, 2013). The European Union Commission suggests that the EU ETS needs to be strengthened by taking measures that include extending the scheme to other gases such as methane (EU, 2007). Just recently, the UK called for major reforms to improve the EU ETS to tackle climate change, including provisions for additional activities and gases (DECC, 2014b). The Department of Food and Rural Affairs commissioned a study exploring CMM and incorporating it into the EU ETS, highlighting its challenges (DECC, 2005).

35.3.1 Market and Infrastructure Factors

British coal mining as a nationalized industry was self-sufficient with regards to research and development (R&D). Companies downsized when the British government privatized the industry in the mid-1990s, and emphasis moved away from long-term R&D to more immediate issues. The industry position has stabilized and some long-term mining-related R&D effort has been taken over by the universities and private businesses.

New CMM utilization projects have tended to be power generation projects. The technology is usually standard modules of 1 to 2 MW_e internal combustion engines as used in the landfill gas industry. Landfill gas is a strong and growing sector in the UK with more than 1,000MW_e installed capacity in 2012 (DECC, 2013d). Pipeline sales can occur if the infrastructure stays in place from previous mining enterprises. However, CMM gas is not of sufficient quality to enter the national natural gas network or even to be upgraded, so the economic viability of pipeline injection is impossible. In some cases, CBM may be of adequate quality to enter the public distribution system, but there is no evidence of this (Coal Authority, 2014).

35.3.2 REGULATORY INFORMATION

Ownership of the methane in coal rests with the UK government, but it passes to the licensee when the methane is captured. The rights to the methane gas are regulated by the Department of Business Enterprise & Regulatory Reform under the Petroleum Act of 1998 (Coal Authority, 2014). Petroleum Exploration and Development Licenses (PEDLs) are awarded in a series of "rounds," the most recent being the 13th Landward Licensing round, which accepted applications on February 6, 2008 (Oil and Gas, 2008a). Methane Development Licenses (MDLs) are used primarily for operating mines. An MDL grants permission to get gas "in the course of operations for making and keeping safe mines whether or not disused." It grants no exclusive rights, so it can overlap geographically with one or more PEDLs. MDLs generally cover much smaller areas than PEDLs; typically each covers one mine, although the Coal Authority holds a license that covers the whole country (Oil and Gas, 2008b). Coal licensing—and through it, the responsibility for environmental and safety standards—is handled by the Coal Authority.

The regulatory system for CMM/AMM/CBM ownership is straightforward and works well, subject to clear delineation of when a mine is open and closed.

CMM currently enjoys an exemption from the UK Climate Change Levy (CCL), a tax on fossil fuels that has not otherwise been taxed (as is the case with oil) (OPSI, 2003). When used for power generation, it currently represents an incentive of 4.41 £ per MW_e (Customs, 2007a). The CCL was indexed to inflation starting April 1, 2007 (Customs, 2007b). These savings are shared with the distribution company that accepts the power into its system; the net benefit to the generator is likely being closer to 3.0 £ per MW_e and is realized by the sale of CCL Certificates. With the exception of this benefit, power from CMM must compete equally with that from all other generators in the electricity market. This has proved difficult in recent times due to the low price of electricity on the wholesale market. Recently, however, prices have risen, generating increased interest in CMM projects.

CMM projects are normally developed by private capital. Recent natural gas price volatility has meant a downturn in activity due to poor projected returns.

CO_2 sequestration into the coal seam is often cited as a possible means of making CBM carbon neutral. CO_2 sequestration technology is immature at present and its potential application in the UK cannot be assessed. However, there are vast areas of coal at depths below 1,200 m that are possibly too deep for mining and thus may be suitable sites for sequestration.

35.4 Profiles of Individual Mines

The Coal Authority maintains coal mining data in an interactive national database (found at http://mapapps2.bgs.ac.uk/coalauthority/home.html), and provides information on past and present coal mining activities in UK.

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36 United States

36.1 Summary of Coal Industry

36.1.1 Role of Coal in the United States

The United States (U.S.) holds the world's largest estimated recoverable reserves of coal (more than 200 years based on current production levels). In 2012, the U.S. was the second largest coal producer in the world (922 million metric tons [MMT]) after China (3,651 MMT), and followed by India (589 MMT) (EIA, 2014a). Coal accounts for 24.7 percent of energy production in the U.S. (EIA, MER March 2014, Table 1.2). The U.S. exports approximately 12 percent of its coal production, while imports equal approximately 1 percent of its total domestic consumption (EIA, MER March 2014, Table 6.1). Table 36-1 quantifies recoverable reserves and recent coal production in the U.S.

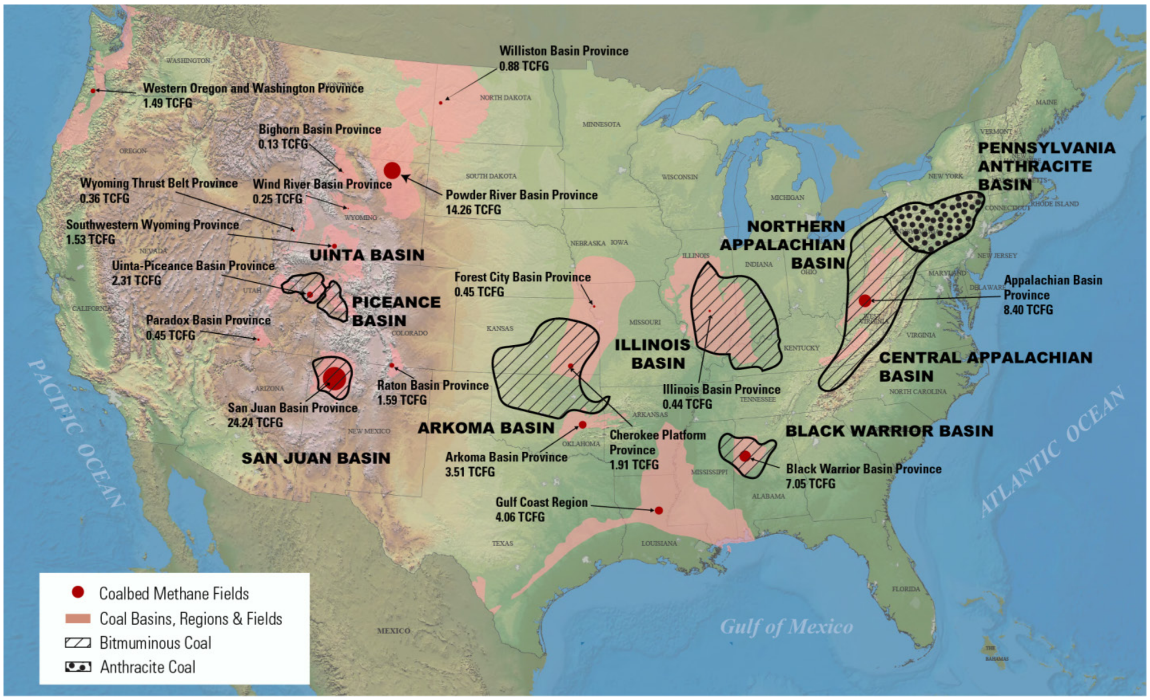
Table 36-1. U.S. Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	107,276	127,340	234,615	1 (26.4%)
Annual Coal Production (2012)	850.51	71.6	922.12	2 (11.69%)

Source: EIA (2014a)

Figure 36-1 highlights U.S. coal basins, as well as the location of gassy U.S. coal seams.

