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Economic Issues of Coal Bed Methane Development and Water Management

By

Dr. Roger Coupal
Department of Agricultural and Applied Economics
University of Wyoming

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The problem of water mgt

- Evidence of a problem - political and legal challenges
  - Water quality issues
  - Water quantity issues
- Is it a problem of too much water at lower quality or too much water at higher quality
- Loss of a valuable resource
- Split estate issues

Economic Issues

- Who's responsibility is it?
  - State (beneficial use approach)
  - CBM companies (externality approach)
- Regulatory/technical approach:
  - Regulated treatment versus tax approach
- Water that is defined beneficial should be used beneficially

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U.S. Department of Energy (DOE). 2002. Powder River Basin Coalbed Methane Development and Produced Water Management Study. U.S. Department of Energy. Office of Fossil Energy and National Energy Technology Laboratory Strategic Center for Natural Gas..

U.S. Environmental Protection Agency (EPA). 2003c. Guidance for Developing Technology-Base Limits for Coalbed Methane Operations: Economic Analysis of the Powder River Basin. February 2003.

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Economics of the Water Treatment Approach

- Increases cost to producers
- Can potentially reduce production depending upon the mandated approach
- Still have water quantity issues (and perhaps quality)

Economic Issues, continued

- State defines how water is managed and treated
- State imposes its responsibility to manage drainage, and therefore water that is disposed of in those drainages
  - Technical approach (water quality requirements
  - Economic approach (discharge fees)

Treatment approaches

Option	Current use estimates	Benefits	Adverse environmental issues	Costs *(in PRB)*/ Comments
Surface discharge direct to surface drainages or land application	• Most produced water in PRB is discharged to surface drainages or soils	• Increased stream flow • Increased riparian habitat • Supplemental irrigation water • Water for livestock or wildlife	• Stream bank erosion • Increased flow at water crossings • Riparian erosion or change in vegetation • Salt deposition • Adverse effects on established irrigation; e.g. creation of hardpan soil • Can dilute naturally turbid waters impacting native aquatic species	Capital costs: • $1,400/well capital cost (Goerold(2002) • $1,500/well (ARI, 2006) O&M Costs: • $0.02/bbl Goerold (2006) and DOE(2002) • $0.04/bbl ARI (2006) •

Treatment approaches

Option	Current use estimates	Benefits	Adverse environmental issues	Costs *(in PRB)*/ Comments
Impoundments Off channel (can be lined or un-lined)	• 121 bonded & permitted by WOGCC as of 8/04	• Stock water • Recharge • Wildlife habitat • Wetlands • Recreation • Fisheries	• Mobilization of salts and other elements by infiltration from unlined pits • Possible surface aquifer degradation from unlined pits • Evaporation increases water salinity (lined pits) • Water source is temporary • Increased mosquito habitat brings West Nile virus concerns	• Average for PRB: • $10,300-$19,237 per impoundment (unlined) capital cost • $0.06/bbl operation & maintenance costs
On channel	• Approx 1,629 permitted as of 12/04 by SEO (Feltner, 2004) • 2,682 permitted by SEO as of 5/05 (LaBonde, 2005)	Same as above for unlined pits	Same as above for unlined pits, plus captures flow from natural runoff	Cost estimate not available at this time, but likely similar to unlined off channel costs

Treatment approaches

Option	Current use estimates	Benefits	Adverse environmental issues	Costs *(in PRB)*/ Comments
Injection Class V DEQ permits (injection to coal or non-coal aquifer for re-use)	• 308 wells statewide (most in PRB) permitted by DEQ with 60 actively reporting (Frederick 6/05) • Gillette drinking water aquifer	• Aquifer recharge • Aquifer storage for recovery and re-use • Avoids environmental impacts of surface discharge	• Water not immediately available for additional beneficial surface uses (e.g., stock and wildlife watering)	• $6,350-$15,150/injectionwell capital costs, depending on depth • $0.045-$0.098/bbl operation & maintenance costs
Class II WOGCC permits (deep well injection, including disposal and/or water flood enhanced oil recovery (EOR))	• Approx 5,000 permits statewide, including conventional oil and gas and CBM (Marvel, 6/05) • 4 injection wells permitted for EOR	• Avoids environmental impacts of surface discharge • Provides a water source for EOR	• Potential for migration and contamination of other aquifers if well is improperly completed • Requires additional surface disturbance for new injection well sites and storage ponds	• $35,200-$62,500/injectionwell capital costs presumably for rework of existing oil & gas well to injection well • Up to > $1 million for new installation of deep disposal well (George, 2005) • $0.095-$0.14/barrel

