OVERVIEW OF U.S. AND INTERNATIONAL CMM/CBM DEVELOPMENT

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Methane to Markets

Presentation Outline

1. Terminology
2. Overview of the U.S. Coalmine and Coalbed Methane Industry
3. Overview of International Coalmine Methane and Coalbed Methane Activity

1. Terminology

Coalbed Methane Terminology

Coalbed Methane (CBM)

Coal Seam Methane

Coal Seam Gas

Virgina Coalbed Methane

Pre-Mine Drainage is CBM Until Well Mined Through

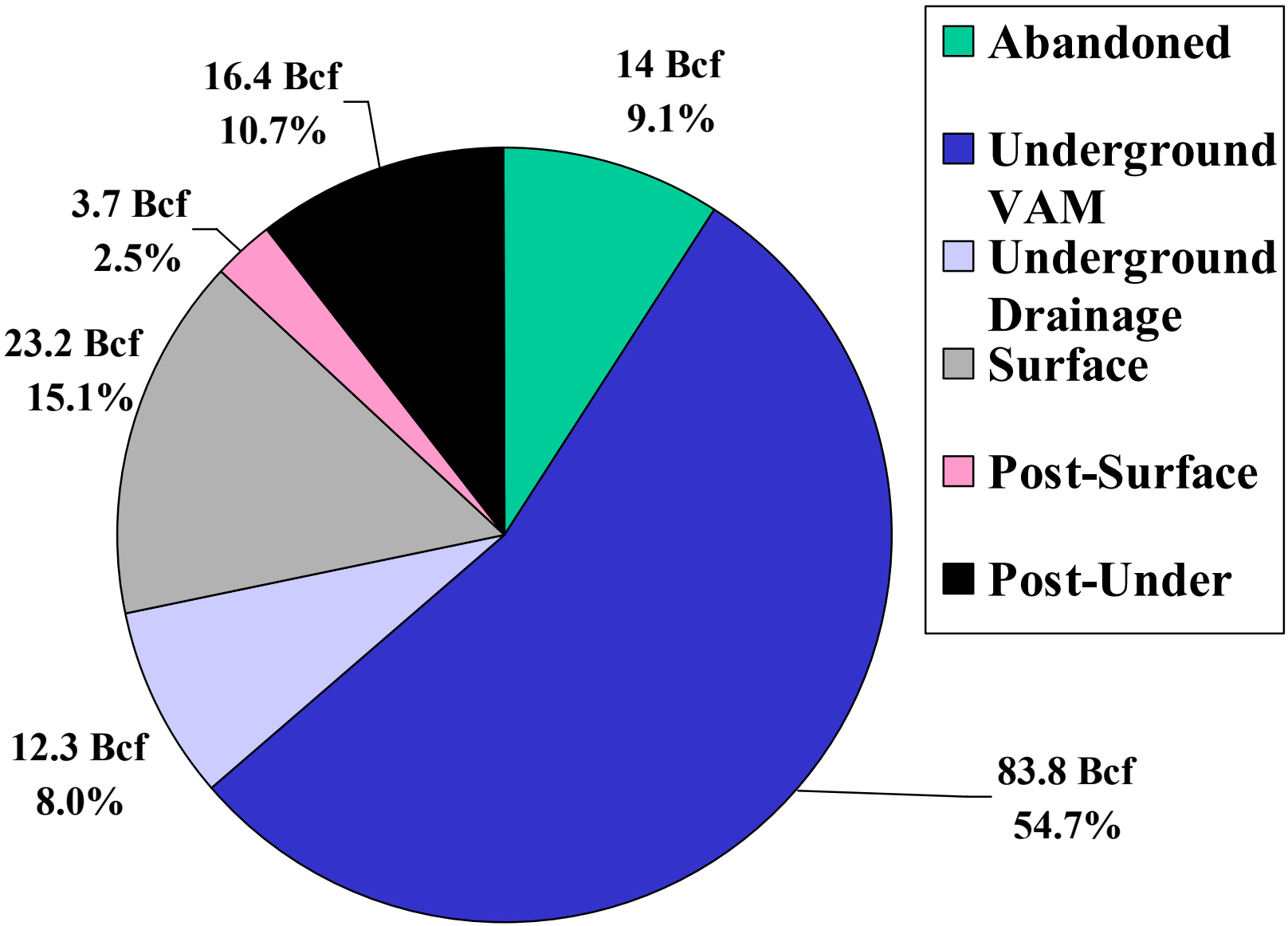
Coal Mine Methane (CMM)

- Ventilation Air Methane
- Abandoned Mine Methane
- Gob/Goaf Gas
- In-Mine
- Pre-Mine Drainage

