36 UNITED STATES

36.1 Summary of Coal Industry

36.1.1 ROLE OF COAL IN THE UNITED STATES

Coal accounts for 29.6 percent of energy production in the United States (EIA, 20010a). The United States exports 5.5 percent of its coal production (EIA, 2010b). Imports equal 2.3 percent of its total domestic consumption (EIA, 2010b). Table 36-1 quantifies recoverable reserves and recent coal production in the United States.

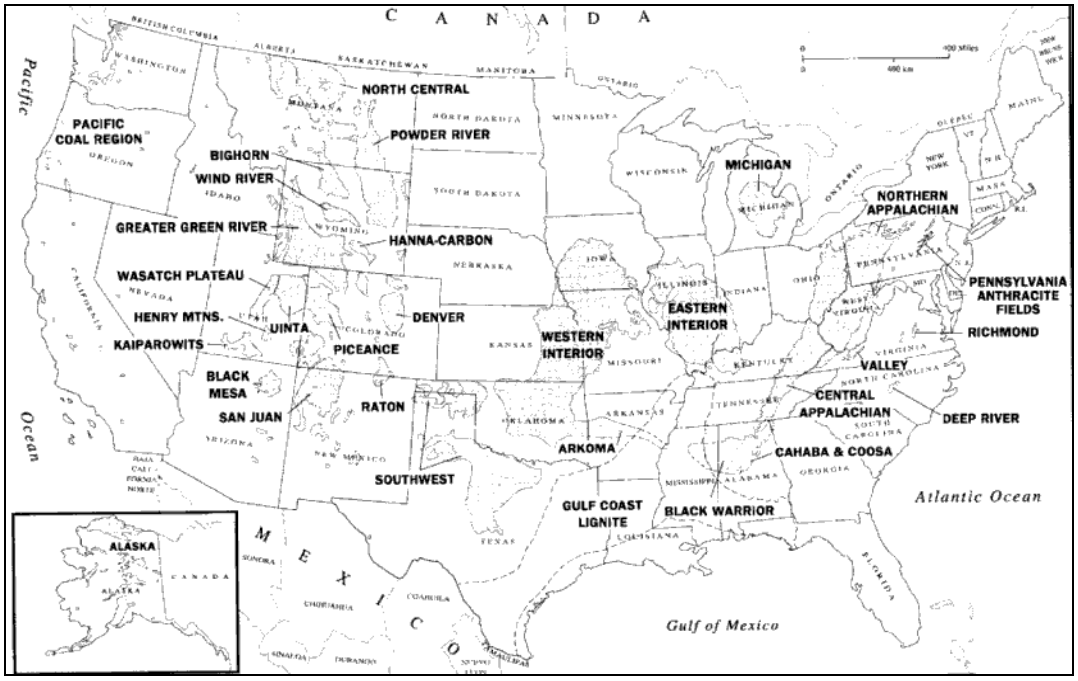
Table 36-1. U.S. Coal Reserves and Production

Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2005)*	110,667.9	128,620.2	239,298.1	1 (28.4%)
Annual Coal Production (2008)**	505.3	557.8	1063.0	2 (16.1%)

Source: *EIA (2010c); **EIA (2010d)