Figure 36-1. Map of U.S. Coal Basins



Sources: USGS (2014); USEPA (2004)

Gassy coal seams of the U.S. are found in four geographic regions: the Appalachian Basins of the eastern U.S. (medium to high volatile bituminous and anthracite), the Illinois Basin in the Midwest (medium to high volatile bituminous), the Rocky Mountain Basins—Piceance, San Juan, and Uinta—in the western U.S. (sub-bituminous to medium/high volatile bituminous), and the Black Warrior and Arkoma Basins of the South/Southeast (sub-bituminous to medium/high volatile bituminous).

36.1.2 STAKEHOLDERS

Table 36-2 identifies mining companies that are currently draining gas and provides 2013 total drained gas estimates and end uses for their projects, as reported to EPA's Greenhouse Gas Reporting Program (GHGRP) (see page 351 for more details). These mining companies are key stakeholders in U.S. coal mine methane (CMM) development as they host CMM recovery and use projects.

Table 36-2. Key Coal Mine Companies Draining Gas at U.S. Mines

Mining Companies Draining Gas	Total Drained Gas in 2013 (thousand cubic meters per day)	End Uses
CONSOL Energy	1,954	Natural gas pipeline injection, Thermal dryer
Walter Energy	720	Natural gas pipeline injection
Alpha Natural Resources	289	Natural gas pipeline injection
Murray Energy	228	Natural gas pipeline injection
Cliffs Natural Resources	172	Natural gas pipeline injection
Drummond Company	153	Mine air heating

Table 36-2. Key Coal Mine Companies Draining Gas at U.S. Mines

Mining Companies Draining Gas	Total Drained Gas in 2013 (thousand cubic meters per day)	End Uses
Arch Coal	58	Electricity generation, Flare, Mine air heating
BHP Billiton	54	N/A
Hallador Energy	39	N/A
Oxbow Carbon & Materials	28	N/A
Bowie Resource Partners	11	N/A

Source: USEPA (2015a)

Additional key stakeholders include:

- CMM treatment and utilization equipment manufacturers;
- Project developers;
- Engineering, consultancy, and related services;
- Universities and research establishments (National Institute for Occupational Safety and Health [NIOSH], U.S. Geological Survey [USGS], U.S. Department of Energy [DOE]);
- Regulatory agencies, including agencies that approve projects (Mine Safety & Health Administration [MSHA]) and lease federal land (U.S. Bureau of Land Management [BLM], U.S. Forest Service); and
- Other organizations, including the National Mining Association and emissions credits brokers.

Many of these individual stakeholders are listed as Network Contacts on the U.S. EPA Coalbed Methane Outreach Program's (CMOP) website at http://www.epa.gov/cmop/networkcontacts.html.

36.1.3 Status of Coal and the Coal Mining Industry

All U.S. coal mines are owned and operated by private sector companies. Coal is produced in 25 states spread across three major coal-producing regions. In 2012, approximately 70 percent of production originated in five states: Wyoming, West Virginia, Kentucky, Pennsylvania, and Illinois. In addition, there are more than 7,500 abandoned underground mines (USEPA, 2004), 492 of which are considered gassy (USEPA, 2015a). Table 36-3 summarizes coal mining in the U.S. by mine type.

Table 36-3. Summary of U.S. Underground and Surface Mine Production, 2013

Type of Mine	Production (million tonnes)	Number of Mines
Underground (active) mines - total	309.5	395
Surface (active) mines - total	581.3	637

Source: EIA (2015)

36.2 Overview of CMM Emissions and Development Potential

In 2012, nearly 60 percent of all U.S. CMM emissions were released through underground mine ventilation fans. Other sources include methane released through gas drainage systems at underground coal mines that employ vertical and/or horizontal wells, fugitive emissions from abandoned coal mines, coal seams that are exposed to the atmosphere through surface mining operations, and post-mine emissions that are released from the handling and transportation of coal following mining activities. The U.S. has been a leader in CMM recovery and use since the 1990s. As of 2013, there were 22 projects at 16 active underground mines in the U.S., as well as 17 projects at 37 abandoned mines. Recovery and use projects at active underground U.S. mines reduced methane emissions by approximately 41 billion cubic feet in 2013 (USEPA, 2015a).

36.2.1 CMM Emissions from Operating and Abandoned Mines

Table 36-4 quantifies methane emissions from the U.S. mining industry in recent years. Underground coal mines in the U.S. contribute the largest share of methane emissions due to the higher methane content of coal in the deeper underground coal seams.

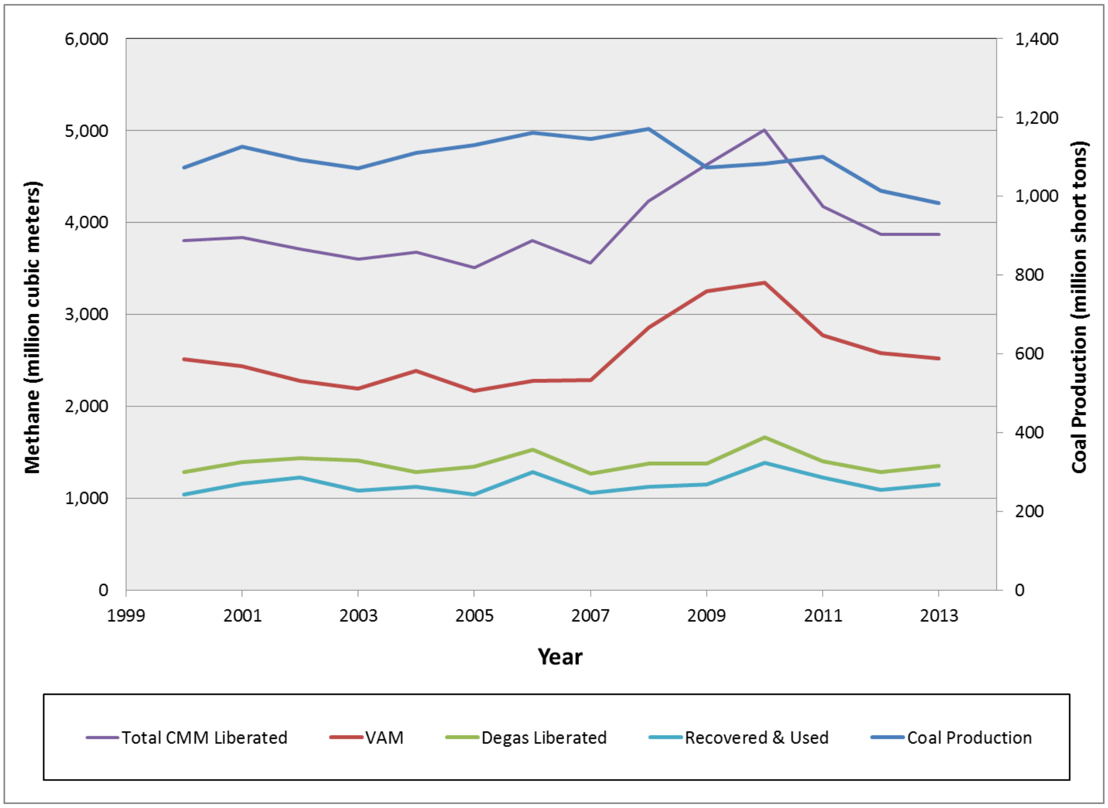
Table 36-4. U.S. CMM Emissions (million cubic meters)