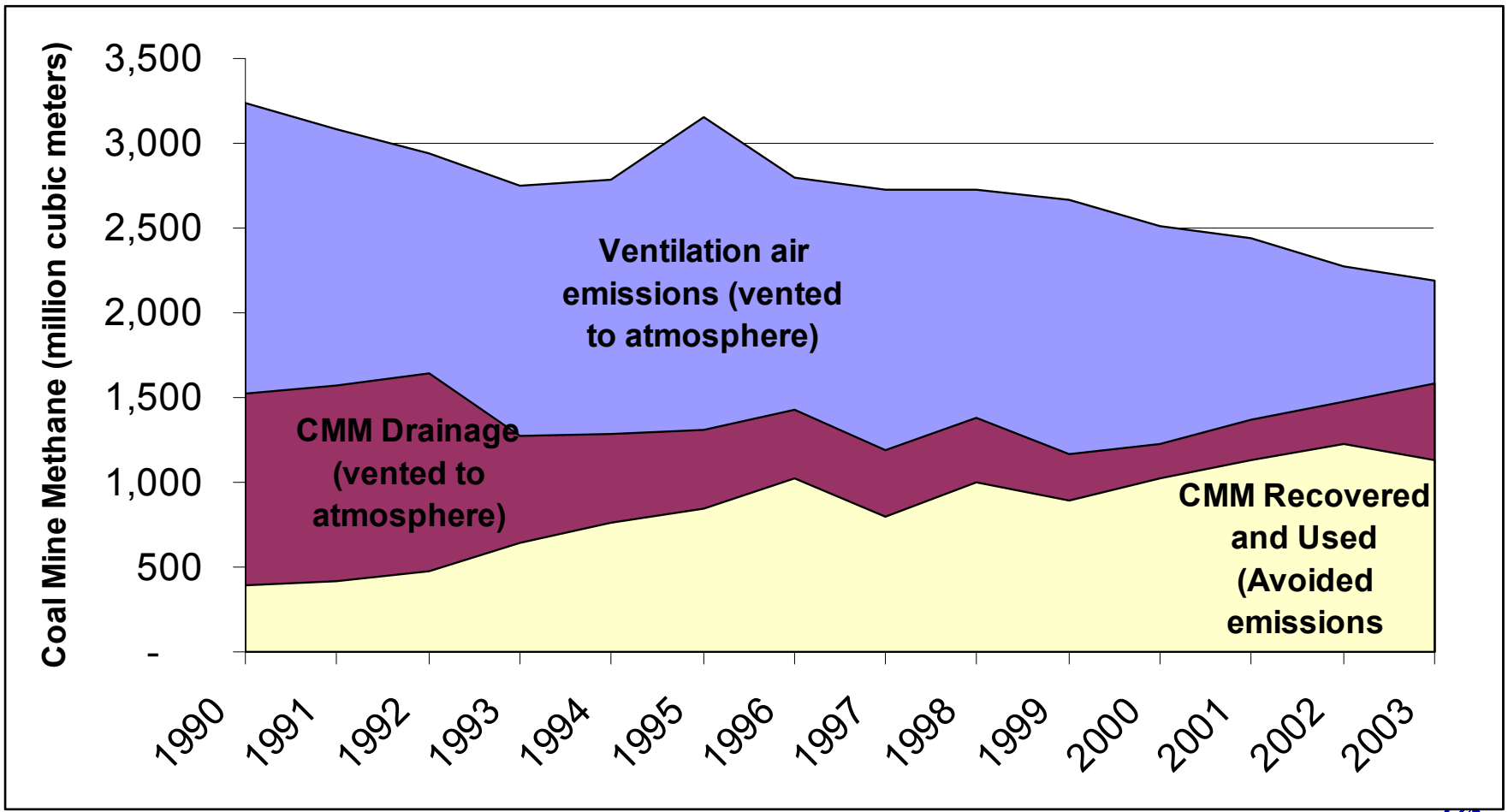
Photos Courtesy Various Sources

2. Overview of the U.S. Coalmine and Coalbed Methane Industry

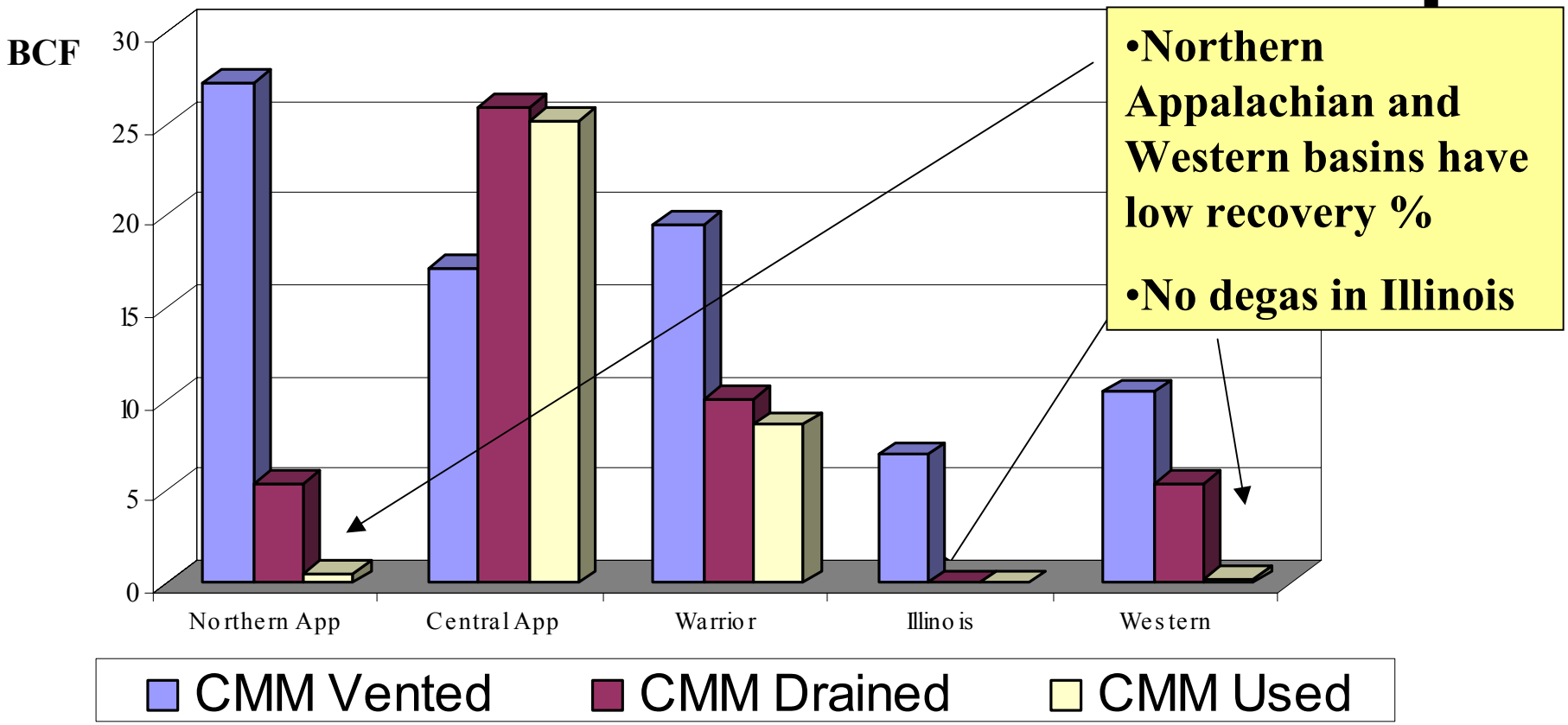
Summary of US CMM Emissions in 2004 (BCF and %)