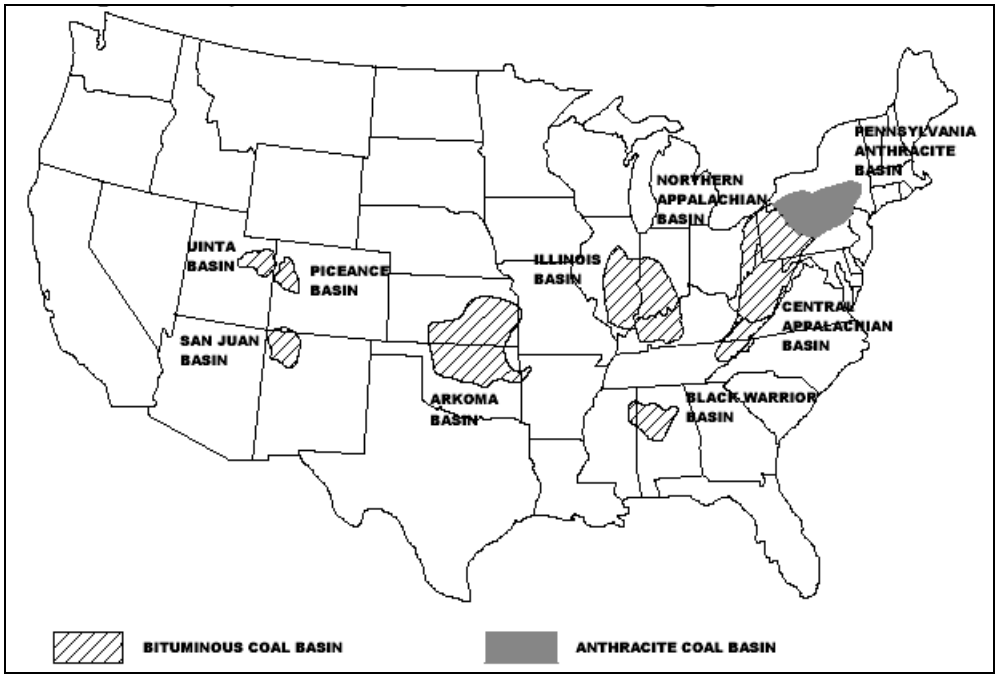
Figure 36-1 highlights all U.S. coal basins, while Figure 36-2 illustrates the locations of gassy U.S. coal basins. The gassy coal seams of the United States are found in four geographic regions: the Appalachian Basins of the eastern United States (medium to high volatile bituminous and anthracite); the Illinois Basin in the Midwest (medium to high volatile bituminous); the Rocky Mountain Basins in the western United States (lignite, sub-bituminous to medium/high volatile bituminous); and the Gulf Coast and Anadarko Basins of the South/Southwest (lignite, sub-bituminous to medium/high volatile bituminous).

Figure 36-1. Map of All U.S. Coal Basins



Source: Schwochow (1997)

Figure 36-2. Map of U.S. Gassy Coal Basins with Underground Coal Mines



Source: USEPA (2004)

36.1.2 STAKEHOLDERS

Table 36-2 identifies potential key stakeholders in U.S. coal mine methane (CMM) development.

Table 36-2. Key Stakeholders in the U.S. CMM Industry

Stakeholder Category	Stakeholder	Role
Mining companies	▪ Allegheny Energy (Electric Power) ▪ Arch Coal ▪ BHP Billiton ▪ Black Warrior Methane (natural gas production) ▪ CONSOL Energy ▪ CNX Gas ▪ Drummond Coal ▪ Eastern Associated Coal (Peabody subsidiary) ▪ Jim Walter Resources ▪ Oxbow Minerals ▪ Peabody Energy ▪ USX Corp. ▪ National Mining Association ▪ Alpha Natural Resources	Project hosts
Equipment manufacturers	▪ Advanced Extraction Technologies ▪ BCCK Engineering ▪ Biothermica ▪ BOC Gases ▪ Caterpillar ▪ Cummins Engine ▪ D'Amico Technologies ▪ Engelhard/Guild Associates ▪ Engineered Gas Systems Worldwide ▪ Gas Separation Technology ▪ HNNG Development ▪ MEGTEC Systems ▪ Membrane Technology and Research ▪ Prometheus Energy ▪ Solar Turbines ▪ Velocys ▪ Waukesha Engines	Methane treatment and utilization equipment
Developers	▪ See www.epa.gov/coalbed, Network Contacts	Project opportunity identification and planning
Engineering, Consultancy, and Related Services	▪ See www.epa.gov/coalbed, Network Contacts	Technical assistance
Universities, Research Establishments	▪ U.S. Geological Survey ▪ Gas Technology Institute ▪ University of Montana (Water Quality Management) ▪ U.S. Department of Energy	Technical assistance
Regulatory Agencies	▪ Mine Safety & Health Administration ▪ Bureau of Land Management ▪ U.S. Forest Service	Project approval Leasing on federal land