Treatment approaches

Option	Current use estimates	Benefits	Adverse environmental issues	Costs *(in PRB)*/ Comments
Treatment Reverse osmosis	• Pilot project on Tongue River • Full operation on Prairie Dog Creek • Permit pending on Crazy Woman Creek (Thomas, 2004)	• Treatment results in high quality water for re-use	• Finding waste brine disposal locations • High cost for brine disposal • Energy-intensive process	• \$450,000-\$1.025 million capital costs for RO w/commercial brine disposal • \$744,278-\$1.269 million for RO w/brine injection • \$0.19-\$0.73 net present value cost/bbl for RO w/commercial brine disposal • \$0.26-\$0.34 net present value cost/bbl for RO w/brine injection (Kuipers, 2004; CDM, 2004)
Ion Exchange (IX) • w/Higgins Loop • Counter-current (CC) Hydro process Zeolites (Z)	• IX w/Higgins loop permitted by WYPDES for 20 cfs operation on the Powder R. (Wagner, 2004) • CC IX used in several locations in PRB • Hydro IX and Z not in use yet	• IX systems remove cations and bicarbonate • Approximately >90% water recovery	• Requires a Class I injection permit • Warm temp, non-turbid effluent water may affect Powder R. fish • IX will not remove unwanted anions • Waste brine can be acidic requiring neutralization prior to disposal • Costs for brine disposal	• IX w/Higgins loop = \$0.60/bbl net present value cost • CC = \$0.35/bbl net present value cost • Hydro = \$0.63/bbl net present value cost (CDM, 2004)

Treatment approaches

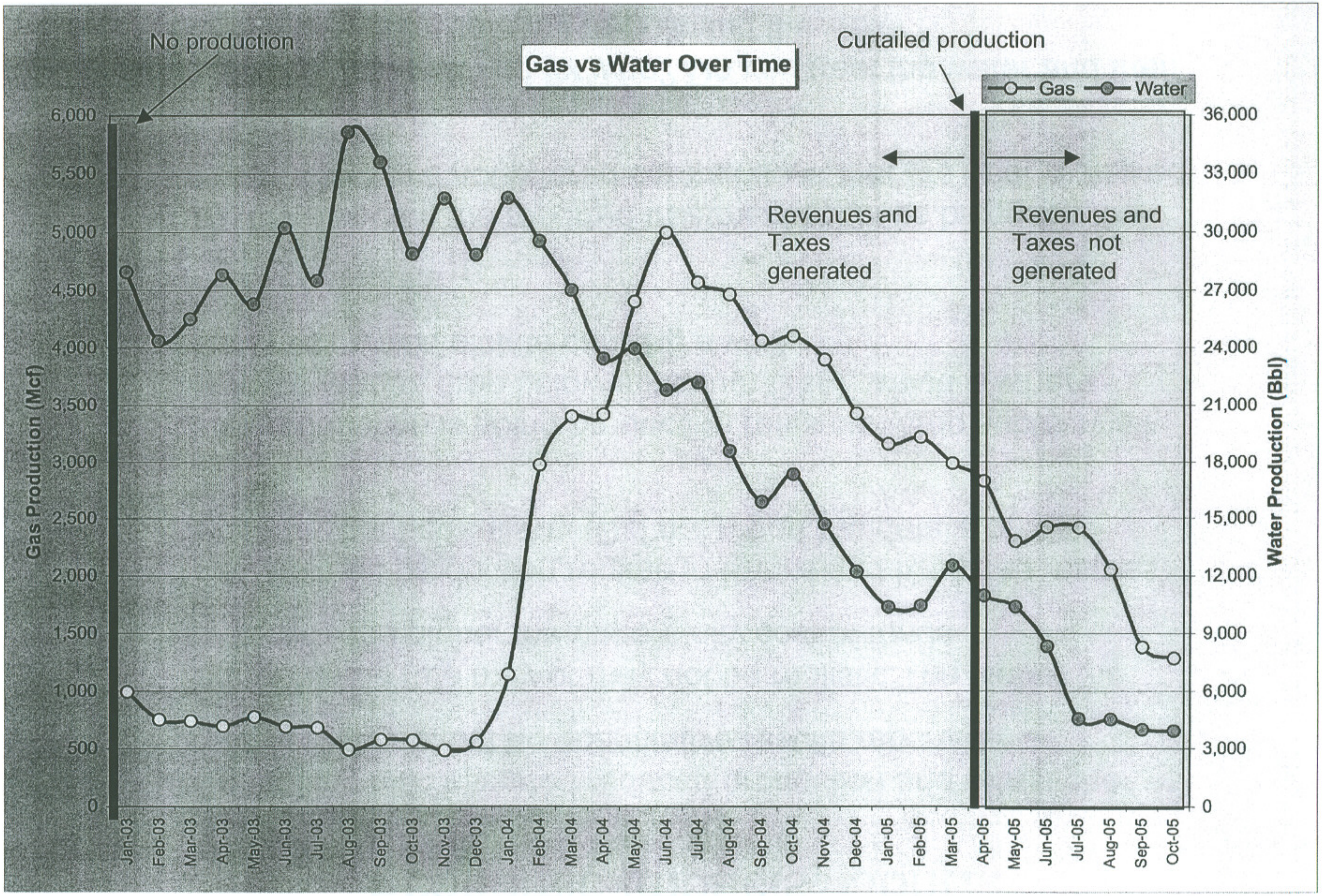
Option	Current use estimates	Benefits	Adverse environmental issues	Costs *(in PRB)*/ Comments
Deionization or capacitive desalination	• Plans for desalination unit for WY, no permit as yet (Thomas, 2004)	• Does not require acid/base regeneration of exchanger	• Energy intensive process	• Costly process • Not suitable for CBM water greater than 2,500 ppm TDS
Atomization (water droplets are dispersed under pressure through a nozzle atop a tower)	• Used some in the PRB	• Reduced water volume	• Ice can form below atomizer • Concentrates contaminants on soil • Water is wasted • Wind drift of plume results in salt deposition to areas not intended for disposal	• Less costly than other treatment options

