An Overview of the Global Market for CBM & CMM

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U.S. Environmental Protection Agency

Overview of the CMM/CBM Market

- Coalbed Methane (CBM) and Coalmine Methane (CMM) - what is the distinction?
- Technologies to recover CBM & CMM
- Conventional and emerging markets for CBM & CMM including us of ventilation air methane
- The global market and opportunities for investment
- Challenges to development

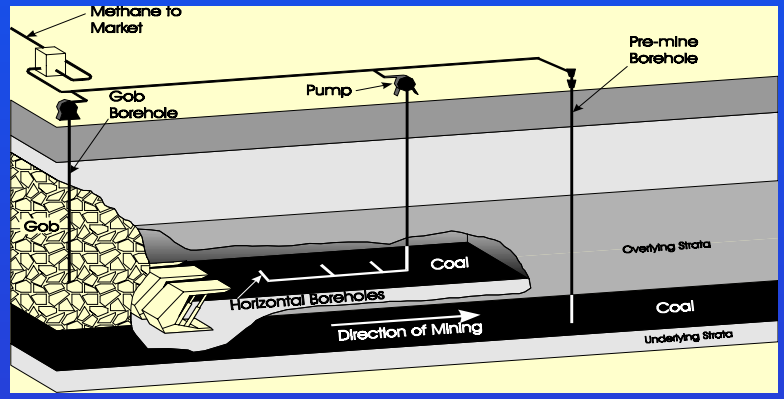
What is Coalbed Methane

Coalbed Methane (CBM):

- Methane gas contained in coal
- Methane is the primary constituent of natural gas

Coal Mine Methane (CMM):

- A subset of CBM; methane gas released from coal or surrounding rock strata during the process of coal mining



Distinction is important because . . .

CMM is a Greenhouse Gases

- Methane is 21 times as potent as potent as CO_2 and is second to carbon dioxide as a contributor to global warming
- Fugitive emissions from coal mines account for 8-10% of anthropogenic global methane emissions
- Methane mitigation - increasing prominence as an effective option for climate change policy
  - Methane is a commodity that has value beyond the emission reduction
  - Hansen and others raising awareness. A strategy focussing on non-CO_2 GHG emissions could reduce the rate of global warming and at lower cost

EPA Coalbed Methane Programs

- Established 1994
- Voluntary program to promote CMM recovery and use
- Domestic program is primary focus
- International programs
  - China
  - NIS
  - Eastern Europe


Energy Independence
GHG Reductions
Cleaner Fuel
Benefits of Recovering CBM & CMM
Improved Coal Production
Revenues/ Cost Savings
Mine Safety

CBM/CMM Recovery Technologies

Pre-Mining Drainage

- Vertical frac wells
- In-mine horizontal boreholes
- Enhanced gas recovery (ie., Nitrogen/CO2 injection
- Directional drilling

Produces high quality gas

Post-Mining Drainage

- Vertical gob wells
- Directionally drilled in- mine horizontal gob wells
- Cross-measure boreholes
- Superjacent method

Produces medium quality gas

The Market for CBM/CMM

High-Quality Gas

- Natural gas pipelines
- Local distribution
- Vehicle fuel

Medium-Quality Gas

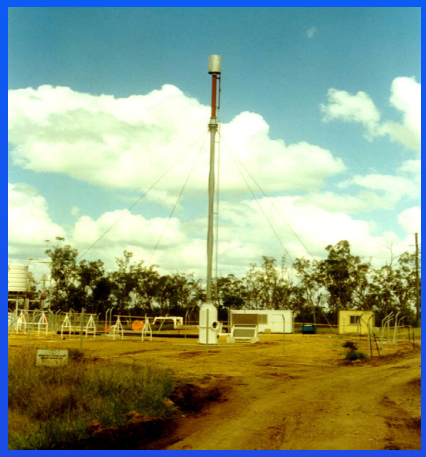
- Power generation
- Combined heat & power
- District heating
- Coal drying
- Boiler fuel
- Industrial applications

Project Financials

- Technologies established
- Markets for CBM/CMM established in a number of countries
- Degasification costs justified for mine safety
- Billions in profitable projects worldwide

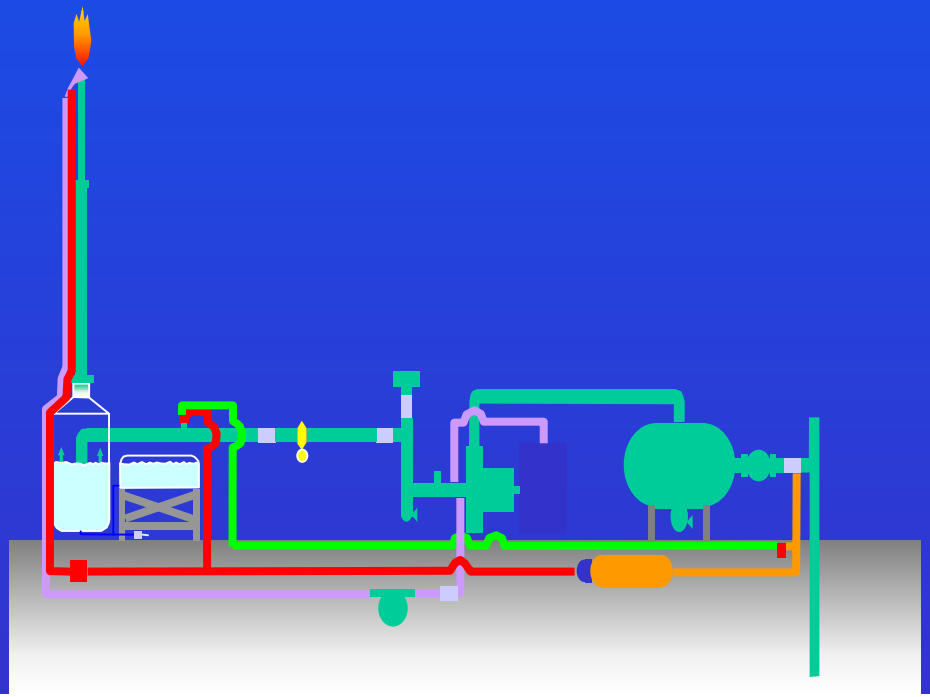
Emerging Markets for CMM

- Drained gas
  - Flaring
- Ventilation air methane (VAM)
  - Oxidation
  - Supplemental fuel for turbines and combustion engines
- LNG
- Fuel Cells