Emission Category	1990	2005	2008	2009	2010	2011	2012	2013
Underground Mining	4,754.7	3,513.3	4,235.7	4,629.5	5,007.7	4,174.2	3,868.5	3,871.8
Surface Mining	632.5	698.1	750.4	677.3	677.3	683.2	603.0	570.4
Post-Mining (Underground)	541.5	449.7	429.4	392.0	397.3	405.2	393.7	386.6
Post-Mining (Surface)	137.0	151.2	162.6	146.7	146.8	148.0	130.6	123.6
Total for Operating Mines	6,065.6	4,812.4	5,578.0	5,845.6	6,229.1	5,410.6	4,995.8	4,952.4
Abandoned Mines	423.1	387.6	371.7	374.0	386.8	378.4	365.5	365.8
Total for All Mines	6,488.7	5,200.0	5,949.7	6,219.6	6,615.9	5,789.0	5,361.3	5,318.2

Source: USEPA (2015a)

The recovery and utilization of methane liberated from coal mine degasification systems has averaged 83 percent since 2000. This is due primarily to the deployment of large scale pipeline injection projects located in the eastern U.S. The remaining portion of the liberated CMM is vented and accounts for the 201 million cubic meters presented in Figure 36-2 for degasification emissions.

Figure 36-2. Active Underground Coal Mine Production and CMM Emissions in the U.S., 2000-2013 (million cubic meters)



Source: USEPA (2015a)

At the end of 2013, there were 22 methane recovery, destruction, or use projects in the U.S. Most of the projects involve upgrading CMM for injection into a commercial pipeline. However, these projects also include four other types of methane utilization and destruction, utilizing either flares and/or thermal oxidizers. In addition, there were 17 abandoned mine methane (AMM) projects operating at 37 abandoned mines in the U.S. All of these mines are located east of the Mississippi River in the Central Appalachian, Northern Appalachian, Illinois, and Warrior coal basins with the exception of two western mines, one in Colorado and one in Utah. One project—the Corinth Project located in southern Illinois—recovers methane from 14 mines that were abandoned between 1926 and 1998. Table 36-5 shows a summary of the various types of CMM utilization deployed at the mines.

Table 36-5. Summary of U.S. Mine Methane Recovery & Destruction Projects

	Number of Mines with Projects	Number of Projects	Types of CMM Utilization					
			Pipeline	Electric Generation	Heater	Boiler/ dryer	Flare	VAM
Underground	16	22	14	2	2	1	1	2
Abandoned Underground	37	17	14	2	0	0	1	0
Surface	0	0*	0	0	0	0	0	0

*There were two projects at the North Antelope Rochelle Mine that were shut-in in 2011.

There were several new projects deployed in 2012, as well as new types of CMM utilization added to existing projects. The Elk Creek Coal Mine project located at Oxbow's Elk Creek Mine in Gunnison County, Colorado is the second active underground coal mine in the U.S. to generate electricity from CMM and the first at a western coal mine. The planned three-Megawatt plant is currently operating one engine with two additional engines to be installed in the future. The project also utilizes a flare and heaters. In addition to selling electricity to a local utility, the project is expected to generate offset credits in the voluntary carbon market and is listed with the Climate Action Reserve or CAR (see page 356).

The VAM project at Murray Energy's Marshall County Mine (formally the McElroy Mine) in Marshall County, West Virginia began destroying methane in May 2012, and is the largest VAM project in the U.S. The project consists of three regenerative thermal oxidizers (RTO) that convert methane to carbon dioxide and water vapor. At startup of the RTO, the ceramic medium bed in the RTO is heated with a propane burner. VAM is then forced through the bed, methane is oxidized, and the released heat is recovered by the ceramic bed medium and the air flow is reversed. The heat recovered from the first cycle heats the incoming VAM and the process repeats. The methane concentration in the VAM ranges between 0.6 and 1.5 percent. The project is listed with CAR and is projected to reduce emissions by 322,000 tonnes of CO_2e per year.

In the U.S., flaring has not been widely implemented at active mines. However, the MSHA has approved flares at the Elk Creek coal mine and the Solvay trona mine. In addition, at two active mines drainage gas is used to preheat incoming ventilation air in cold months to both condition the incoming air and prevent the formation of large icicles at the ventilation shaft opening; these heaters essentially constitute horizontal flares.

36.2.2 Coalbed Methane from Virgin Coal Seams

The U.S. is the world's leading producer of coal seam gas or coalbed methane (CBM). Production has been established in 10 coal basins nationwide (primarily San Juan, Black Warrior, and Central Appalachian) as shown in Figure 36-1 (EIA, 2009a). Total annual CBM production in 2012 was estimated at 1,655 billion cubic meters (EIA, 2014b). Table 36-6 summarizes the proved U.S. CBM reserves by state.

Table 36-6. U.S. CBM Proved Reserves (billion cubic meters)

Location	2005	2006	2007	2008	2009	2010	2011	2012
Alabama	50.2	58.6	60.2	48.9	38.0	36.8	34.3	28.5
Arkansas	0.8	1.0	0.9	0.9	0.6	0.8	0.6	0.3
Colorado	191.8	179.6	222.8	233.3	208.1	183.6	186.3	143.7
Kansas	7.3	6.6	9.6	8.5	4.6	7.3	6.5	5.2
Louisiana	0.0	0.03	0.2	0.3	0.0	0.0	0.0	0.0
Montana	2.1	2.2	1.9	2.1	1.0	1.8	0.7	0.3
New Mexico	148.6	138.6	118.1	113.0	103.2	100.0	95.1	78.5
Ohio	0.0	0.03	0.03	0.03	0.0	0.0		
Oklahoma	16.1	19.4	35.8	14.5	9.6	9.2	7.8	12.4
Pennsylvania	1.3	1.4	3.1	2.9	3.7	3.7	3.5	3.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
Utah	25.5	21.2	26.1	25.3	20.5	20.3	19.2	14.7
Virginia	44.5	51.3	55.2	52.4	64.0	49.6	46.0	43.5
West Virginia	5.3	5.5	7.2	7.0	6.2	6.2	3.9	3.0
Wyoming	69.3	69.3	77.5	78.7	65.9	76.0	71.9	49.2
Other States*	0.5	0.8	0.8	1.2	0.5	0.5	0.5	0.4
U.S. Total	**563.3**	**555.6**	**619.4**	**588.9**	**526.1**	**495.8**	**476.2**	**384.9**[4]

*Other States includes Arizona, Illinois, Indiana, Maryland, Missouri, Nebraska, Nevada, Oregon, South Dakota, and Tennessee.
Source: EIA (2014c)

36.2.3 Opportunities and Challenges to Greater CMM Recovery and Use

As shown in Table 36-7, the U.S. is a signatory to UNFCCC and the Kyoto Protocol, but did not ratify the Kyoto Protocol.