Stakeholder Category	Stakeholder	Role
Other	▪ Emissions Marketing Association ▪ Less Carbon ▪ See www.epa.gov/coalbed, Network Contacts	Emissions credits brokers

Source: M2M-US (2005), Marshall (2008)

36.1.3 Status of Coal and the Coal Mining Industry

The U.S. coal industry is privatized. Table 36-3 summarizes coal mining in the country by mine type. In 2005, there were 8,000 abandoned underground mines, 440 of which are considered gassy (USEPA, 2004).

Table 36-3. Recent U.S. Coal Statistics

Type of Mine	**Production** (million tonnes)	Number of Mines
Underground (active) mines - total	357.1	583
Surface (active) mines - total	813.3	852

Source: EIA (2010e)

36.2 Overview of CMM Emissions and Development Potential

The Global Methane Initiative (formerly Methane to Markets Partnership) International CMM Projects Database currently identifies 39 operating CMM projects, 13 of which are in place in active underground mines and 26 in abandoned mines. Thirty-two projects use the methane for pipeline injection, one for coal drying, one for heating or cooling, two for power generation, one in ventilation air methane (VAM) destruction, and two for other uses (M2M Projects, 2010).

36.2.1 CMM Emissions from Operating Mines

Table 36-4 quantifies methane emissions from the U.S. mining industry in recent years. The data in this table may vary from the U.S. Environmental Protection Agency (U.S. EPA) data presented in the Executive Summary due to differences in inventory methodology and rounding of digits.

Table 36-4. U.S. CMM Emissions (million cubic meters)

Emission Category	1990	1995	2000	2005	2006	2007	2008
Underground Mining	4363.9	3272.9	2767.1	2452.5	2501.0	2514.2	3143.5
Surface Mining	843.4	806.3	861.2	930.8	982.2	968.8	1000.5
Post-Mining (Underground)	541.5	485.1	467.7	449.8	438.9	425.8	429.3
Post-Mining (Surface)	137.0	131.0	140.0	151.3	159.5	157.5	162.6
Total	5885.6	4694.7	4235.9	3984.5	4081.6	4065.4	4735.8

Source: USEPA (2010a)

There are a limited number of CMM-to-power projects currently in existence or planned at U.S. mines (M2M-US, 2005). CONSOL Energy and Allegheny Energy operate a combined power project at the VP#8 and Buchanan mines in Virginia. The 88 megawatts (MW) power generation station is currently the second largest CMM power plant in the world, although it is used only for power peaking and operates very infrequently. This CMM project uses large turbines (two 44-MW turbines) where most projects use small ones. In addition, CONSOL recovers approximately 56,620 cubic meters (m^3) per day from these mines to use in drying coal (USEPA, 2005). Another CMM power project is operating at CONSOL's Bailey/Enlow Fork mining

complex in Pennsylvania. This demonstration of a 70-kW microturbine running off of the mine's ventilation air will be developed as a full VAM project with Green Holdings (CONSOL, 2010a).

There is currently one VAM project in operation in the United States. It began operation in 2009, destroying VAM at the Jim Walter Resources Mine No.4 in Alabama. In February 2010 the equipment supplier, Biothermica, announced that the project had been listed with the Climate Action Reserve as the carbon registry's first CMM project. The project is expected to generate 27,000 carbon offset credits in its first year, and 35,000 per year at full capacity (Biothermica, 2010). The project captures 51,000 m^3 per hour, reducing emissions by 40,000 tons carbon dioxide equivalent (CO_2e) (Biothermica, 2009).