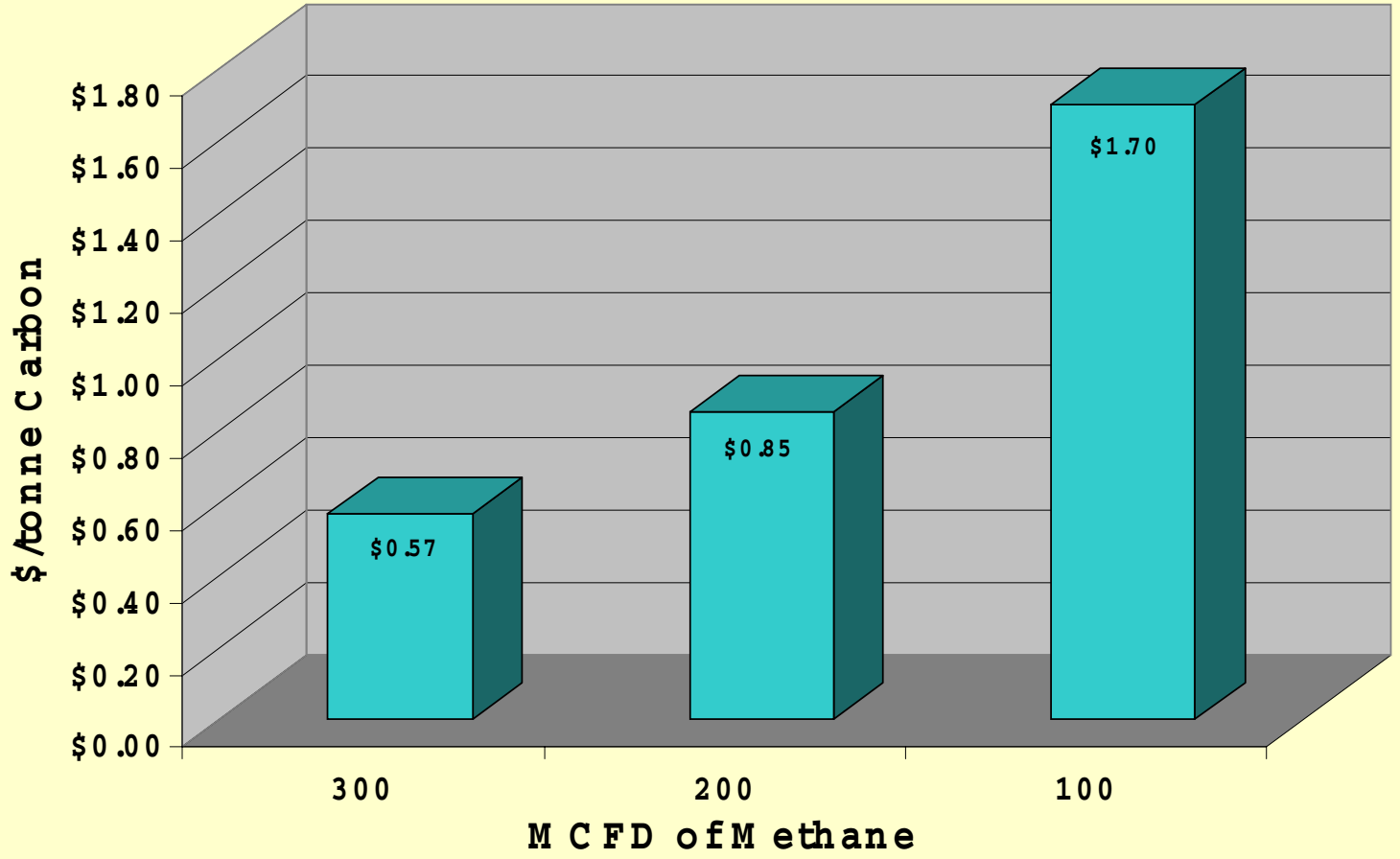


Flaring

- Advantage
  - Low cost
  - Common in oil & gas and landfill industries
  - Ties into existing degas system
- Barriers to Implementation
  - Institutional concerns
  - Requires a market for the emission reduction