Trends: CMM Emissions at US Underground Coal Mines



Drained Gas at Active Mines: *Comparison of US Coal Basins*

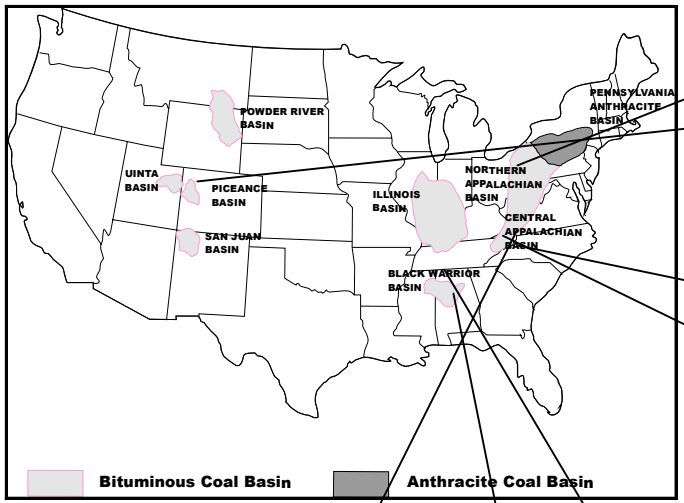


- **Northern Appalachian and Western basins have low recovery %**
- **No degas in Illinois**

Source: 2004 CMOP Inventory

Key US CMM Projects

**a few projects account for a large extent of utilization activity*



Peabody Federal No. 2
1.2 MW power generation

Mountain Coal Company West Elk Mine
On-site use for mine heating

CONSOL VP and Buchanan Mines
Integrated CMM projects: pipeline, 88 MW power plant, coal drying

Pinnacle Mine
Uses CDX Gas Pinnate Surface Directional Drilling resulting in increased production

CONSOL Blacksville No 2 Mine
Gas upgrade and sales to pipeline

JWR Blue Creek Mines
BCCK Cryogenic plant converts 72 Mil M3/yr gob gas into 41 Mil M3/yr of pipeline quality gas

Drummond Shoal Creek and US Steel Oak Grove
Natural Gas Pipeline

Primary CMM Use: Eastern US Pipeline Injection

- Well-capitalized and extensive natural gas infrastructure in Appalachian Basins
- Large portion of CMM is high-quality gas requiring minimal treatment
- Gob (goaf) gas in the Eastern US can be upgraded
  - Economically blended with high-quality gas
  - Processed to meet pipeline standards

Photos courtesy of Resource Enterprises and BCCK

CMM Use at Active Mines: Other Uses

- Power generation
  - ~90 MW capacity total in U.S. (most is peaking capacity)
- Coal drying
  - ~500 mmcf (14 mm cubic meters)
- Heating mine ventilation air
  - At least 2 US mines
- Flaring
  - To date, only at abandoned (not active) mines