In addition to the Bailey/Enlow Fork project, CONSOL has announced plans for a 2011 VAM project in conjunction with Verdeo Group, Inc. at its McElroy Mine in West Virginia (CONSOL, 2010b). Additionally, from 2007 to 2008 the U.S. EPA and the U.S. Department of Energy (DOE) were co-funding a demonstration project using simulated ventilation air (diluted drainage gas) from the abandoned Windsor Mine in West Liberty, West Virginia (USEPA, 2007).

In the United States, flaring has been used at closed mines but has not been widely implemented at active mines. The coal industry has expressed concerns about the safety of flaring due to the potential for the flame to propagate back down to the mine and cause an underground explosion. Implementing flaring at active mines requires greater acceptance by miners, union parties, mine owners, and the Mine Safety and Health Administration (MSHA). It should be noted, however, that 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 CMM Emissions from Abandoned Mines

Currently, there are 26 projects using gas from approximately 36 abandoned U.S. coal mines for direct gas sales and pipeline injection. Table 36-5 quantifies methane emissions from abandoned mines in the United States (USEPA, 2004).

Table 36-5. U.S. Abandoned Mine Methane Emissions (million cubic meters)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Inventory 1990–2002	238	242	270	303	319	357	413	392	341
Inventory 1990–2003	425	436	466	492	583	591	606	568	502
Inventory 1990–2004	420								483
Inventory 1990–2005	420					574			
Inventory 1990–2006	423					577			

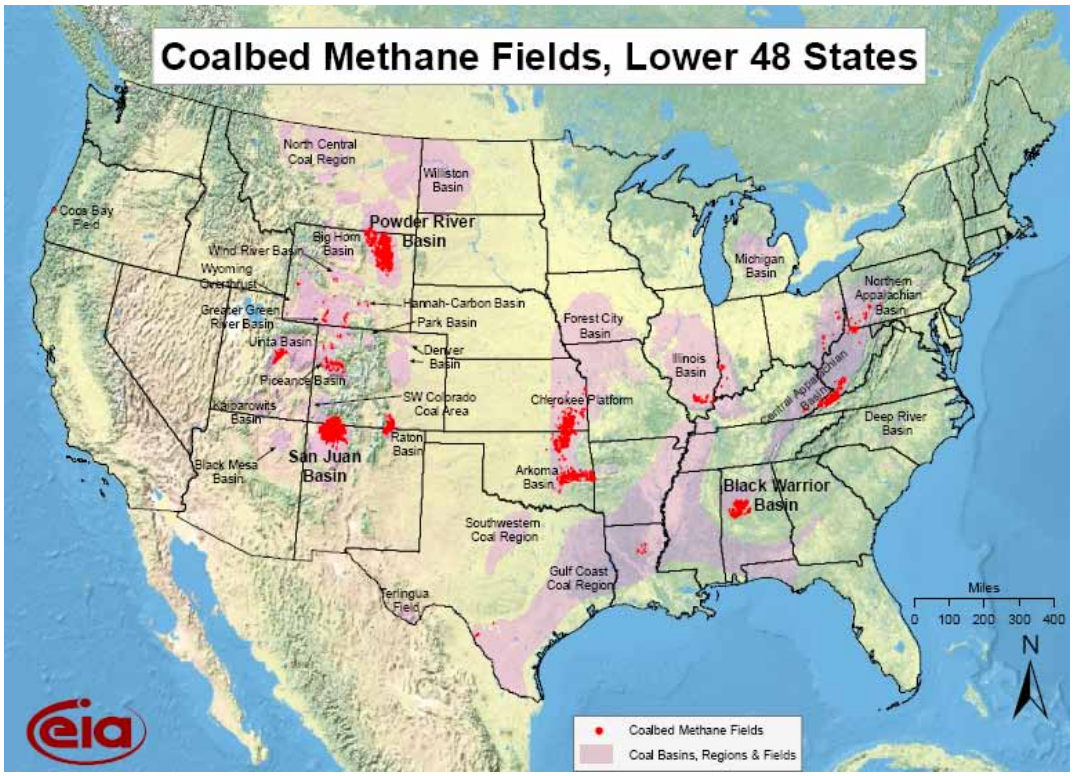
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Inventory 1990–2002	311	311	296	290						
Inventory 1990–2003	514	544	488	448	448					
Inventory 1990–2004	490	504	455	420	406	392				
Inventory 1990–2005		511	462	427	420	406	392			
Inventory 1990–2006		515	469	431	417	406	389	378		
Inventory 2010*				431.2	416.9	407.6	390.4	387.9	395.9	412.7