Breakeven Cost of Flaring: US Example

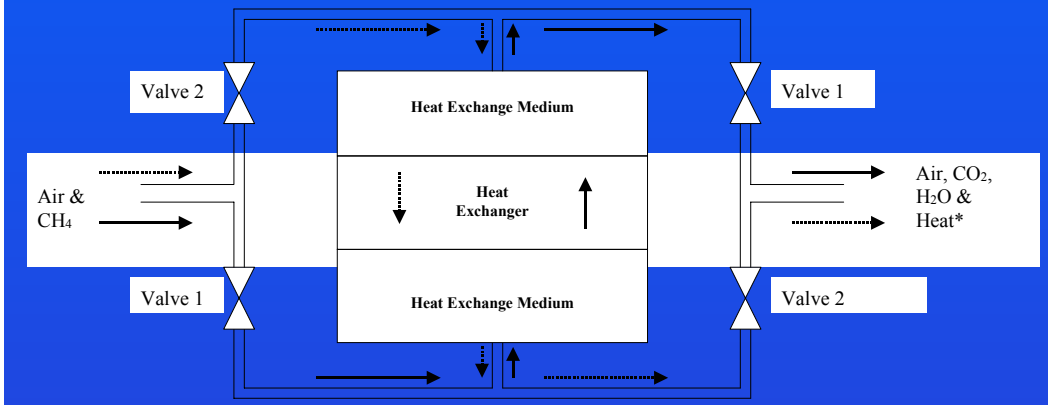


VAM
Supplemental Fuel Example: Appin Colliery,Australia

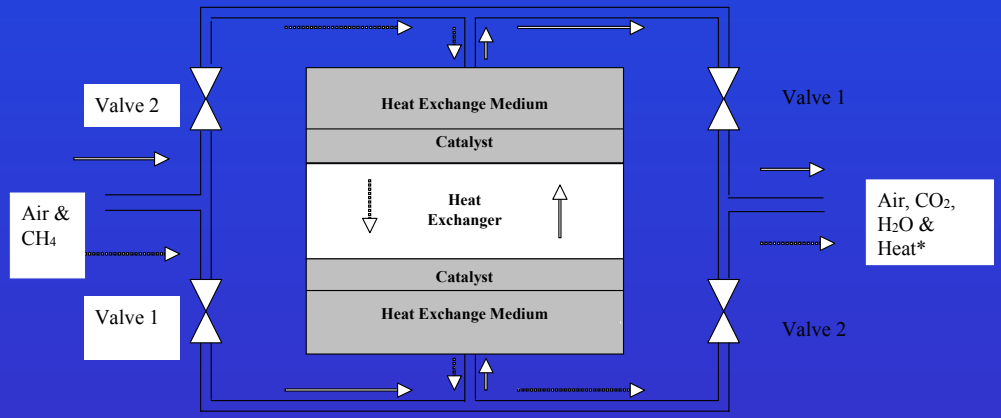
- Installed in 1995
- 54 x 1 MW IC Engines Produce Power from Gob Gas
- VAM Used as Feed Air, Supplied 7% of Energy

VAM
Primary Fuel For Flow Reversal Reactors

Megtec Thermal FRR



CANMET/Neil and Gunter Catalytic FRR



VAM Concentrators: A Possible Supporting Technology

- Concentrator: used to reduce costs of oxidizers to control volatile organic compounds
- May increase CH4 in Ventilation Air from .5% to 20%

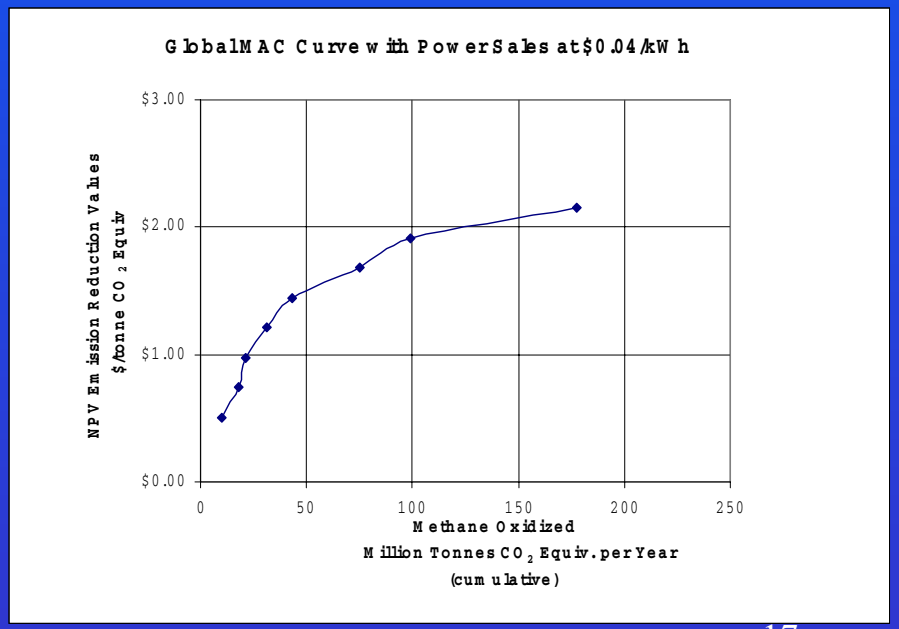
Fluidized Bed Concentrator (Environmental C & C)

VAM
Hybrid Technologies

- Use of Flow Reversal Reactor (FRR) and Turbine
- Use of FRR and Concentrator
- Use of Turbine and Concentrator

VAM Marginal Abatement Costs

- Tool to estimate market size with different price signals
- Marginal cost in $/tonne CO2 equivalent
  - 1 tonne CO2e=2.5 mcf
- 175 million tonnes < $2.25



The Global Market Place

Global Overview

- CMM/CBM activity in > 20 countries
- Greatest potential in economies in transition and developing countries
- Activity increasing as energy and environmental benefits become clear
  - US, Canada, Western Europe, Japan, Australia technologically advanced
  - Abandoned mines a major focus in Western Europe, Japan
  - NIS and Eastern Europe have large CBM/CMM resources and experience capturing CMM but face a challenging investment climate
  - Asia, especially India and China, are very active and attracting investment

Global CBM Resource Base

(Various Sources)

Country	Estimated CBM Resource Base (Trillion cubic meters)
Canada	17-92
Russia	17-80
China	30-35
Australia	8-14
US	4-11
Ukraine	2.0-12
India	0.85-4.0
Germany	3.0
Poland	3 .0
United Kingdom	2.45
Kazakhstan	1.1-1.7
South Africa	1 .0
Czech Republic	0.38
Turkey	0.10