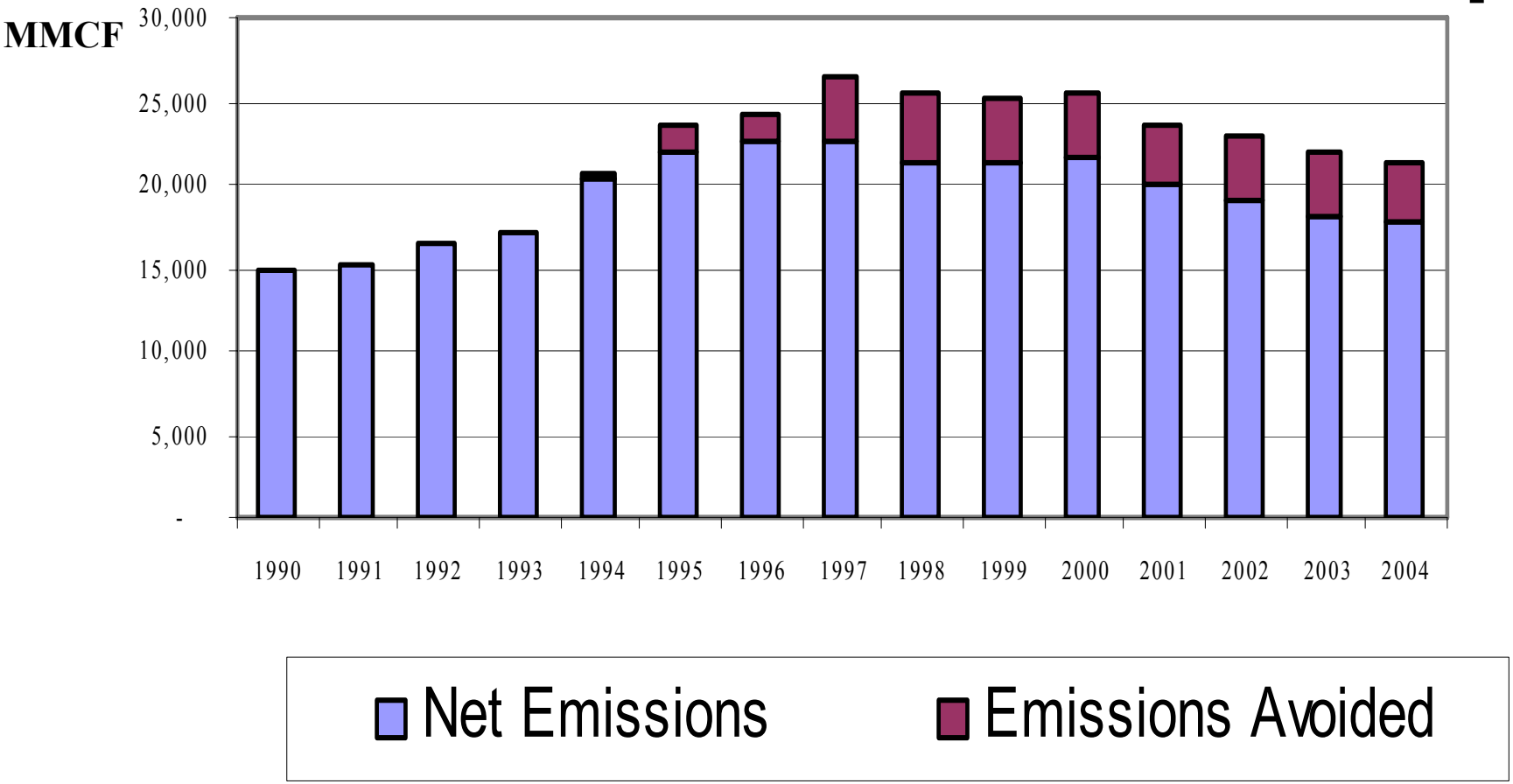
Coal dryer

Shell Central Colliery, Australia

Why has CMM Recovery and Use Been Successful in the US?

- Section 29 Credits (now expired) provided incentives to drill CBM/CMM wells
- Strong institutional knowledge
  - Degasification operations began in the early 1970's to enhance mine safety
- Forward-thinking industry
  - Companies such as Jim Walter Resources and CONSOL now consider themselves to be *energy companies* rather than coal producers
  - Methane as a commodity rather than a nuisance

Increasing Abandoned Mine Methane Recovery



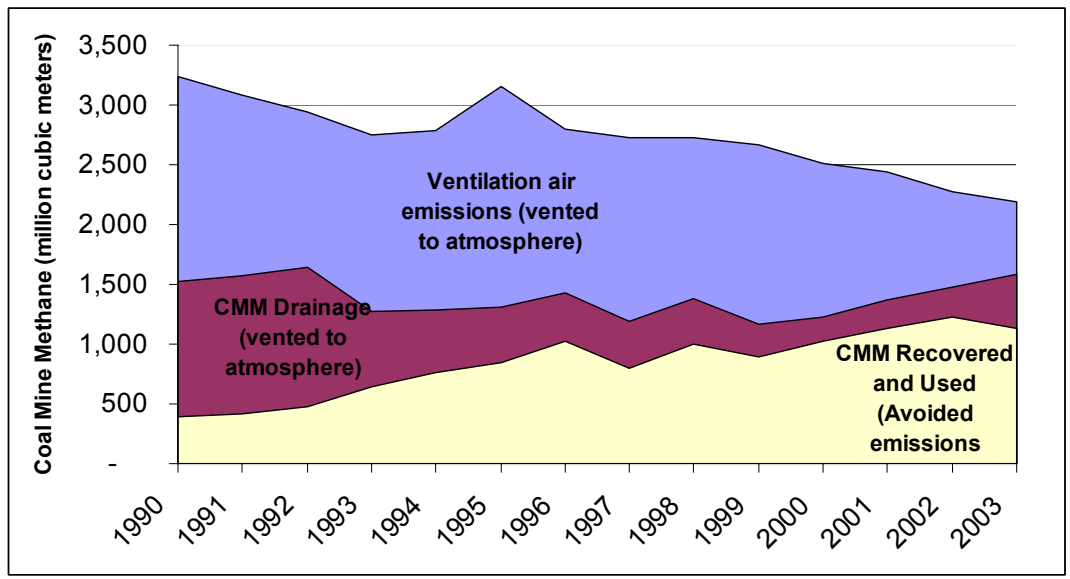
Source: US EPA. *Methane Emissions Estimates & Methodology for Abandoned Coal Mines in the United States* 2004.

Harnessing Ventilation Air Methane (VAM)

- Largest source of coal mine methane
- Low methane concentrations (< 1%)
- Technologies emerging to harness ventilation air methane

-as primary fuel

-as secondary fuel



Harnessing Ventilation Air Methane (VAM)

- As Primary Fuel
  - World's first commercial project being installed in Australia
  - EPA and DOE developing a demonstration project at abandoned mine in PA
  - Other uses (ex: catalytic turbine)