Source: USEPA (2004); Marshall (2008); *UNFCCC (2010a) Note: Revisions of calculation methods, map information, and mine closing information resulted in adjusted emissions figures from previous years' inventories.

36.2.3 CBM FROM VIRGIN COAL SEAMS

The United States is the world's leading producer of coal seam gas. Production has been established in 10 coal basins nationwide (primarily San Juan, Black Warrior, and Central Appalachian) as shown in Figure 36-3 (UNFCCC, 2010a; EIA, 2009a). Total annual production of coalbed methane (CBM) in 2007 was estimated at 49,668 million m^3 (EIA, 2009b). Table 36-6 summarizes the proved U.S. CBM reserves up to 2007.

Figure 36-3. Map of U.S. Coalbed Methane Fields



Source: EIA (2009a)

Table 36-6. U.S. CBM Proved Reserves (billion cubic meters)

Date	USA	Alabama	Colorado	New Mexico	Utah	Wyoming	Virginia*	Eastern States	Western States	Other States
1989	104.1	15.2	31.6	57.3						0.0
1990	144.0	34.7	37.4	71.1						0.9
1991	231.2	48.5	58.8	119.1						4.7
1992	284.1	55.7	76.9	133.8						17.7
1993	288.4	35.0	88.0	135.2						30.2
1994	275.0	27.6	82.5	117.1						47.7
1995	297.3	27.5	98.0	121.7						50.0
1996	299.2	23.3	105.1	118.4						52.4
1997	324.6	30.5	110.2	123.2						60.7
1998	344.9	29.1	119.2	119.8						76.7
1999	374.6	30.0	136.7	115.5						92.4
2000	444.8	35.1	159.1	121.1	45.1	43.6		39.6	1.2	
2001	496.4	32.9	177.0	122.4	47.7	65.0		41.1	10.1	
2002	523.6	36.3	189.5	124.0	48.8	67.1		42.1	15.7	
2003	530.7	47.1	183.3	124.5	34.7	78.1		43.3	19.8	
2004	520.7	53.8	163.9	146.3	26.4	59.0		45.9	25.4	0.0
2005	563.3	50.2	191.8	148.6	25.5	69.3		51.6	26.3	
2006	555.6	58.6	179.6	138.6	21.2	69.3	51.3	7.7	29.2	
2007	619.4	60.2	222.8	118.1	26.1	77.5	55.2	11.1	48.4	

Source: EIA (2009b)

36.3 Opportunities and Challenges to Greater CMM Recovery and Use

Source: M2M-US, 2005 unless otherwise noted

The United States is a signatory to the UNFCCC and the Kyoto Protocol, but currently, does not intend to ratify the Kyoto Protocol (see Table 36-7). Therefore, it is not subject to Kyoto emissions targets. There are no alternative national emission restrictions or regulations limiting carbon dioxide or other greenhouse gas (GHG) emissions in the United States at this time, but some states have begun establishing emissions limits. EPA has issued regulatory actions under the Clean Air Act and in some cases other statutory authorities to address issues related to climate change (USEPA, 2010b). In the spring of 2010, EPA finalized the GHG Tailoring Rule, which specifies that beginning in 2011, projects that will increase GHG emissions substantially will require an air permit (USEPA, 2010c). In addition, some firms are

voluntarily engaging in the carbon market through self-imposed carbon emissions reductions or financial investments in GHG emission reductions.