[4] Coal reserves are generally classified as "probable" and "proved," with the resources in the "proved" category having a high degree of being economically recoverable at current prices and operating costs. As coal is produced, the amount in the proved category is reduced by that amount. Additions to the proved category can be made through exploration findings or by moving reserves from the probable category to the proved category if those reserves are deemed to be economically recoverable to a high degree of certainty (usually by further development of the coal deposit). Both additions and reductions from the proved category can be made depending on the relative price of coal and operating costs and their effect on the economics of recovery. Another factor that influences the quantity of reserves reported is gas prices. With the steady decline in gas prices since 2008, this could also account for the decline in coal reserves during the same period.

Table 36-7. The United States' Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 12, 1992	October 15, 1992
Kyoto Protocol	November 12, 1998	--

Source: UNFCCC (2014)

At the present time, GHG emissions from coal mining activities are not regulated in the United States. The U.S. Environmental Protection Agency (USEPA) has developed voluntary programs aimed at partnering with industry, states and communities to reduce GHG emissions, including CMOP (www.epa.gov/cmop). CMOP is a voluntary program whose goal is to reduce methane emissions from coal mining activities by promoting profitable CMM recovery and use. By working cooperatively with coal companies and related industries, CMOP helps to address barriers to using CMM instead of emitting it to the atmosphere. In turn, these actions mitigate climate change, improve mine safety and productivity, and generate revenues and cost savings.

The California Air Resources Board (CARB) recently adopted the Compliance Offset Protocol Mine Methane Capture (MMC) Protocol. The MMC Protocol allows for projects which quantify GHG emission reductions from the capture and destruction of methane that would otherwise be vented to the atmosphere at active underground and surface mines (via VAM and mine methane drainage activities) as well as abandoned underground mines (via mine methane recovery). Under this protocol, projects must meet a number of eligibility requirements to qualify, plus all offsets are subject to verification.

CMM offset projects are also eligible for carbon credits through a number of voluntary GHG registries located in the U.S., namely the Verified Carbon Standard (VCS), CAR, and the American Carbon Registry (ACR). Whether a CMM project is eligible for carbon credits depends on a number of project specifics, such as project start-up date, end use technology (i.e., electricity generation vs. pipeline sales), and origin of methane (i.e., active vs. abandoned mines, surface vs. underground mines). Each GHG registry also has its own rules governing project eligibility, additionality, and registration. Currently, CMM projects at underground coal mines are eligible to some degree in all three GHG registries, the exception being that CAR does not accept CMM pipeline sales projects. AMM projects are accepted only by VCS, and SMM projects are accepted only by VCS and ACR.

Many states in the U.S. have developed renewable energy portfolio standards (RPS) or clean energy goals (CEG) that direct electricity providers to generate or obtain minimum percentages of their power from "eligible energy resources" by certain dates. Utilities in 42 states offer their customers "green pricing," in which customers opt to pay a premium on their electric bills to have a portion or all of their power provided from renewable sources (EERE, 2012). Six states include CBM or CMM in their renewable/alternative energy standards: Colorado, Indiana, Pennsylvania, West Virginia, Ohio, and Utah (DSIRE, 2014).

36.2.4 MARKET AND INFRASTRUCTURE FACTORS

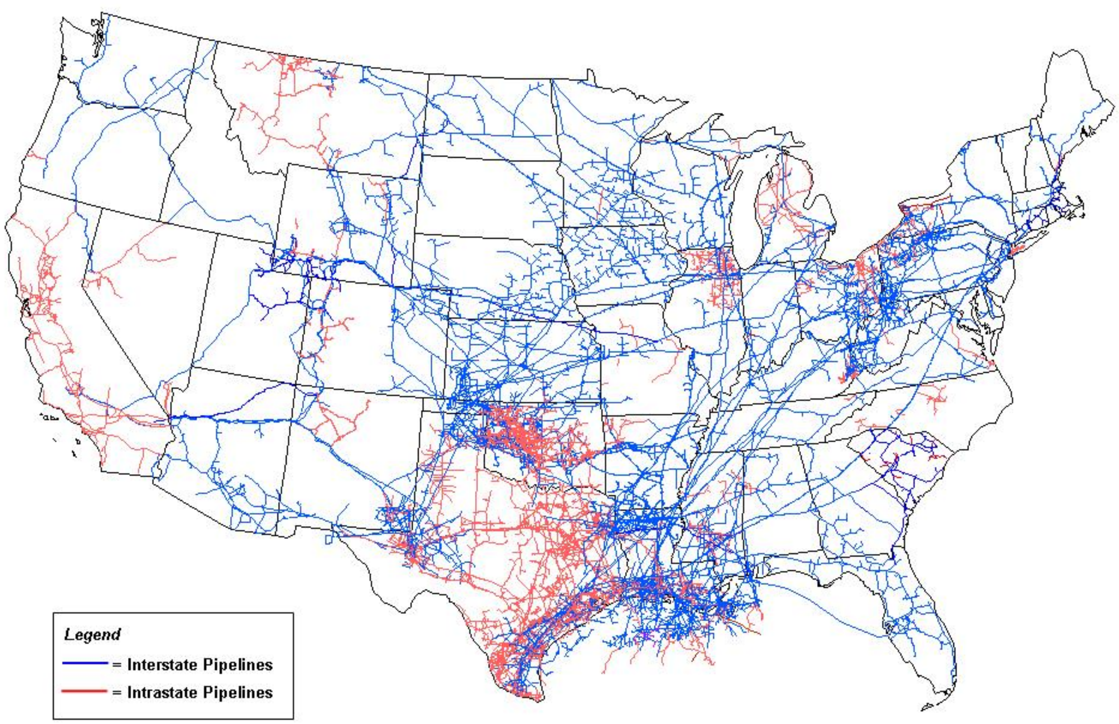
Infrastructure Issues

The majority of CMM recovery projects in the U.S. involve selling the methane directly to natural gas pipelines. Generally, only gas from wells drilled into virgin seams in advance of mining is suitable to meet the high-quality gas standards required by pipelines (usually 95 percent or greater methane with minimal contaminants). However, medium-quality CMM (e.g., gob well gas) can be processed to remove contaminants and upgraded to pipeline quality. Several technologies for upgrading methane are now easily available through vendors (USEPA, 2008).

The existing U.S. gas pipeline infrastructure plays an important role in determining if and where pipeline sales are feasible. In the eastern U.S., the natural gas pipeline system is more extensive and is located closer to gassy coal mines than in the western U.S. In some instances, mines may need to construct a feeder pipeline to transport the CMM to the pipeline from the wellhead or from the gas upgrading/processing facility. Mines in the western U.S. often have little or no access to pipelines and thus the option for pipeline sales is limited, since building feeder pipelines would be cost prohibitive. Unlike Europe or China, large population centers in the U.S. are not typically located in close proximity to coal mines. Thus, there are not always readily accessible major methane markets near mines given the absence of reasonably accessible long-distance pipelines.