CMM Emissions

*Does Note Include Abandoned Mine Emissions

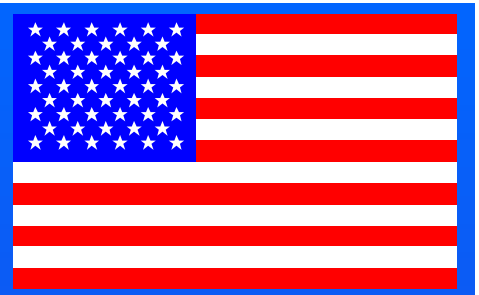
Country	2000 CH4 Liberated (Million m^3)	2000 CO2 Equivalent (MMT)	2010 CH4 Liberated (Bm^3)	2010 CO2 Equivalent (MMT)
China	10,000	142.7	15,753	224.7
US	5,461	77.9	5,748	82.0
Russia	2,236	31.9	2,138	30.5
Australia	1,381	19.7	2,004	28.6
Ukraine	1,970	28.1	1,689	24.1
India	683	9.7	1,319	18.8
Poland	1,037	14.8	939	13.4
Germany	1,030	14.7	764	10.9
South Africa	496	7.1	506	7.2
Kazakhstan	488	7.0	447	6.4
United Kingdom	365	5.2	343	4.9
Czech Republic	351	5.0	266	3.8
Turkey	123	1.8	184	2.6
Japan	133	1.9	147	2.1
Canada	98	1.4	91	1.3

(sources: U.S. EPA. *Non-CO2 Greenhouse Gas Emissions from Developed Countries: 1990-2010*. 2001 and compiled from developing country reports

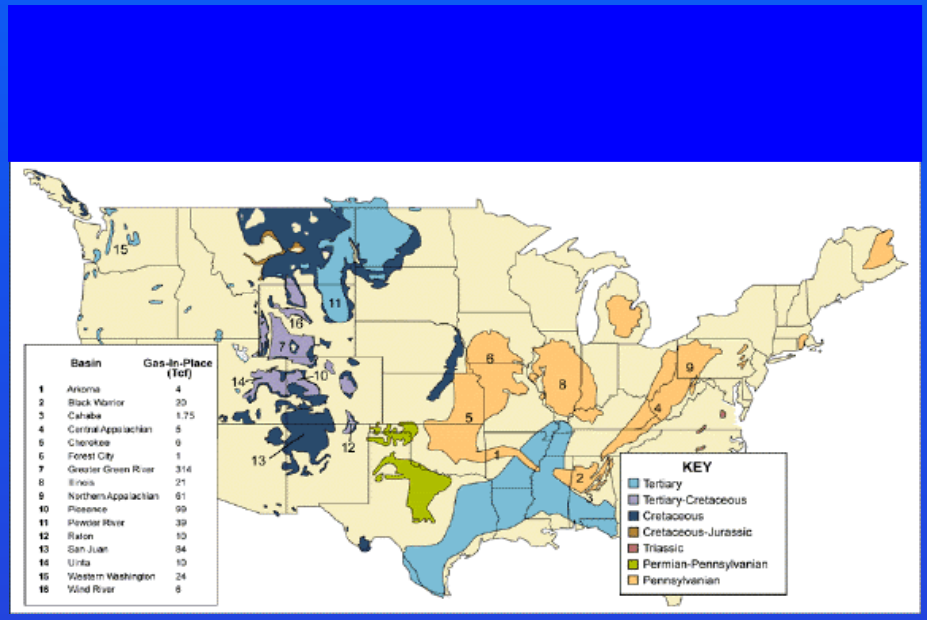
Canada

- Potential is almost all CBM
- Interest in CBM development has increased in recent years
- Alberta has well-developed pipeline network
- Domestic & US export markets
- CANMET CH4MIN VAM oxidizer

United States

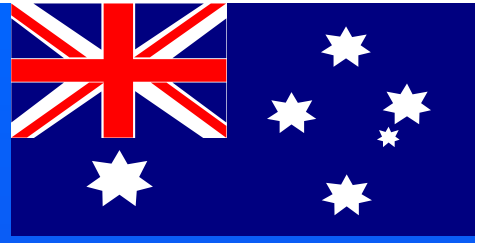


- Mature CBM/CMM industries:
  - Conventional markets may emerge in the West
  - Focus on emerging markets, especially VAM
- Production:
  - 36 bil m3 of CBM
  - 1 bil m3 CMM
- Almost all CBM/CMM injected into natural gas pipeline grid
- Growing interest in power generation;Consol/Allegheny Power - 88 MW power plant