Economic impacts

Bank and Kruskraa

- Choice of treatment approach will affect production levels
  - Cost/price relationship - assumes either a well is marginal enough where they do not produce or they cut off production earlier than they would have otherwise.
  - 15 percent hurdle rate

Water disposal and mgt option	Reduction in production $4 / MCF	 $7 / MCF
Impoundments	8.17%	NA
Shallow Re-injection	12.6%	NA
Partial RO with trucking of residual - 500mg/l 1,000 mg/l	27.0% 12.4%	6.9% 4.5%
Ion Exchange - 500 mg/l 1,000 mg/l	17.57% 6.67%	5.0% 3.3%



Gas vs Water Over Time
No production
Curtailed production
Gas
Water
Revenues and Taxes generated
Revenues and Taxes not generated
Gas Production (Mcf)
Water Production (Bbl)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
0
3,000
6,000
9,000
12,000
15,000
18,000
21,000
24,000
27,000
30,000
33,000
36,000
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Feb-03
Mar-03
Apr-03
May-03
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Oct-03
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Economic Impacts, Cont.

All Consulting also asserted reduced production and with higher cost approaches, but no quantitative results reported

- Higher hurdle rate may or may not be realistic:The higher the hurdle rate the higher the opportunity cost of funds
- The assumed production regime in Banks and Kruskraa across fields may not be realistic. (Did not report the details of the model.)
- Once production is going production rates can drop substantially before revenues drop below minimum O&M, which is where economics would dictate capping a well.

General comments

- Industry disputes the reported treatment costs as being too low though they have not offered comparisons that are peer reviewed as a response.
- Treatment for what and for who? Do you treat the water and then dispose of it later, thereby re-polluting the water?

Other approaches

Building incentives to use the water:

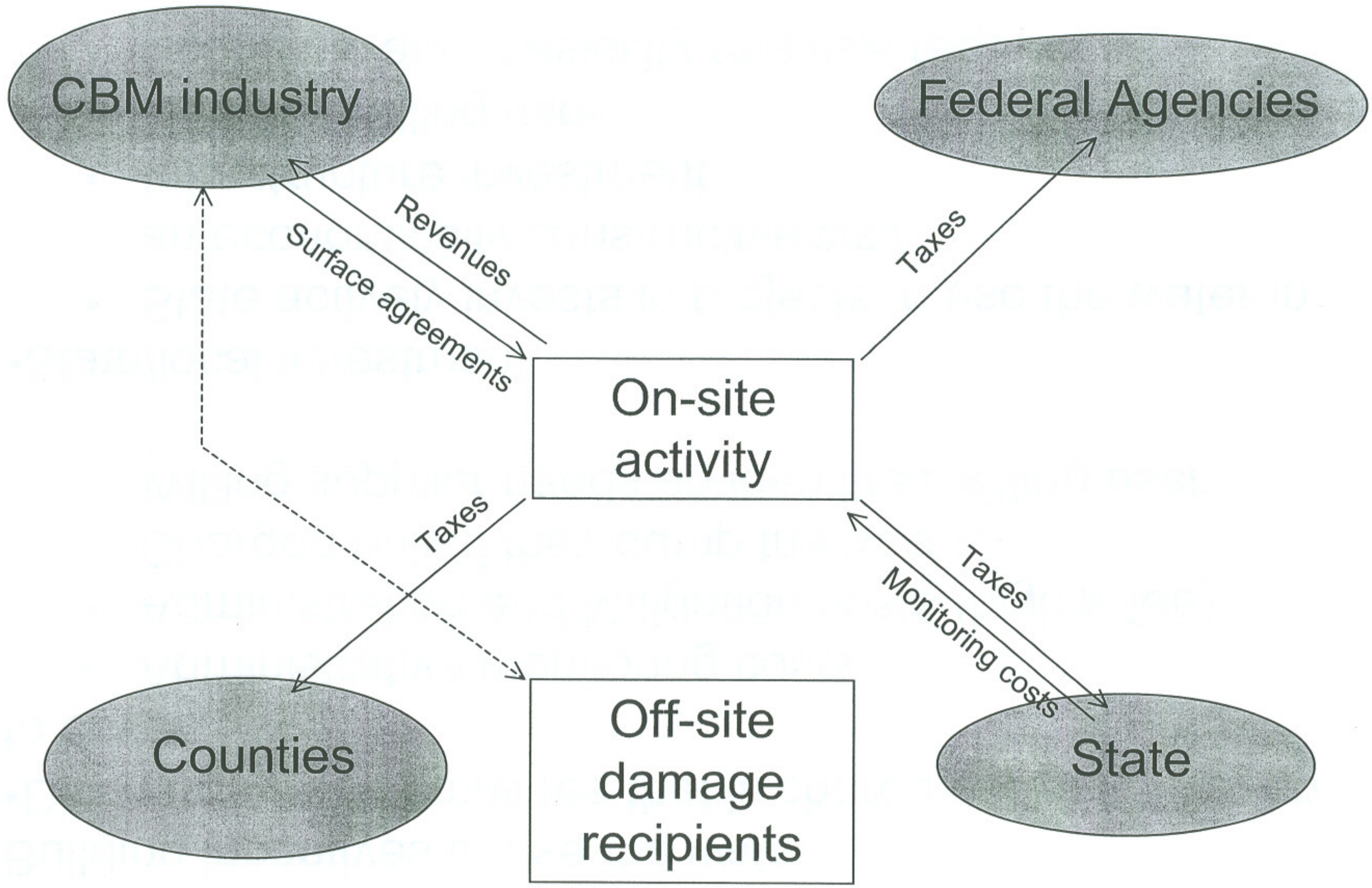
•Discharge Fee - small fee that is charge per unit. Can go to cover:

- Administrative monitoring costs
- Administration and Mitigation costs (higher fee)
- Charged only if they dump the water.
- Willing supplier needs an identified willing user

•State/local investment

- State actively invests in projects to use the water in an economically constructive way.
- Infrastructure investment.
- Needs a willing user
- Economic and feasibility analysis required

Value of Monetary arrangements within CBM development



Benefits and costs:

Who Benefits and who incurs costs:

Stakeholder	Gross Benefits* (+) / Costs (-)	Quantifiable estimates based on public information
Firm Level Gross revenues $MM	+	1,528.07
State (Tax revenues) $MM	+	74.26
County (property tax revenues) $MM	+	73.31
On-site landowners	+	(D)
Off-site landowners	-	< 0

*Gross benefits are used because costs are not readily available

(D) non-disclosed

Concluding Thoughts

- Need more information on accurate costs of alternatives
- Economic impacts are unclear based upon the methodology of the reports.
- The State needs to identify who might use the water
- Is it purely an industry responsibility, or a negotiated mix between industry, the State, and the County