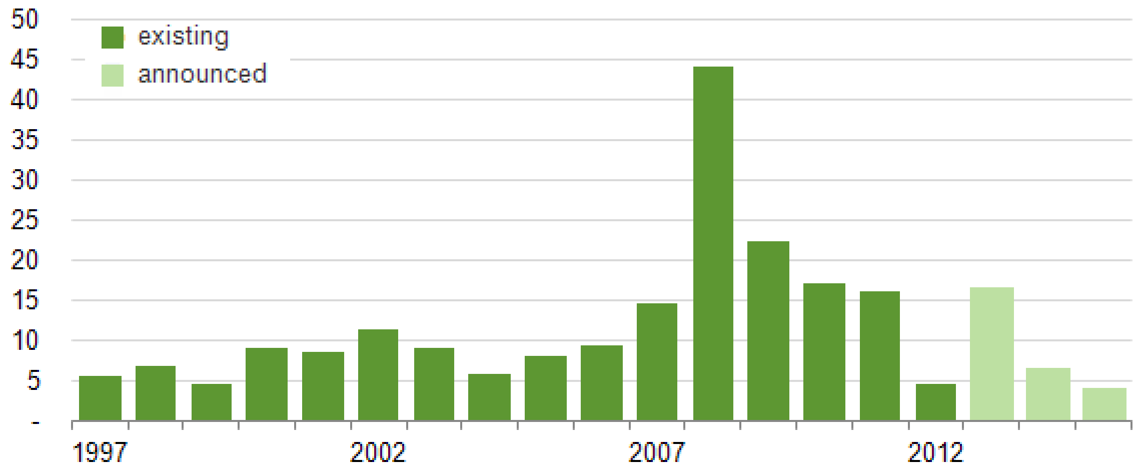
Figure 36-3 illustrates interstate and intrastate natural gas pipelines in the U.S. as of 2009. Figures 36-4 and 36-5 summarize the U.S. natural gas pipeline expansion from 1997 to 2012, with estimations through 2015. From 1997 to 2012, natural gas pipeline capacity was expanded by nearly 180 billion cubic feet per day and more than 32,000 miles of new natural gas transmission pipeline were placed in service. However, both natural gas pipeline capacity and mileage peaked in 2008, and new additions reported in 2012 were the lowest since 1997 (EIA, 2013b).

Figure 36-3. U.S. Interstate Natural Gas Pipelines, 2009



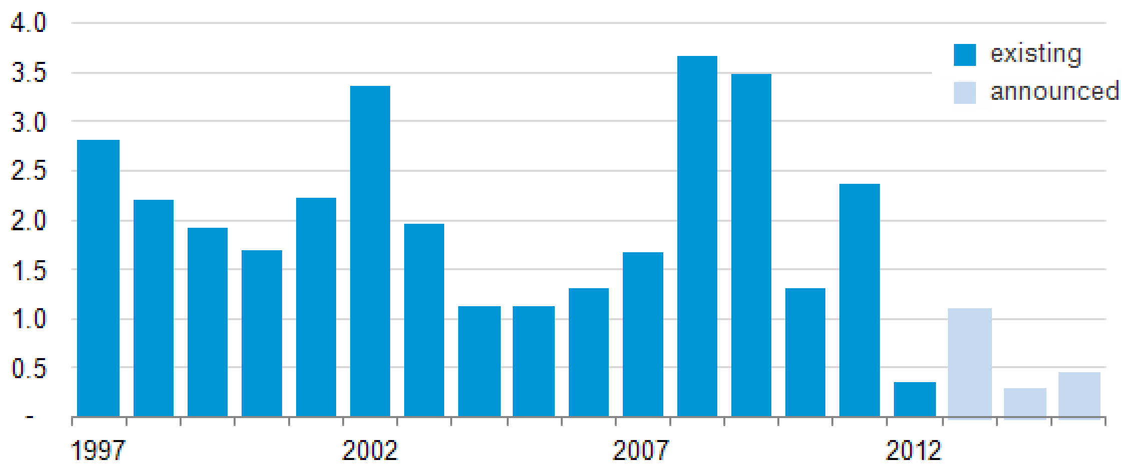
Source: EIA (2009b)

Figure 36-4. Annual Increases in U.S. Natural Gas Pipeline Capacity (billion cubic feet per day)



Source: EIA (2013b)

Figure 36-5. Annual Increases in U.S. Natural Gas Pipeline Length (thousand miles)



Source: EIA (2013b)

Institutional Issues

Disputes over ownership of methane produced from coal seams can present a barrier to further development of the CMM industry in the U.S. Ownership of carbon-based mineral rights is often divided between the oil/natural gas estate and the coal estate. Whether on public or private land, the coal lessee has had the right to capture and discharge methane without paying royalties to maintain safe working conditions. Although some states have attempted to clarify the ownership issue through legislation, the U.S. government has only done so in specific regions. BLM, within the U.S. Department of the Interior, has established an incentive in Wyoming's Powder River Basin that encourages pre-mine gas drainage prior to surface mining in return for reduced natural gas royalty payments to the U.S. government. The areas in which this incentive applies are called Conflict

Administration Zones (CAZ). The CAZs were established with BLM Instruction Memorandum No. 2003-253 in 2003 and were re-delineated in December of 2009 (BLM, 2010) and again in January of 2013 (BLM, 2013). Other disputes are settled on a case-by-case basis.

For in-mine boreholes and gob wells at active mines, mine operators receive approval directly from MSHA. However, licenses are granted by the state in cases where the wells are drilled for exploration and production for pre-mine drainage on property outside the jurisdiction of MSHA and for production of methane from abandoned mines that no longer fall under MSHA's jurisdiction.

Mineral leases are either owned by the U.S. government, as is the case in many parts of the West, or privately owned, as is the case in most other areas of the country. For private leases, laws in each individual state govern ownership of the resource. Federal law governs U.S. government-controlled leases, and the BLM manages the mineral rights on those properties.

The markets for coal, gas, and electricity have been largely deregulated. Power generation is deregulated, and there is free and open access in the wholesale market. Power transmission rates are regulated, but there is open access to transmission lines. Power distribution (retail) also continues to be regulated, the prices of electricity being regulated closely by regional public utility commissions. For natural gas, generation and distribution are deregulated and there is open access in the wholesale market, with free and open competition. However, transportation of coal and natural gas is regulated by the federal government for interstate transport and by states for intrastate transport.

U.S. natural gas prices rose fairly steadily from 2001 until they peaked in 2008 and then declined during 2009-2012, as shown in Table 36-8.

Table 36-8. Recent U.S. Natural Gas Prices

Year	U.S. Natural Gas Wellhead Price (dollars per thousand cubic meters)
2012	$93.94
2011	$139.49
2010	$158.21
2009	$129.61
2008	$281.46
2007	$220.72
2006	$225.66
2005	$258.86
2004	$192.82
2003	$172.34
2002	$104.18
2001	$141.26

Source: EIA (2014d)

In 2012, coal delivered to the U.S. steam-electric utility plants averaged $45.77 per short ton, while coal delivered to coke plants (metallurgical) averaged $190.55 per short ton (EIA, 2013a).

Financing

Capital investment costs for CMM projects vary greatly depending on the project scope and site-specific requirements. Similarly, operating costs vary greatly depending on the site characteristics. The vast majority of direct project funding has come from the private sector, especially mining companies or private investment firms that have provided the capital investment for gas processing, blending, and transport for pipeline sales.

Several U.S. government agencies provide funding resources for CMM recovery and utilization projects located in the U.S. DOE grants have provided funding for a number of demonstration projects. The Small Business Administration operates a loan fund that assists small businesses engaged in energy technology and energy efficiency by guaranteeing loans if key conditions are met. EPA's Environmental Finance Program assists communities in funding environmental projects by helping to lower costs, increase investment, and build partnerships.