MEGTEC Thermal flow reversal reactor

CANMET Catalytic flow reversal reactor

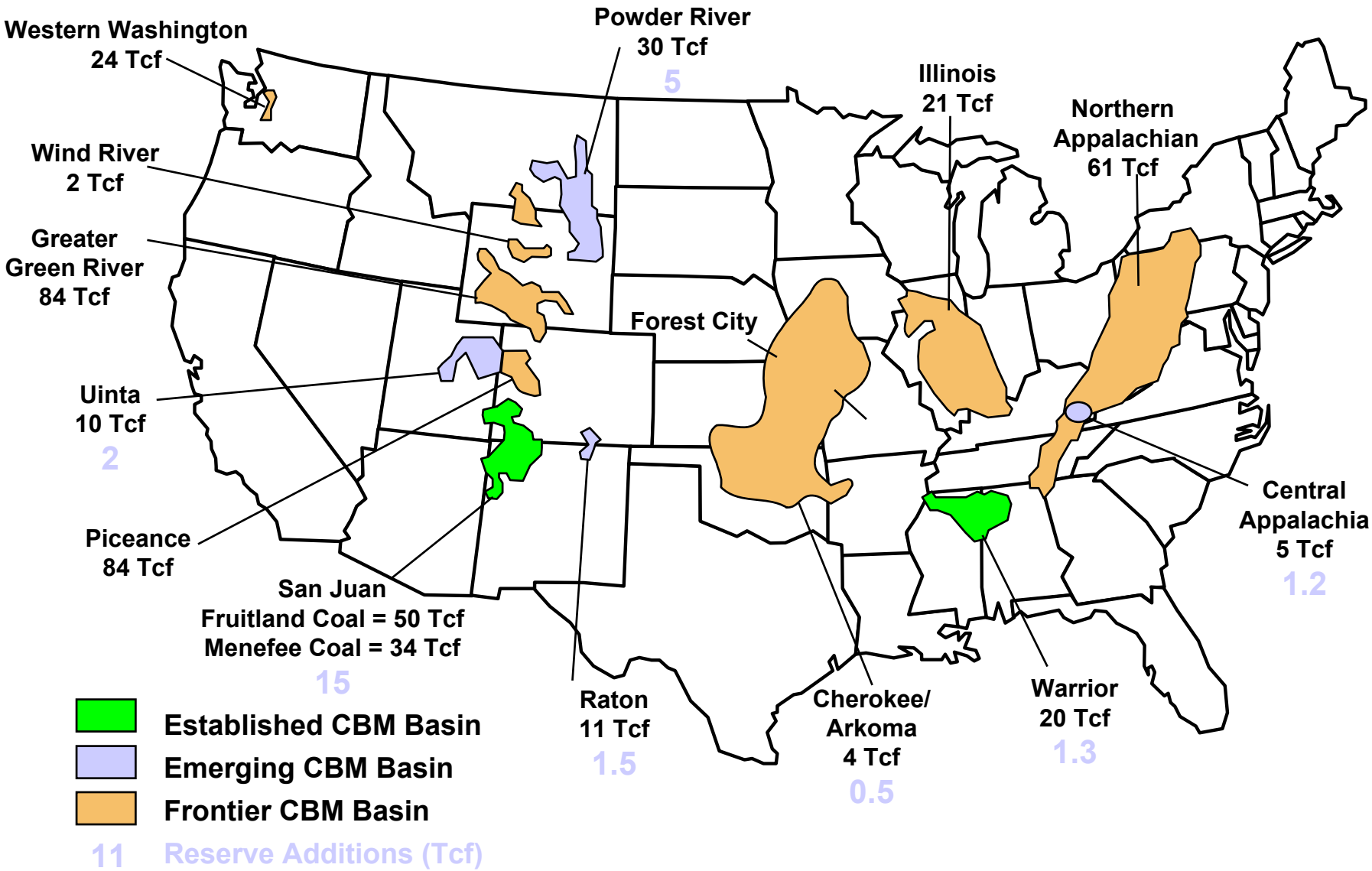
Photos courtesy of MEGTEC & CANMET

Harnessing Ventilation Air Methane (VAM)

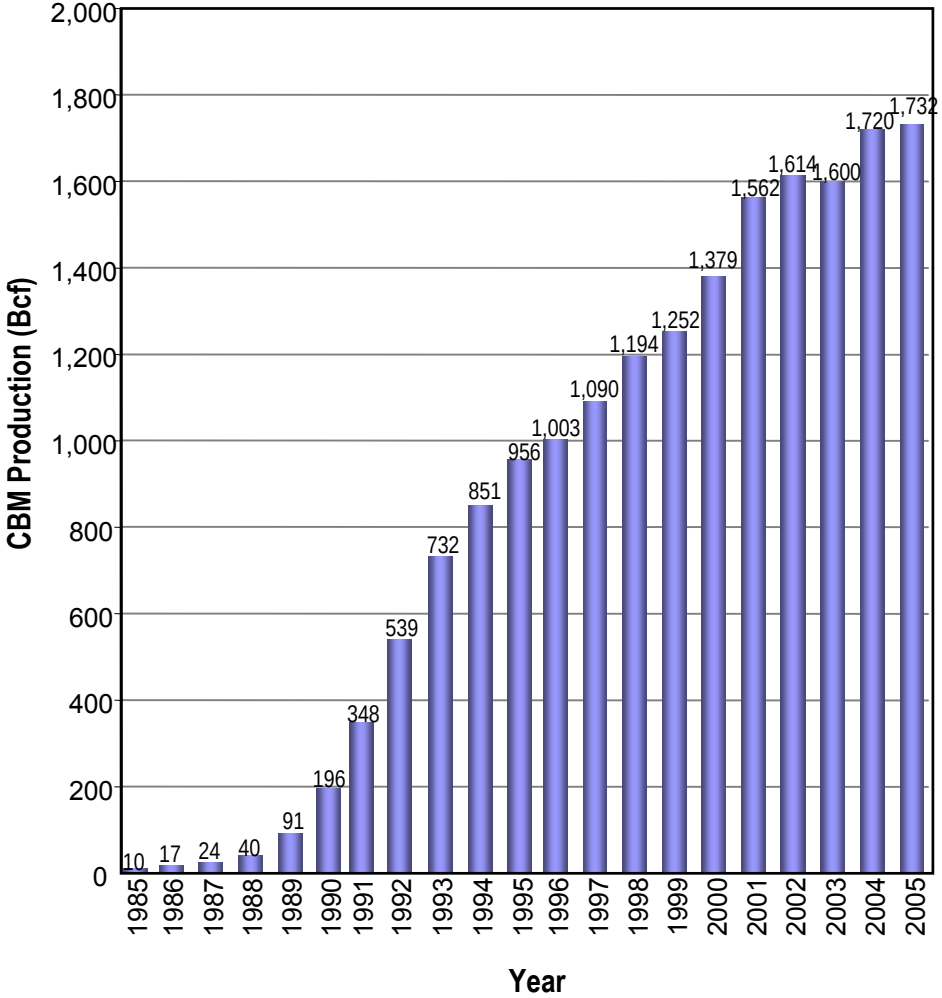
- As Supplemental Fuel at Appin/Tower Collieries (Australia)
  - Installed in 1995
  - 54 x 1 MW IC engines produce power from gob gas
  - VAM used as feed air: supplied 7% of energy