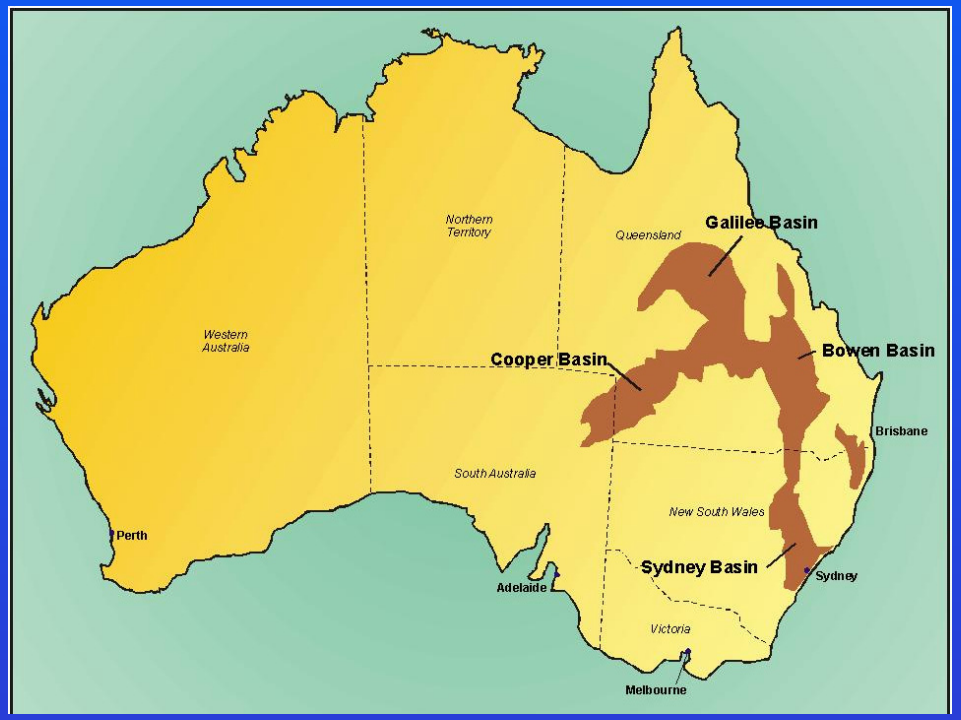


Source: Gas Technology Institute

Australia

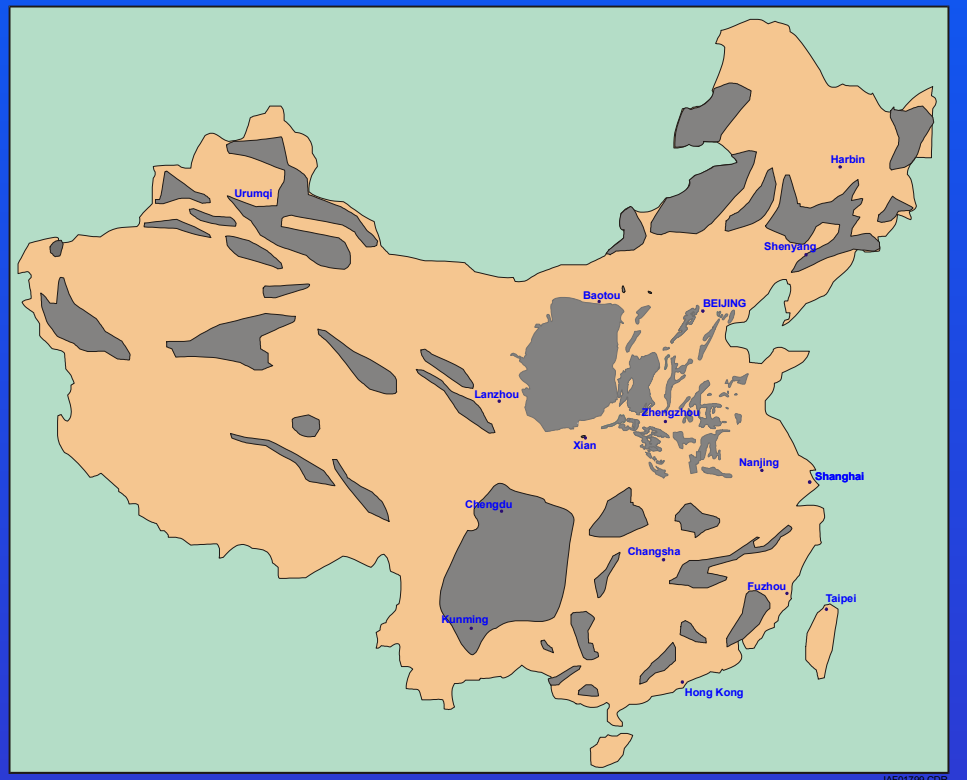


- Innovative CBM & CMM Industries
- Large reserves near population centers
- 94 MW CMM project at Appin & Tower Collieries
- VAM pilot at Appin
- CMM flare at Central colliery
- Government awarded US$15 in 2001 to 3 CMM projects



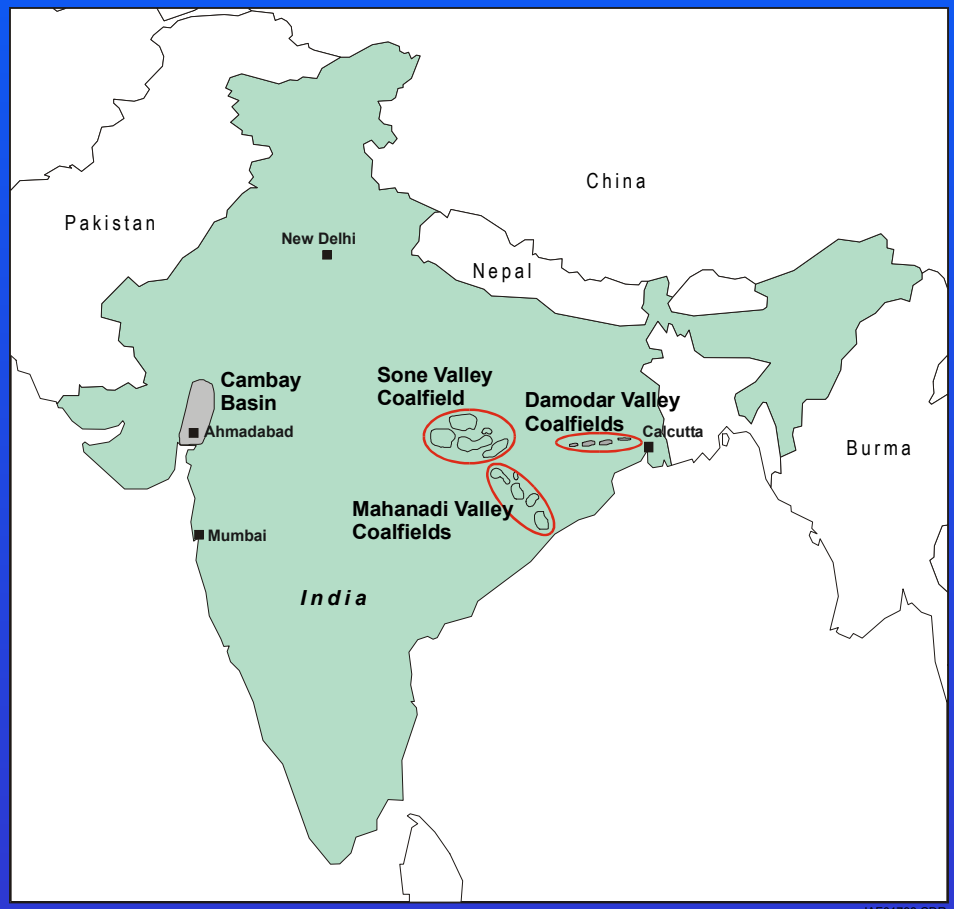
China

- Substantial opportunity for CBM & CMM
- CMM 400 mil m3 per yr used
- Planned projects at Yangquan (methanol & power), Jincheng (power 120 MW), Tiefa (local supply)
- Strong gov't support for energy production & mine safety
- Major oil companies have invested
- China United Coalbed Methane Corp. & China Coalbed Methane Clearinghouse
- EPA, UK DTI & JCOAL support CBM/CMM projects in China