Tax credits were used to encourage the production of so-called "unconventional" sources of natural gas, including virgin coal seam CBM and CMM. Known as "Section 29" tax credits (referring to the chapter of the Internal Revenue Service tax code), they allowed for tax credits beginning at nominally $3 per barrel of oil equivalent and gradually being reduced. The credits were enacted in 1980 and expired on 31 December 2002. The Section 29 tax credit is widely believed to have spurred CBM production throughout the U.S. Reauthorization of Section 29 (now Section 45) credits was removed before the Energy Independence and Security Act of 2007 was passed in the 110th Congress (NBSA, 2007). The tax credits were reinstated and revised under the Energy Improvement and Extension Act of 2008 (IRS, 2009) and ended on 31 December 2013.

Although royalty fees are negotiable for private leases, a standard royalty of 12.5 percent of revenues on sales is usually paid by the operator/lessee to the owner of the mineral estate. Severance taxes are paid to state governments on revenues from natural gas sales. Power sales and other uses generating revenues are also taxed. The U.S. does not have a Production Sharing Agreements regime. The U.S. has removed all gas tariffs for gas exports / imports to or from Mexico and Canada through the North American Free Trade Agreement enacted in 1994.

36.2.5 Regulatory Information

Methane recovery projects must comply with stringent environmental standards, especially in environmentally sensitive areas and near urban centers. Environmental protection measures generally can be categorized as pollution control measures and habitat/land use protection. Pollution control requirements include (1) air quality standards for production of nitrous oxides, sulfur oxides, and particulate matter; (2) water quality standards limiting stormwater and wastewater discharge from facilities; and (3) noise abatement. Habitat/land-use restrictions include compliance with the Endangered Species Act and protection of forests and habitat such as limiting access in roadless and wilderness areas. In some instances, especially on federal lands, it is often necessary to prepare a formal environmental impact assessment.

Safety relating to operating a CMM recovery project is governed by two regulatory agencies. MSHA has jurisdiction over mining-related matters including operation of any in-mine drilling and gas gathering equipment. MSHA also retains jurisdiction over most surface equipment. The Occupational Safety & Health Administration has jurisdiction over worker health and safety for equipment unrelated to the mining operation (e.g., gas engines away from mine facilities).

In 2009, U.S. EPA issued the Mandatory Reporting of Greenhouse Gases Rule that requires reporting of GHG data and other relevant information from large sources and suppliers throughout the U.S. The GHGRP (http://www.epa.gov/ghgreporting/index.html) requires underground coal mines above the reporting threshold to report methane liberated through ventilation streams and degasification systems. The mines report the net ventilation and drainage flows along with the portion of that flow that is emitted and the portion recovered for utilization or flaring. If the recovered methane is flared, the CO_2 from methane destruction is also reported. Methane utilized in an engine or other combustion device requires that the facility reports CO_2 emissions under the subpart covering combustion devices, if it is a size and type that fits the subpart requirements.

In June 2013, President Obama announced a series of executive actions to reduce carbon pollution, prepare the country for impacts of climate change, and lead international efforts to address global climate change. As part of this Climate Action Plan (White House, 2013a), President Obama issued a Presidential Memorandum directing EPA to complete carbon pollution standards for the power sector (White House, 2013b).

In March 2014, the White House released the "Strategy to Reduce Methane Emissions," which outlines steps to further cut methane emissions from landfills, coal mining, agriculture, and oil and gas systems through cost-effective voluntary actions (White House, 2014). For the coal mining sector, the strategy includes both a voluntary element through CMOP, and a component highlighting potential regulatory action on federal lands under BLM's jurisdiction. In April 2014, BLM released an Advanced Notice of Proposed Rulemaking (ANPRM) to gather public input on the development of a program for the capture and sale, or disposal of waste mine methane[5] on lands leased by the federal government (BLM, 2014).

36.3 Profiles of Individual Mines

Information on U.S. mines can be found on CMOP's interactive "CMM Recovery at Active and Abandoned U.S. Coal Mines: Current Projects and Potential Opportunities" map (http://epa.gov/cmop/resources/map.html). The map and accompanying matrix provide information about current projects and potential opportunities to develop CMM recovery and utilization projects at active U.S. coal mines. The information presented is a condensed version of CMOP's earlier report "Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines 2002-2006" (http://epa.gov/cmop/docs/profiles_2008_final.pdf), which provides information about specific opportunities to develop methane recovery and use projects at large underground coal mines in the U.S. The report contains profiles of 50 U.S. coal mines that may be potential candidates for methane recovery and use, as well as on-going recovery and use projects at 14 of the mines.

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[5] Term used by BLM meaning methane emitted from coal mines, or CMM.

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37 Vietnam

37.1 Summary of Coal Industry

37.1.1 Role of Coal in Vietnam

Coal accounted for 21 percent of Vietnam's electricity generation in 2011 (IEA, 2014). Although Vietnam has historically relied on hydropower for electricity, coal-fired power plants are expected to account for 48 percent of Vietnam's total electricity production by 2020 (Mayer Brown JSM, 2011). Vietnam suffered a shortage of electricity of 8–10 Terawatt-hours in 2008-09. By 2020, the shortage could be 115 – 225 Terawatt-hours as energy demand is growing up to 14 percent per year (Baruya, 2010; Economist, 2013).

The country's coal reserves, as shown in Table 37-1, are estimated at 150 million tonnes (Mmt), with almost all of the reserves as anthracite. Since the 1980s, Vietnam has become a major player in coal production in Southeast Asia. Production reached a peak of 44.7 Mmt in 2010 and declined slightly to 41.8 Mmt in 2012 (EIA, 2014). Vietnam's *Master Plan on Coal Sector Development to 2020 with Vision to 2030* projects annual coal output to reach 55 Mmt by 2015 (Le, 2013).