Photo courtesy of BHP Billiton

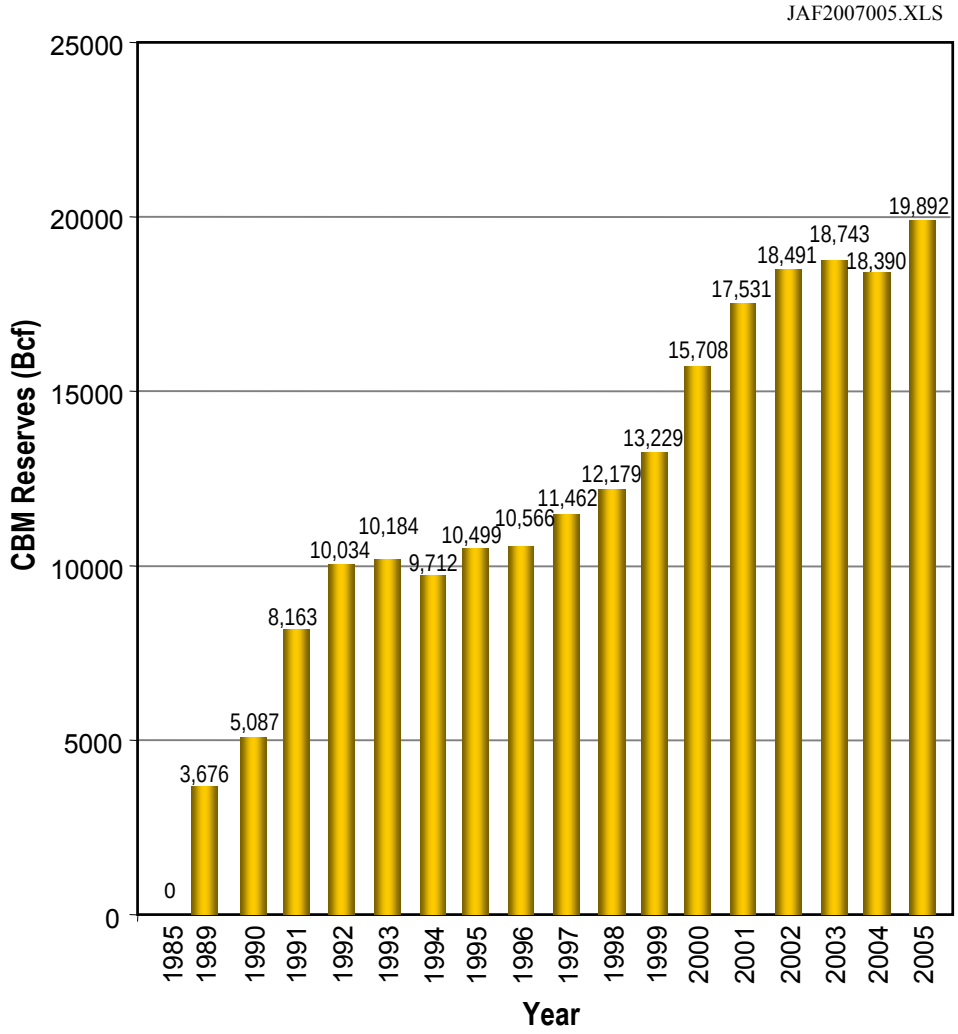
OF 400 TCF OF CBM GAS IN PLACE, OVER 20 TCF OF RESERVES HAVE BEEN BOOKED



CBM Production



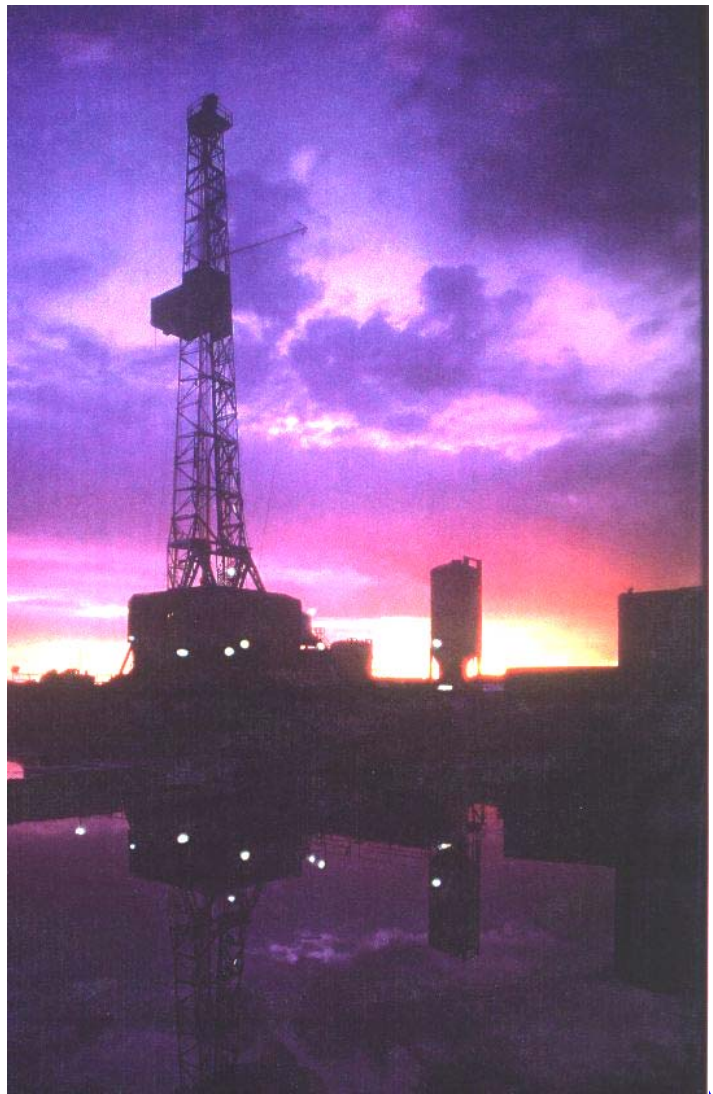
CBM Reserves



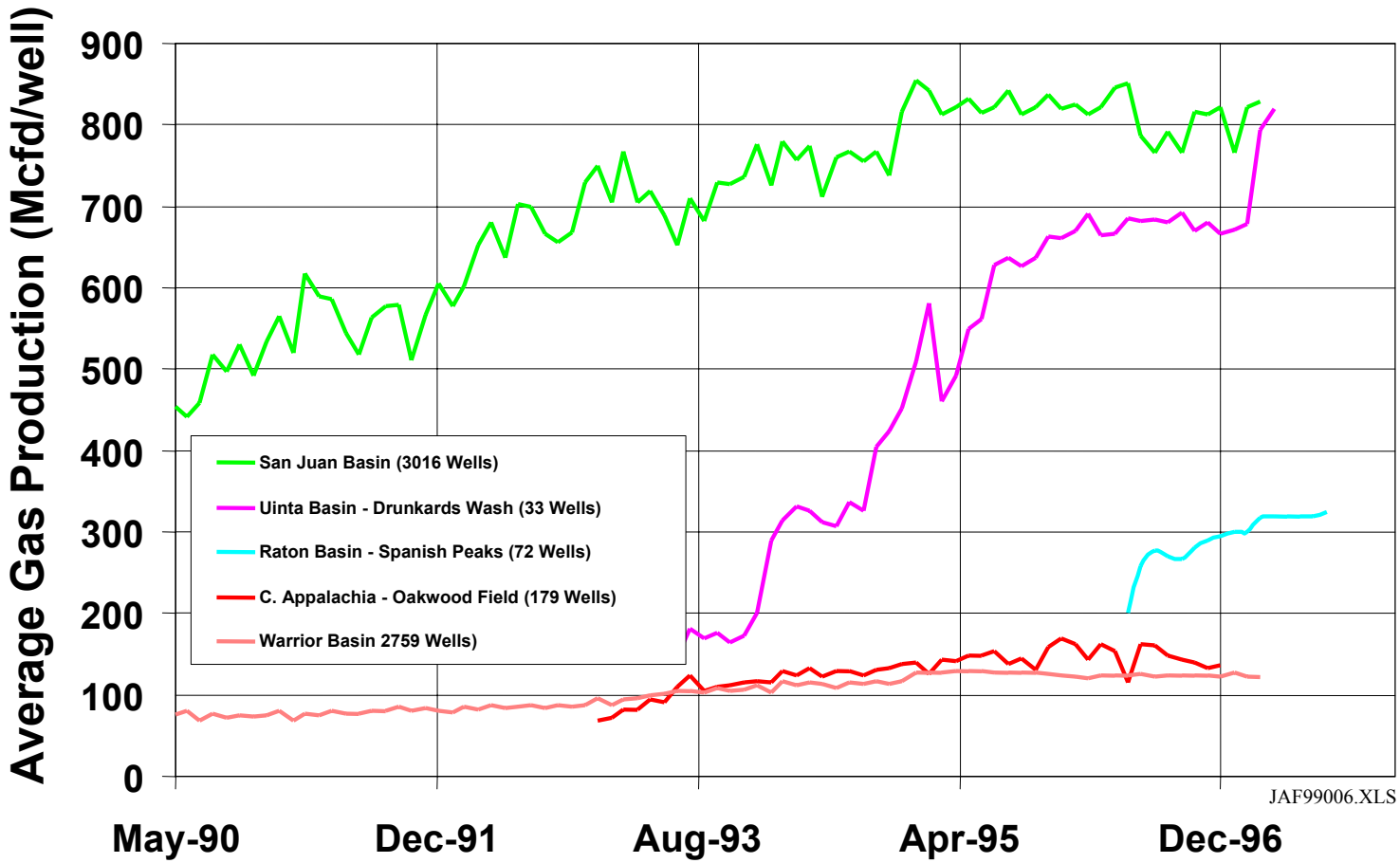
Source: EIA 2005.

The U.S. has drilled nearly 40,000 CBM wells

• Alabama	5,453
• New Mexico	5,498
• Colorado	3,436
• Utah	854
• Wyoming	18,436
• Montana	350
• Virginia	4,200
• West Virginia	300
• Pennsylvania	350
Total	38,877



Well Productivity in U.S. CBM Basins



3. International Activity

China

- **CMM emissions: 1st globally**
  - Nearly 200 MMTCO2e in 2004 (~ 14 billion cubic meters)
- **Ranks 1st in global coal production**
  - ~90% of coal production is from underground mines
  - ~50% of large, state-owned mines are considered gassy
- **Estimated CBM resource base: ~ 31.5 trillion cubic meters**
  - About 200 CBM wells in production in 2005
  - Ambitious plans for CBM production
- **Challenges to CMM/CBM development:**
  - Most mines are not accessible to gas pipeline network
  - Limited drainage technologies/low drainage rates
  - Regulations for foreign project developers may be unclear

China

- **~ 60 CMM projects operating at active mines**
  - Over 200 mines have drainage systems (2004)
  - Power generation:
    - > 100 MW total installed capacity
  - Over 500,000 houses provided with town gas (heat / fuel)
  - Other uses:
    - Boiler fuel
    - Industrial applications
    - Vehicle fuel
  - Total, ~ 240 million cubic meters/yr methane emissions mitigated