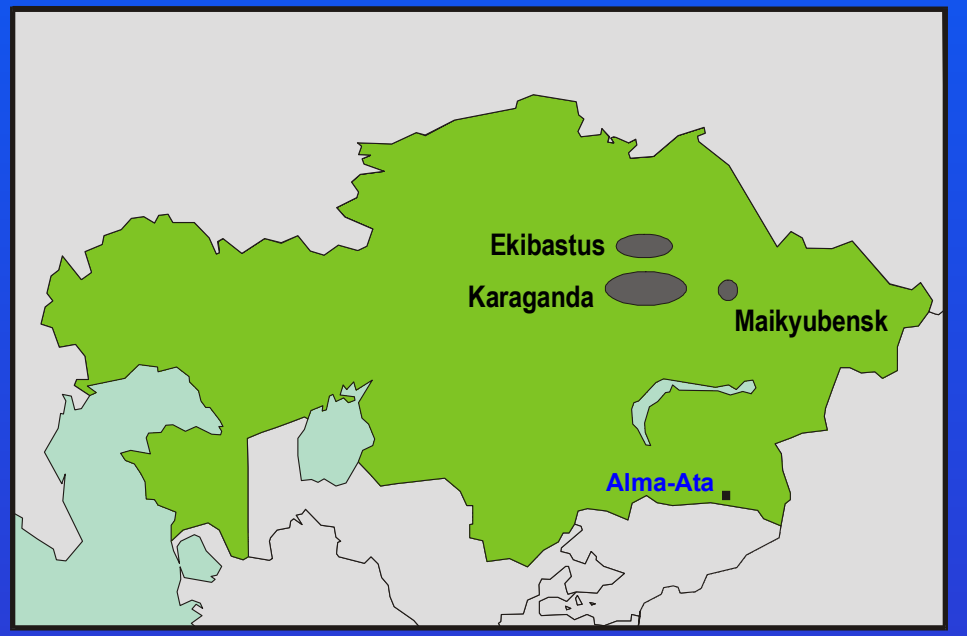
India

- Generating investor interest
- Strong government support for CBM/CMM development
- US$18 GEF CMM project
- Recent tender awarded 5 E&P licenses



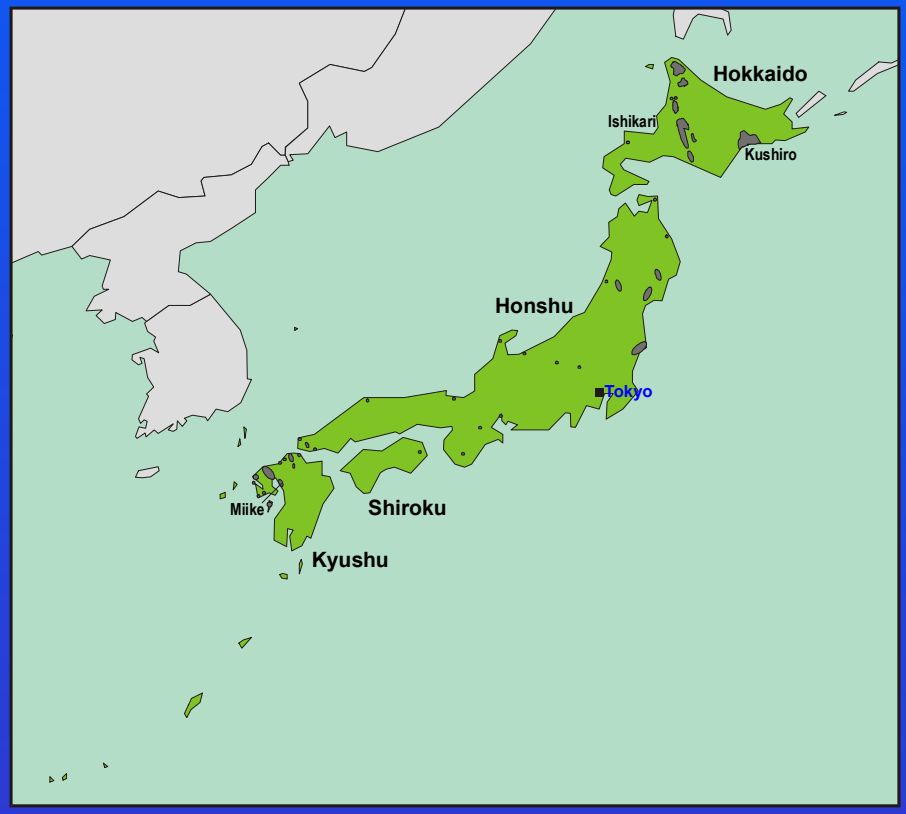
Kazakhstan

- Young industry but heightened gov't interest
- CBM/CMM resources located near near population centers
- Developing State Strategy on CBM/CMM
- Methane Center of Kazakhstan is in-country resource



Japan

- In-country focus on CMM
- Very gassy, closed mines are resource
- Innovative CMM industry with efforts directed to power generation and dimethyl ether
- Sumitomo experimenting with microturbines
- Japan Coal Energy Center very active in assessing CBM/CMM opportunities inside & outside Japan