Table 36-7. U.S. Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC*	June 12, 1992	October 15, 1992
Kyoto Protocol**	November 12, 1998	No

Source: *UNFCCC (2010b); **UNFCCC (2010c)

Utilities in 41 U.S. 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, 2010). Four states include CMM in their renewable/alternative energy standards: Pennsylvania, West Virginia, Ohio, and Utah (Colorado is considering) (World Coal, 2010; DSIRE, 2010). Pennsylvania does not have a green pricing program in place at this time.

There are four major voluntary GHG registries in the United States that accept CMM offset projects: the Voluntary Carbon Registry (VCS), the Chicago Climate Exchange (CCX), the Climate Action Reserve (CAR), and the American Carbon Registry (ACR). The specifics of each CMM project will determine its full eligibility for each of these registries (World Coal, 2010).

36.3.1 Market and Infrastructure Factors

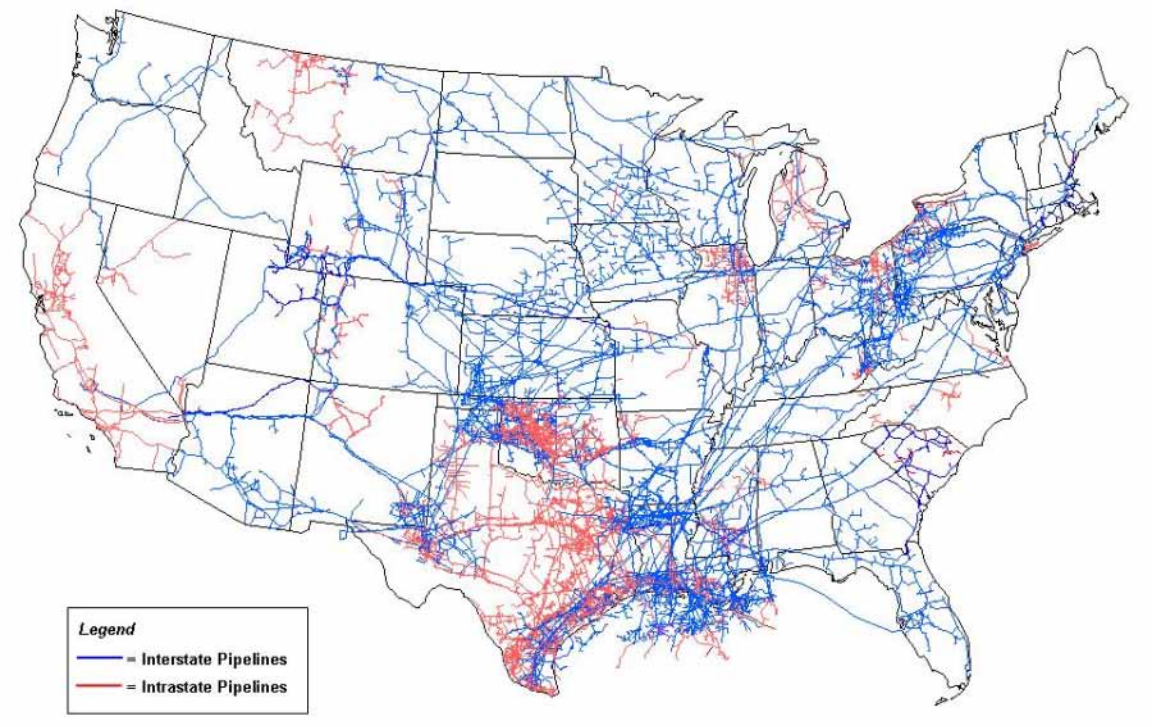
Infrastructure Issues

The majority of CMM recovery projects in the United States 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). If necessary, lower-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, 2008a).

The existing gas pipeline infrastructure in the United States plays an important role in determining if and where pipeline sales are feasible. In the eastern United States, the natural gas pipeline system is more extensive and is located closer to gassy coal mines than in the western United States. 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 United States 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 United States are not typically located in close proximity to coal mines. Thus, in the absence of reasonably accessible long-distance pipelines, there are not readily accessible methane markets near most mines.

