CO_2 Sequestration in Thin and Shallow Coal Beds: Eastern Kansas

Saibal Bhattacharya and K. David Newell

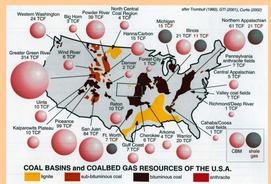
Kansas Geological Survey (University of Kansas), Lawrence, Kansas

ABSTRACT

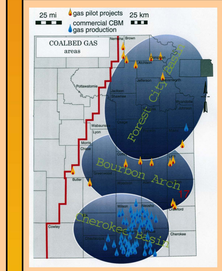
Coals that are not attractive mining targets can be utilized for coalbed gas (CBM) production and CO_2 sequestration. Eastern Kansas is underlain by several shallow (<1500 ft depth) and thin (1 to 4 ft) Pennsylvanian coals, which range in rank from high-volatile C to A bituminous. These coal beds can serve as sinks for large point-source emitters of CO_2 because the number of beds at a given locality can have an aggregate thickness of several feet. These coals have the potential to produce CBM, and theoretically they can sequester approximately twice that volume in CO_2. Gas content of the coals can be as great as 375 scf/ton (as-received), and the composite thickness of several coalbeds can improve economics for enhanced coal bed methane (ECBM) projects.

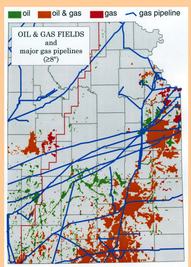
A study area underlying a metropolitan landfill in eastern Kansas investigated the CBM and ECBM potential for several underlying coal beds. Two cores tested coals for gas content and desorption characteristics. Structural and isopachous maps of the coal seams were integrated into a 3D geomodel covering 640 acres beneath the landfill. Critical factors affecting numerical simulations of CBM and simultaneous ECBM production include bed thickness and gas content, cleat spacing, porosity and permeability, and adsorption isotherms. Varying these parameters within geologically reasonable ranges in every possible combination created high, medium, and low scenarios for storage and flow parameters in the geomodel. Results from the model runs were integrated with a Monte-Carlo simulator to quantify the inherent parametric uncertainty in terms of probability.

Results indicate that CO_2 sequestration and ECBM recovery are difficult to maximize simultaneously. Ultimate recovery in CBM production may be cut short due to CO_2 breakthrough at production wells surrounding the injector. At 80% confidence, several years of CO_2 produced from point-sources such as an ethanol plant, cement kiln, or landfill can be locked in the coal beds if the goal is solely to optimize CO_2 sequestration. Considering the current rates of CO_2 production from the above mentioned point sources, many 160-acre injector sites will be necessary to sequester 20 years of CO_2 production from any one of these sources in these thin and shallow coal beds. This is feasible due to small footprint of each injector, but several square miles of open acreage and a pipeline infrastructure around the point source is necessary.

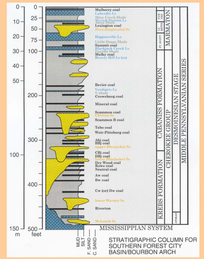


The size of the "bubbles" in this schematic map indicates the projected reserves of unconventional gas (i.e., CBM and shale gas) in the major coal-bearing basins in the U.S.A. The major CBM reserves are in the western states. Smaller but nevertheless economic reserves are farther east in some of the more venerable oil producing regions such as eastern Kansas and western Missouri.

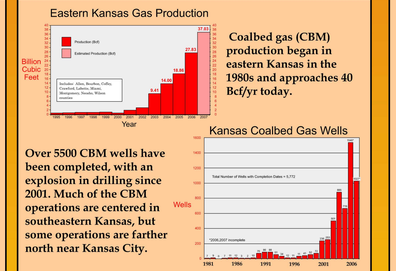




Eastern Kansas constitutes part of the Western Interior Coal Basin. This region is structurally subdivided into the Cherokee Basin in northeastern Oklahoma and southeastern Kansas, and the Forest City basin in northeastern Kansas. The low-lying Bourbon Arch separates these two basins. Most CBM development is in a five-county region in southeastern Kansas. Many natural gas pipelines cross eastern Kansas. These pipelines were originally built to take gas from the giant Hugoton Field to urban areas to the east. As the Hugoton Field depletes, these pipelines have excess capacity that is being partly filled by CBM operations.