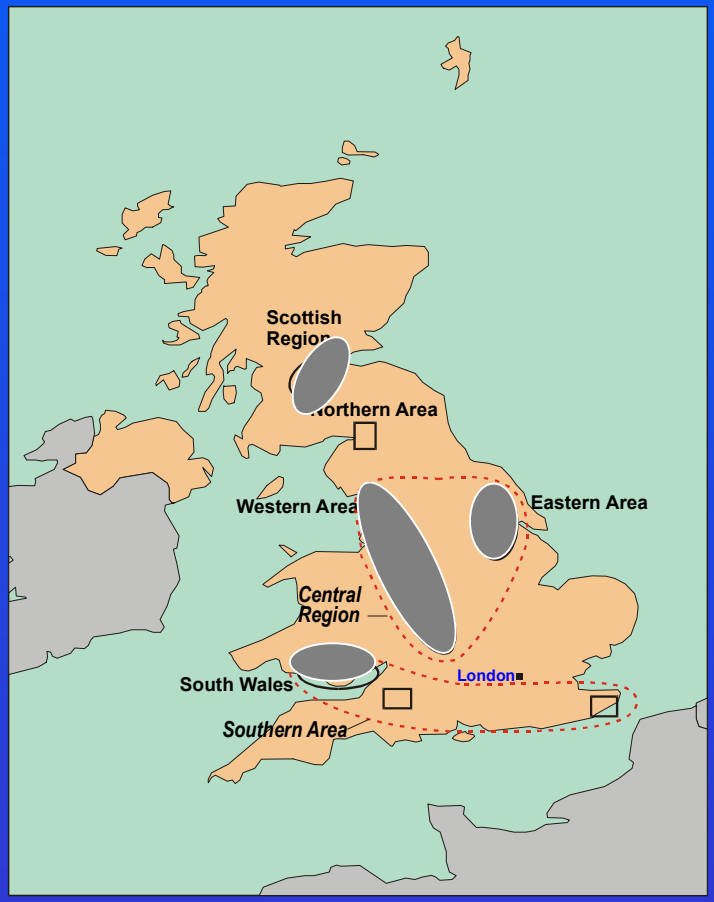


Germany

- History of CMM utilization; almost all power generation
- Leader in use of CMM for combined heat & power (CHP)
- Mine closures mean abandoned mines offer opportunity
- Experimental CBM production
- CMM association: Interessenverband Grubengas

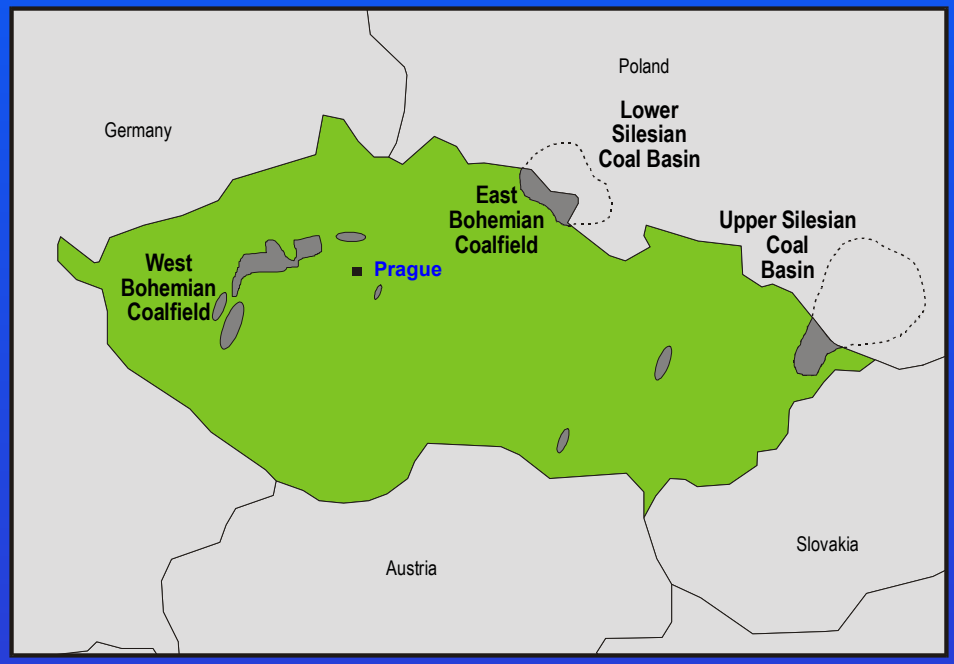
United Kingdom

- Focus on CMM, but some experimental CBM
- Abandoned mines offer largest resource
- 6 projects in UK - 42 MW at abandoned mines
- 2 projects - 22 MW at operating mines
- Plans call for 500 MW of generation from abandoned mines by 2004.
- UK Dept of Trade & Industry promoting CBM/CMM projects
- UK Assn of Coal Mine Methane Operators