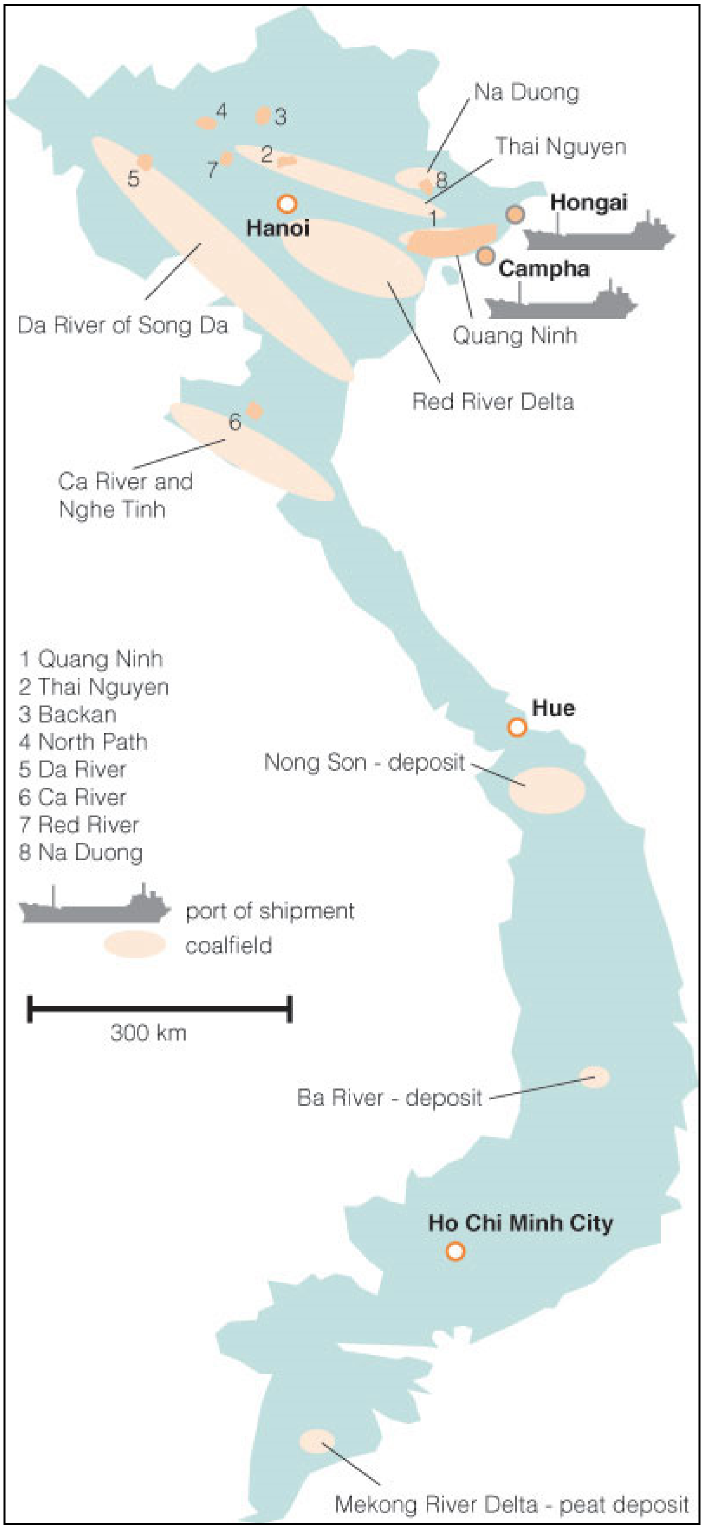
Table 37-1. Vietnam's Coal Reserves and Production

Indicator	Anthracite & Bituminous (million tonnes)	Sub-bituminous & Lignite (million tonnes)	Total (million tonnes)	Global Rank (# and %)
Estimated Proved Coal Reserves (2011)	150	0	150	54 (0.02%)
Annual Coal Production (2012)	42.1	0	42.1	17 (0.53%)

Source: EIA (2014)

Most of Vietnam's coal resources are located in the north. The Quang Yen anthracite region basin, east of Hanoi near the Red River Delta, is the central mining area where coal deposits cover a total area of 3,500 square kilometers (km^2). These deposits are estimated to be 190-272 billion tonnes, lying 250-1,200 meters beneath the basin. The dip makes about half of it suitable for surface mining while the other half must be deep mined (Omdahl et. al., 2009). In 2013, Vietnam's Prime Minister approved a plan for a pilot project to test and evaluate technologies for underground coal mining and gasification in the Red River coal basin. The pilot project is expected to be completed by 2020 (Vinacomin, 2013). Figure 37-1 below shows Vietnam's coal resources.

Figure 37-1. Vietnam's Coal Resources



Source: Baruya (2010)

37.1.2 STAKEHOLDERS

Vietnam's coal mining industry is owned and operated by the state coal mining company, Vinacomin (Vietnam National Coal and Mineral Industries Group), which was created by the merger of the Vietnam Coal Corporation (Vinacoal) and Vietnam Minerals Corporation. Vinacomin operates 95 percent of all coal mines (Le, 2012).

Table 37-2. Key Stakeholders in Vietnam's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ Vinacomin	Project hosts
Equipment Manufacturers	▪ Vietnam Research Institute of Electronics, Informatics and Automation	
Universities, Research Establishments	▪ Institute of Mining Science and Technology, Hanoi, Vietnam ▪ University of Mining and Geology, Hanoi, Vietnam	Technical assistance
Regulatory Agencies and Government Groups	▪ Vinacomin ▪ PetroVietnam ▪ PetroVietnam Exploration Production Corporation	Project identification and assessment support

37.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

As of 2010, Vietnam had 30 underground mines, five of which have an annual production capacity of more than 2 Mmt and nine of which have production more than 1 Mmt (Trần, 2010). Vietnam is seeking to increase production of its deeper anthracite reserves for high-quality export grade coals, as well as for its expanding coal power sector. Purchases of heavy mining equipment from Australia have enabled the expansion of existing underground mines and development of new underground mines.

Vietnam now has 24 open surface mines. Five of these mines have an annual production capacity of more than 2 Mmt each. There are 15 surface mines with annual production capacity between 100 and 700 thousand tonnes. Production from surface mines accounts for 55 to 60 percent of coal produced in Vietnam (Trần, 2010).

Vietnam exported 17.8 Mmt of coal, primarily to China, Japan, and South Korea in 2012, a decrease from a peak of 31.3 Mmt in 2007 (EIA, 2014; Trần, 2010; Dao, 2014). Exports decreased further in 2013, falling to 12.8 Mmt. In recent years Vietnam has cut its annual export volumes of coal to fill growing demand from domestic coal-fired power plants (Dodson, 2014). Domestic coal demand increased from 18 Mmt in 2007 to 24.8 Mmt in 2012. Exports are projected to fall to 9 Mmt per year by 2015 (Le, 2013). Vietnam began importing coal to meet power plant demand in 2011, importing 9.5 thousand tonnes of bituminous coal from Indonesia annually (VPBS, 2013). Vietnam's state-owned oil and gas group, PetroVietnam, is reportedly planning to purchase 10 Mmt of coal per year from Australia and Indonesia beginning in 2017 to supply three new power plants. Vinacomin is also planning to increase imports, with purchases to be made from Australia and Russia (Ho, 2014).

As of 2013, Vietnam had 18 coal-fired power plants with a total capacity of 6,766 MW and 13 gas turbine plants with a total installed capacity of 7,285 MW. Coal-fired capacity is growing rapidly, with new plants such as Uong Bi 2, Nghi Son 1 (1st unit), Quang Ninh 2 and Hai Phong 2 commissioning in 2013. Vietnam's *National Plan for Power Development for the 2011-2020 Period with Vision to 2030* (Master Plan VII) approved 52 coal-fired power plant projects and as of 2013, 31 projects were in various stages of planning and construction (VPBS, 2013). To meet the demand outlined by Master Plan VII, Vietnam's annual coal demand will reach 62-72 Mmt by 2020, with demand for power totaling 42-72 Mmt and other industries consuming 20-22 Mmt (Le, 2013).

37.2 Overview of CMM Emissions and Development Potential

Vietnam has not hosted any coal mine methane (CMM) recovery and utilization projects; however, the coal bed methane (CBM) industry is emerging in areas where mining is poised to take place, and thus may evolve into CMM projects as CBM activity intersects with mining.

A recent study of Vietnam's 25 gassy hard coal mines was commissioned to determine gas content of coals and to forecast methane release into the mines. Seven mines were classified as especially gassy. The results of the forecasts and a study of the capacities of these mines' ventilation systems are being used to estimate the amount of methane that may be captured by drainage systems. Additionally, the gassiest mine, Mao Khe, was equipped with an automatic methane content measurement control system (Somers, 2010).