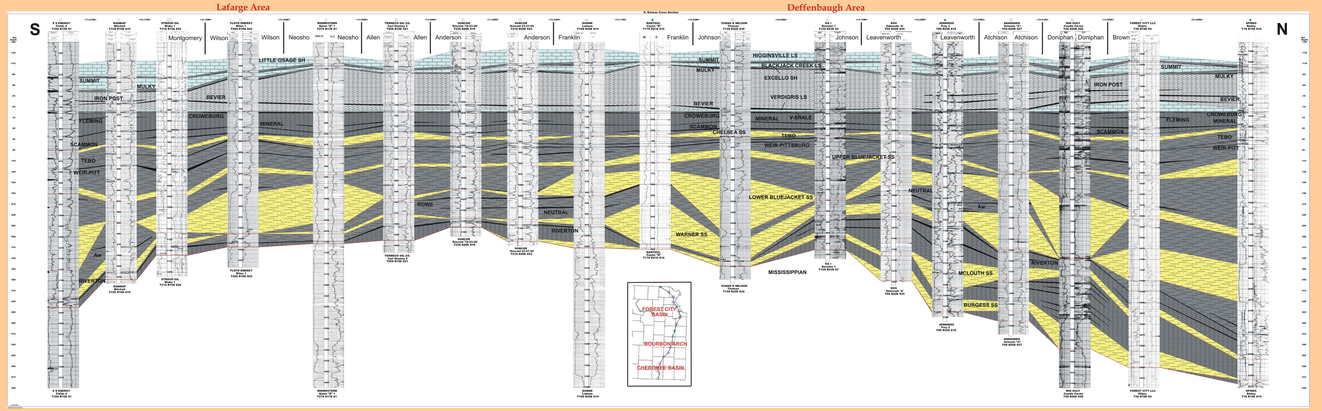


Approximately 25 named coal beds are present in the Middle Pennsylvanian (Desmoinesian) Cherokee and Marmaton Groups in eastern Kansas. High-volatile A bituminous-rank coals dominate southeastern Kansas, but maturation decreases northward to high-volatile C bituminous-rank in northeastern Kansas (Newell and Carr, 2007).



Coalbed gas (CBM) production began in eastern Kansas in the 1980s and approaches 40 Bcf/yr today.

Over 5500 CBM wells have been completed, with an explosion in drilling since 2001. Much of the CBM operations are centered in southeastern Kansas, but some operations are farther north near Kansas City.

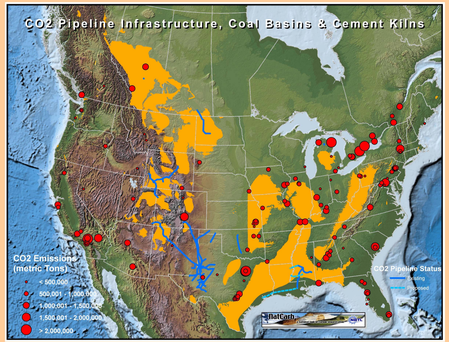


Newell and others, 2004

Coals in eastern Kansas are generally less than 2 ft (0.6 m) thick and are as deep as 3000 ft (900 m) along the axes of the Forest City and Cherokee basins. These coals dip approximately 10 ft per mile (2 m/km) to the northwest toward the basin axis, and they crop out farther east in extreme southeastern Kansas and western Missouri. Channel sandstones can disrupt the continuity of coals beds throughout the Pennsylvanian section. The high in the central part of the cross-section is known as the Bourbon Arch, which separates the Forest City Basin (to the north) from the Cherokee Basin (to the south).

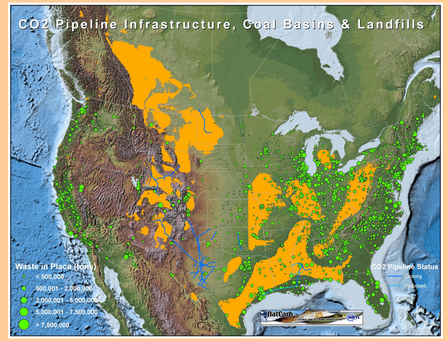
Cement plants and landfills represent point-sources for CO_2 and other gases that can either be injected into coal seams raw or after minimal upgrading.

By volume, kiln gas, with O_2 and H_2O removed, is approximately 81% N, and 19% CO_2. LFG, with O_2, H_2O, and NMVOCs removed, is approximately 50% CO_2 and 50% CH_4. CO_2 emitted during cement production accounts for a significant portion of global industrial and energy CO_2 emissions (IEA, 1999). While large quantities of CO_2 are produced from the fuel combusted, an even greater amount of CO_2 is produced during calcination and the production of "clinker", which is ground up to produce powdered cement.



Acknowledgement - Tim R. Carr (West Virginia University)

Landfill gas (LFG) forms from waste degradation. LFG is approximately 50% CH_4 and 42-45% CO_2, with small amounts of N_2, O_2, and trace amounts of non-methane volatile organic compounds (NMVOCs) (Tchobanoglous, and others, 1993). CH_4 may be recovered from both abandoned and existing landfills, since organic material in landfills generates LFG for 10-30 years, or more.



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