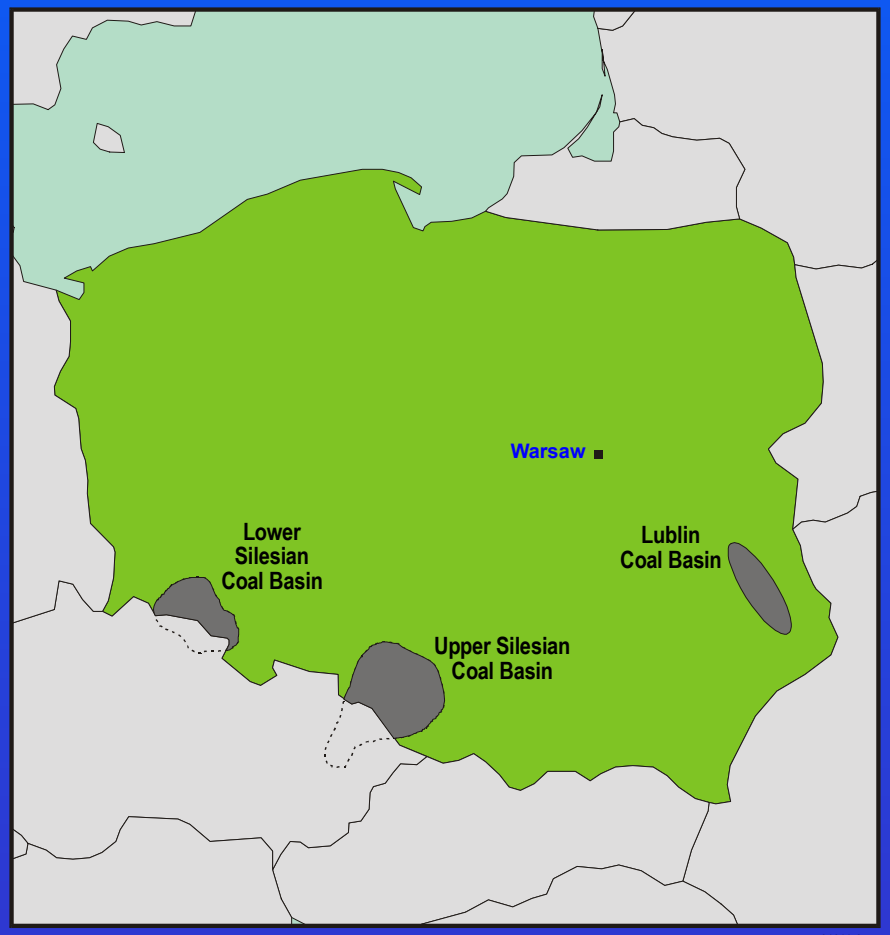
Czech Republic

- Focus on CMM with some CBM
- Long history of CMM utilization (early 1990's)
- 100 mil m3 per yr used
- Domestic and European markets
- DPB Paskov is leader in Czech CMM/CBM



Poland

- Expertise in CMM recovery
- 70% of degas used in conventional markets (e.g., power, heating, coal drying, industrial)
- Changing industry means abandoned mines could be significant resource
- Wesola mine project to use VAM & drained gas for power



Russia

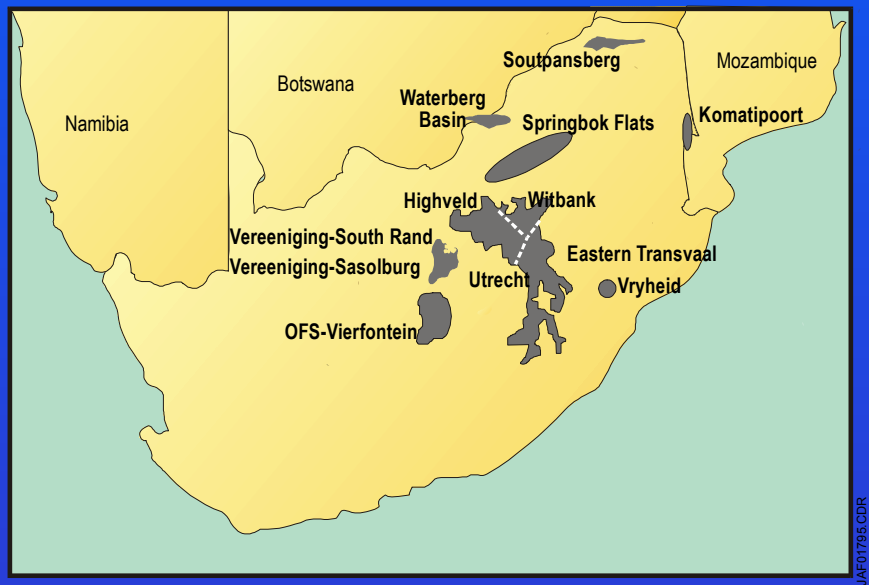
- Opportunities for both CMM & CBM
- Experience employing gas drainage and use, with CMM typically used on site
- Need to deploy more advance technologies
- GEF project planned but not submitted
- Russian CBM Center: in-country expert in Kuzbass Region

Ukraine

- Ample opportunities for CBM & CMM development.
- 4% of Ukraine CMM liberated is used
- CBM development has strong support of Ukraine Gov't
- Gov't amending laws/taxes to seek investment
- Many feasibility studies on Ukraine CBM/CMM prepared
- CBM/CMM resources: Partnership for Energy & Environmental Reform and Alternative Fuel Center

South Africa

- High gov't interest
- Low gas content in coals and location of mines has limited CBM/CMM activity
- Some gold mines have methane and have used the methane on-site for heating
- More investigation needed before large-scale investment



Challenges Facing CBM/CMM Projects

- Unmatched expectations
- Lack of downstream markets and/or infrastructure
- Lack of access to capital markets
- Uncertainty in greenhouse gas markets
- Technological challenges - what works well in one location or coal seam does not work well in another

Challenges Facing CBM/CMM Projects (cont.)

- Developing legal/tax systems
- Cultural challenges
- Unclear or conflicting objectives among governments, developers and mine operators
- Political instability and corruption
- Environmental concerns - especially water issues

EPA United States Environmental Protection Agency

Coalbed Methane Outreach Program

COALBED METHANE OUTREACH PROGRAM

International

http://www.epa.gov/coalbed

Climate Protection Award: 2002

- Climate Protection Award:

  "Recognize exceptional leadership, personal dedication, and technical achievements in protecting the Earth's climate."

- CONSOL Energy
  - Largest Producer of Coal Mine Methane
  - Innovative Upstream, Downstream Projects
  - Now CMM for Power Generation

Announcing 3rd International Methane/Nitrous Oxide Mitigation Conference

- In China, in June 2003
- Following successful 2nd Conference in Novosibirsk, Russia in June 2000
  - 200 participants from 30 countries
- Sponsorship Opportunities
- More information available: see me.

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