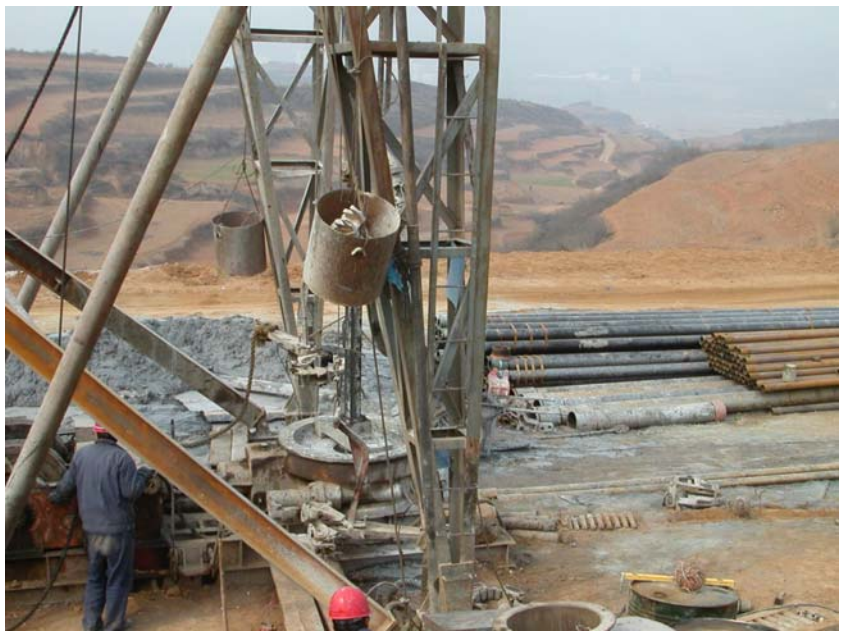
China

- **Many more CMM projects planned and under development**
  - Power generation:
    - Over 220 MW total capacity (additional)
  - Plans for towngas
    - 46,000 more households
  - Other planned projects:
    - Vehicle fuel,
    - Industrial / chemical uses
  - Total additional ~240 million cubic meters/yr CMM to be used

China

Key project under development

- Sihe Mine, Jincheng Mining Group, Shanxi Province
- 120 MW power generation project to use IC engines
  - World's largest CMM power generation plant
- $237 million project funding from ADB, World Bank, local entities, JBIC, US TDA



Ukraine

- **CMM Emissions: 3rd globally**
  - 27 MMTCO2e of CMM emissions in 2001 (about 1.9 billion cubic meters)
- **Ranks 11th in global coal production**
  - Almost all coal production from underground mines, >75% considered gassy (2001)
- **Estimated CBM resource base: 1.7 trillion cubic meters**
  - Several CBM pilot test wells have been drilled
  - CBM associated with a huge tigh gas sand resource
- **Challenges to CMM/CBM development include:**
  - Lack of investment in new degasification infrastructure
  - Aging degasification systems
  - No competitive pricing or market system for coal or gas
  - Limited natural gas transportation infrastructure

Ukraine

- **About 10 CMM projects operating or being developed at active mines**
  - ~14% of liberated CMM is recovered and used: 178 million cubic meters avoided (2005)
  - 42 mines have degasification systems
  - CMM uses: power generation; heating / boiler fuel; industrial applications; vehicle fuel
- **Noteworthy projects**
  - Belozerskaya Mine: US Dept. of Labor / US AID in-mine drilling project
  - US TDA grant for feasibility study for CBM / CMM project

Russia

- **CMM Emissions: 4th globally**
  - ~ 21 MMTCO$_2$e of CMM emissions in 2003 (~ 1.4 billion cubic meters)
- **Ranks 5th in global coal production**
  - 44% of mines are underground (2005); 85% of underground mines are considered gassy
- **Coal industry was restructured and privatized (1996 – 2001)**
  - 77% of coal now comes from independent producers
- **CBM industry not yet commercialized**
  - Large resources; exploration underway
  - Gazprom implemented pilot well drilling program (2003)
- **Challenges to CMM/CBM development**
  - Large competing natural gas resources with low, state-regulated gas sales price
  - Lack of appropriate technology
  - Complex rules on foreign investments (PSA required)

Russia

- **CMM utilization projects at mines in Kuzbass and Pechora Basins**
  - ~ 43 million cubic meters emissions avoided, primarily in Pechora
  - Boiler fuel, power generation, mine heating projects
  - UNDP and GEF project (ongoing): remove barriers to financing and implementing CMM recovery and utilization projects

Australia

- **CMM Emissions: 5th globally**
  - 22.6 MMTCO2e of CMM emissions (estimated, 2005), ~1.6 billion cubic meters
- **Ranks 4th in global coal production**
  - NSW: 59% from underground mines
  - 340 million tonnes produced (2004)
- **Estimated CBM resource base: 8 trillion cubic meters**
  - One of three countries in world with commercial CBM industry
- **Few challenges to CMM/CBM development**
  - No national legislative framework for CMM (state level only)

Australia

- **About 11 CMM projects operating at active mines**
  - At least 7 additional projects in development
  - 445 million cubic meters of emissions avoided per year
  - CMM projects generate 169 MW capacity
  - First commercial VAM oxidation project under construction at West Cliff Colliery

India

- **CMM emissions: 6th globally**
  - 14.3 MMTCO2e (estimated 2005), ~ 1 billion cubic meters
- **Ranks 3rd in global coal production**
- **About 15% of production is from underground mines**
  - ~24 underground mines classified as “Degree III” gassy mines
- **Estimated CBM resource base: 1.5 to 2 trillion cubic meters**
  - Leased CBM blocks; >30 core holes drilled; 2 pilot wells drilled
- **Challenges to CMM/CBM development include:**
  - Technology development due to cost and lack of investment capital
  - Lack of natural gas transportation infrastructure in the coal producing regions
  - Need for competitive bid rounds similar to CBM bid rounds

India

- **Currently no CMM projects operating, but some drainage in place**
- **Noteworthy projects / activities**
  - Global Environment Fund project: to demonstrate commercial feasibility of utilizing methane gas recovered before, during, and after coal extraction. CMM to be used for power generation and CNG for mine vehicles.

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