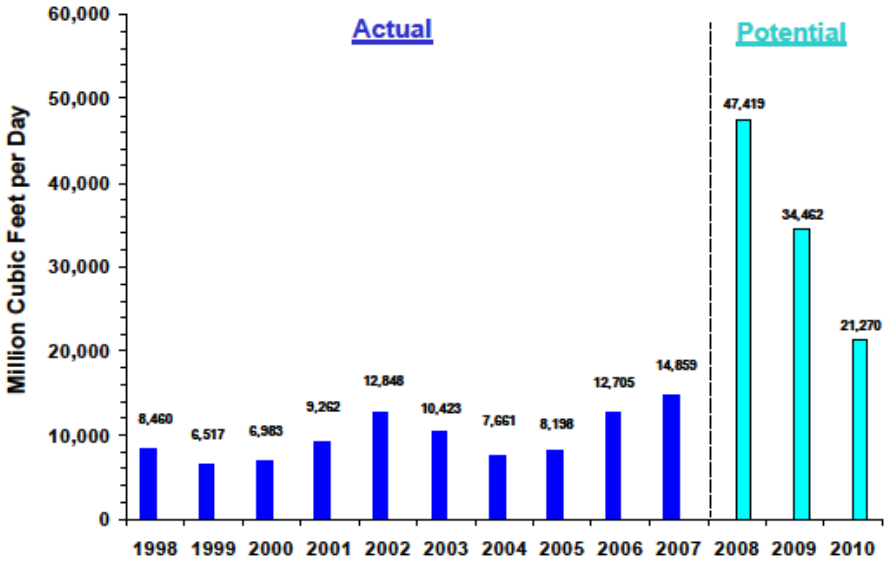
Figure 36-4 illustrates interstate and intrastate natural gas pipelines in the United States in 2009. Figures 36-5 and 36-6 summarize the U.S. natural gas pipeline expansion from 1998 to 2007, with estimations through 2010. From 1998 to 2008 more than 32,000 kilometers (20,000 miles) of new natural gas transmission pipeline were placed in service. New major gathering systems and interstate natural gas pipelines were built to accommodate the expansion of CBM and tight-sands natural gas production in the Powder River, Green River, Piceance, and Uintah basins of Wyoming, Colorado, and Utah. Nearly 400 million m^3 (14 billion cubic feet) per day of interstate natural gas pipeline capacity and almost 170 million m^3 (6 billion cubic feet) per day of new intrastate headers and laterals were built to transport this additional gas (Tobin, 2008).

Figure 36-4. U.S. Interstate Natural Gas Pipelines, 2009



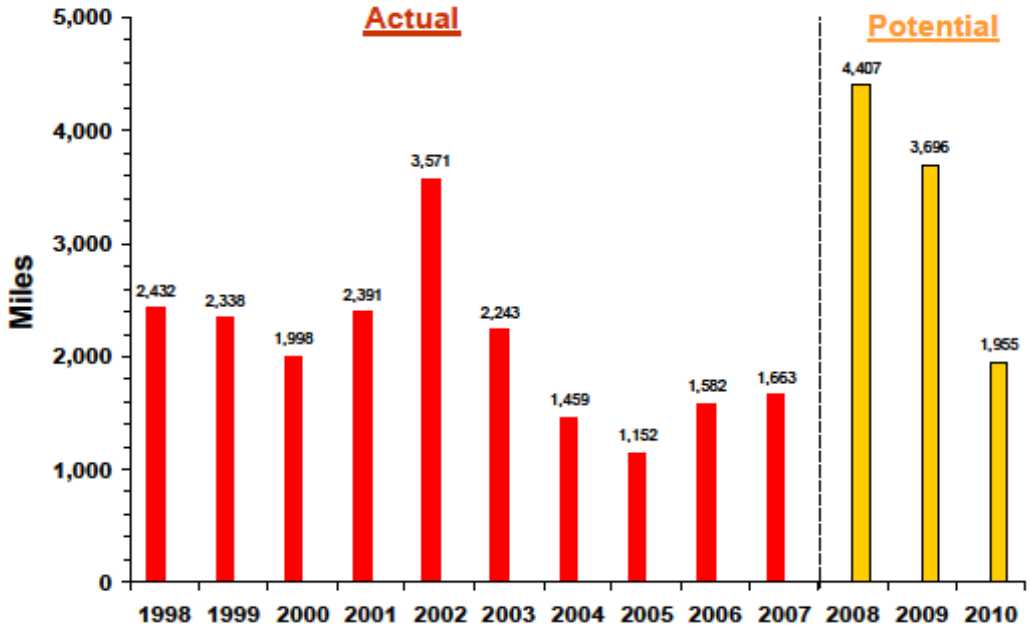
Source: EIA (2009c)