The Khe Cham coal mine in Quang Ninh Province implemented a drainage system in 2012, reducing the concentration of methane in ventilation air and improving mine productivity. The mine plans to use drained methane to produce electricity for onsite use at the mining complex which includes four underground mines. The proposed power generation project has the potential for reducing greenhouse gas emissions by more than 360 thousand tonnes of CO_2e annually (GMI, 2013).

37.2.1 CMM Emissions from Operating Mines

With increasing coal production and the mining of deeper seams, CMM emissions in Vietnam have also increased. Table 37-3 summarizes Vietnam's CMM emissions.

Table 37-3. Vietnam's CMM Emissions (million cubic meters)

Emission Category	2000*	2005	2010	2015 (projected)
Total Emissions from Underground Coal Mines	129.8			
Total Emissions from Surface Mines	1.4			
Total Emitted	**131.2**	**366.3**	**484.2**	**530.4**

Source: USEPA (2012); *UNFCCC (2010)

37.2.2 CMM Emissions from Abandoned Mines

No information relating to recovery or use of CMM from abandoned mines is available.

37.2.3 CBM from Virgin Coal Seams

A number of potential areas for CBM development exist in Vietnam. The Red River Basin is an economically important area of northern Vietnam. The area has coal deposits lying at depths of 250 to 1,200 meters spread over a 3,500 square kilometer area. Gas content of the basin's sub-bituminous coal is estimated at 0.94 to 1.6 cubic meters (m^3)/tonne (30 to 50 scf/ton), with conservative resource estimates ranging from 170 to 280 billion m^3 (6 to 10 Tcf). Another area of interest is the Quang Yen Basin, which extends over 200 km from east to west in northeast Vietnam and covers approximately 5,000 km^2. Though yet undetermined, CBM and CMM potential of this area is a target for study (Thai, 2008).

Most of Vietnam's CBM activity to date has been confined to the Red River Basin. Keeper Resources worked on the first CBM exploration projects. A negotiated CBM concession with PetroVietnam and PetroVietnam Exploration Production Corporation (PVEP) covered approximately 3,600 km^2 of the Red River Basin to the southeast of Hanoi. Three years of negotiations were concluded with the signing of a CBM Production Sharing Contract (PSC) in early 2010. The project proceeded with the signing of drill site construction and preparation contracts after acquiring land access approvals (Dragon Capital, 2008; Dragon Capital, 2010). According to a company announcement, however, preliminary field desorption testing results determined that the coals were under-saturated with no significant quantities of methane reported and further test wells were cancelled. The PSC was relinquished in April of 2012 (VRI, 2011; Woodhouse, nd).

Arrow Energy signed a PSC with PVEP in a CBM concession block of 2,610 km^2 in the Red River Basin, referred to as the Hanoi Trough. Arrow, now Dart Energy Ltd., holds a 70 percent interest in the block with a subsidiary of PetroVietnam holding the remaining 30 percent. The block is in the vicinity of the Tien Hai-Thai Binh industrial area and approximately 150 km southeast of Hanoi. In 2009, Dart Energy completed Phase 1 of an initial eight-well exploration drilling campaign. Results from two wells indicated increasing gas volumes at depth. In 2010, Dart Energy commenced a second phase of exploration drilling, focusing on deepening a number of the earlier exploration wells, which indicated some potential for commercial CBM production, at depths greater than 1,000 meters. Dart Energy has been given approval for an extension of the PSC exploration period for the purpose of enabling further technical studies and pilot studies. The Hanoi Trough block currently has 22.7 billion m^3 of gross original gas in place (OGIP) and 7.1 billion m^3 of gross 2C resource[6], as certified by Netherland, Sewell & Associates Inc. (Dart, 2013).

PetroVietnam developed a joint venture with Italian utility Eni SpA in early 2013 allowing Eni to enter into partnerships for CBM and shale oil exploration projects in Vietnam. Eni drilled an offshore exploration well in 2013 and studies are underway on CBM potential (Koh, 2013; Le, 2014).

37.3 Opportunities and Challenges to Greater CMM Recovery and Use

Vietnam is a signatory to both the UNFCCC and the Kyoto Protocol (see Table 37-4). As a Non-Annex I Party to the Kyoto Protocol, it has no national emissions targets and was eligible to host

[6] Contingent resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations, but the applied project(s) are not yet considered mature enough for commercial development due to one or more contingencies. Contingent resources are further categorized in accordance with the level of certainty associated with the estimates (low/best/high estimates are denoted as 1C/2C/3C, respectively) (PRMS, 2007).

mitigation projects under the Clean Development Mechanism (CDM). Vietnam hosted 251 registered CDM projects; however, none were CMM recovery and utilization projects (UNEP, 2014).

Table 37-4. Vietnam's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 11, 1992	November 16, 1994
Kyoto Protocol	December 3, 1998	September 25, 2002

Source: UNFCCC (2014)

37.3.1 Market and Infrastructure Factors

Increased coal mining to meet electricity demand as well as increased demand for natural gas makes CBM and CMM attractive in Vietnam. Coal mining is poised to continue escalating in Vietnam to meet the demand of up to 72 Mmt by 2020 (Le, 2013). With electricity consumption growing by 12-16 percent annually through 2015 due to increased industrial and residential demand, power shortages are expected (USCS, 2013). The government strictly controls electricity retail prices which have been criticized as being too low to encourage investment in the power sector; however, in order to attract more investment from the private sector in developing Independent Power Producer (IPP) projects, Vietnam's Ministry of Industry and Trade and EVN are formulating plans to increase prices. As of late 2013, the average price paid by retail customers was $0.07 USD per kilowatt hour (kWh); however, the Prime Minister approved an increase to $0.09 per kWh to be implemented by 2015 (USCS, 2013; Folkmanis, 2013).

Gas currently provides 30 percent of installed electric capacity in Vietnam (USCS, 2013). In 2012, 7.6 billion m^3 of gas was used to generate 40.7 billion kWh of electricity. In 2013, 8.4 billion m^3 of gas was consumed to generate 44.4 billion kWh, an almost 9 percent increase. The total gas consumption in Vietnam is forecast to reach 17 billion m^3 in 2025, around 75 percent of which is expected to be used for power generation. Gas prices are increasing in Vietnam, rising from $4.80 USD per million BTU (MMBtu) in 2011 to $5.19 USD per MMBTU in March of 2013. As of late 2013, the forecasted natural gas price for March 2014 was $5.61 USD per MMBTU (VPBS, 2013). Vietnam's gas demand is expected to exceed domestic supply by 2015 (Folkmanis, 2013) and as such, additional gas-fired power plants are not currently planned. Vietnam is also limited in pipeline networks (Le, 2014).

37.3.2 Regulatory Information

Vietnam's natural gas sector is controlled by the state-owned PetroVietnam, which is under the control of the Ministry of Industry. CBM activity is conducted through PSCs and is treated legally as petroleum. CBM is part of the government's Petroleum Development Planning; however, there are currently no specific targets for unconventional gas production (Le, 2014). The Vietnam Petroleum Institute cited a number of constraints to CBM production in Vietnam as of early 2014 including lack of incentives for unconventional gas production as well as a lengthy negotiation process for gas prices and a time-consuming process to acquire land (Le, 2014).

37.4 Profiles of Individual Mines

Profiles of individual mines in Vietnam are not available.

37.5 References

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