Figure 36-5. Annual Increases in U.S. Natural Gas Pipeline Capacity



Source: EIA (2008b)

Figure 36-6. Annual Increases in U.S. Natural Gas Pipeline Length



Source: EIA (2008b)

Institutional Issues

Disputes over ownership of methane produced from coal seams present one of the most significant barriers to further development of the CMM industry in the United States. 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. U.S. government agency Bureau of Land Management (BLM) in the Department of the Interior has setup 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 recently re-delineated in December of 2009 (BLM, 2010). 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 the 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 are no longer 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 the other areas of the country and in parts of the West. For private leases, laws in each individual state govern ownership of the resource. Federal law governs U.S. government 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, as shown in Table 36-8 (EIA, 2010f). Natural gas prices have tended to rise more slowly than oil prices and are expected to steadily rise again as the economy recovers from the 2008–2009 recession (EIA, 2010g). Higher natural gas prices will thus continue to spur interest in CMM development projects.

Table 36-8. Recent U.S. Natural Gas Prices

Year	Nominal Annual Wellhead Gas Price (per million cubic meters)
2009	$ 131.02
2008	$ 281.10
2007	$ 220.72
2006	$ 225.66
2005	$ 258.86
2004	$ 192.82
2003	$ 172.34
2002	$ 104.18
2001	$ 141.26

Source: EIA (2010f)

In 2008, coal delivered to the U.S. steam-electric utility plants averaged $45.55 per tonne, while coal delivered to coke plants (metallurgical) averaged $130.17 per tonne (EIA, 2009d).

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 (M2M, 2005). 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 United States. 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. U.S. EPA's Environmental Finance Program assists communities in funding environmental projects by helping to lower costs, increase investment, and build partnerships.

The United States does not receive foreign assistance or assistance under multilateral organizations. However, there are three key export-financing agencies within the U.S. government to provide financing for projects based outside the country that result in significant exports: the U.S. Trade & Development Agency, the U.S. Export Import Bank, and the Overseas Private Investment Corporation.

Research and development associated with methane capture and use is funded by two U.S. government agencies: U.S. DOE, which focuses on gas production and utilization, and the National Institute of Occupational Safety & Health, which focuses on mine safety research.

36.3.2 REGULATORY INFORMATION

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 US$3 per barrel of oil equivalent and gradually being reduced. The credits were enacted in 1980 and expired on December 31, 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, however, were reinstated and revised under the Energy Improvement and Extension Act of 2008 (IRS, 2009). The current credit is US$4.375 per ton of qualified refined coal.

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 United States does not have a Production Sharing Agreements regime. The United States 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.

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 areas. In some instances, especially on federal lands, it may be 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).

36.4 Profiles of Individual Mines

Profiles of individual mines in the United States can be found in the U.S. EPA report, "Identifying Opportunities for Methane Recovery at U.S. Coal Mines" at http://epa.gov/cmop/docs/profiles_2008_final.pdf.

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