November 30, 2011

Environmental Protection Agency
Washington, DC

Regarding: Docket ID Number EPA–HQ–OAR–2010–0505 – Comments submitted on behalf of Earthworks, Powder River Basin Resource Council and San Juan Citizens Alliance

We appreciate the opportunity to provide these two sets of written comments to you. One set of comments, prepared on behalf of Earthworks, addresses the gap in the proposed rules for existing sources of emissions. The second addresses the issue of whether emissions from CBM wells should be exempt from portions of the rules. Powder River Basin Resource Council and San Juan Citizens Alliance have joined with Earthworks in submitting this set of comments.

Collectively, we have thousands of members throughout the Rocky Mountain states, in Texas and in the Marcellus shale region. Many of our members are impacted by the currently unregulated emissions from oil and gas operations throughout those states. So this proposed regulation providing a new source performance standard for Volatile Organic Compounds; a new source performance standard for sulfur dioxide; an air toxics standard for oil and natural gas production; and an air toxics standard for natural gas transmission and storage is of great importance to our members.

Overall, we strongly support the draft rule as a significant first step in addressing emissions from upstream oil and gas operations. Generally, we believe that the rule will lead to greater transparency from this powerful industry in the form of accounting for the numerous sources of emissions that are currently ‘invisible’ due to the lack of regulation. We also believe that the rule will provide health benefits to those who live close to the thousands of gas facilities covered by this rule. And we believe that the rule will provide an economic benefit to this industry, through the capture of additional ‘product’ that can be sold in the marketplace. We are confident that an industry which has figured out horizontal drilling techniques, and the thousands of versions of hydraulic fracturing chemical 'cocktails' which have unlocked access to shale gas, will also be able to find a way to comply with this rule while remaining highly profitable.

Consistent with the recommendations of the Department of Energy's Shale Gas Subcommittee recommendations, we also believe that the final rule should be expanded to include the thousands of existing wells and facilities, which already constitute a significant source of emissions, and resulting impacts to people living, working or going to school nearby.

Respectfully submitted,

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11-30-2011

Comments prepared on behalf of Earthworks' Oil & Gas Accountability Project, by Cherelle Blazer, MSc

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

	)	
Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews	)	**Docket No. EPA-HQ-OAR-2010-0505**
	)	
	)	*Via regulations.gov and e-mail*
	)	*November 30, 2011*

I. Introduction

Earthworks' Oil and Gas Accountability Project (OGAP) appreciates the opportunity to provide written comments on the Proposed NSPS and NESHAPS rules by EPA for hydraulically fractured gas wells. Earthworks is a national non-profit organization that works to protect communities and the environment from the impacts of irresponsible mineral and energy development while seeking sustainable solutions.

Since 1999 OGAP has been working with people in rural, tribal and urban communities to protect their homes and environment from the devastating impacts of oil and gas development -- bringing together such diverse partners as Native Americans, ranchers, sportsmen and environmentalists.
OGAP's accomplishments include: the permanent protection of New Mexico's Valle Vidal, the passage of precedent setting reforms for landowner rights and environment from oil and gas wastes in New Mexico, the first-ever governmental requirements for disclosure of gas drilling chemicals in Colorado, and the local government adoption -- in eight states -- of OGAP-initiated best practices.

While we applaud EPA for taking this important first step to regulating emissions from new gas wells, Earthwork's OGAP urges EPA to ease the suffering of communities already near oil and gas facilities by strengthening EPA's proposed New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants to include all new <u>and existing</u> wells and storage tanks, compressor and processing facilities and all related equipment. We support EPA providing more protection for the health of our environment and communities. In the comments below we lay out the case for more rigorous and protective rules that will prevent the emission of additional pollution and create even more profit for industry and land owners.

II. Why Existing Sources Must Be More Rigorously Regulated

Upstream crude oil and natural gas activities are a significant source of air pollution. Activities in the natural gas exploration and production ("E&P"), storage, processing, transmission and distribution sectors and in the oil E&P sectors (cumulatively "oil and gas activities") emit substantial amounts of volatile organic compounds ("VOCs"), oxides of nitrogen ("NOx"), methane ("CH_4") and hazardous air pollutants ("HAPs"). These airborne contaminants contribute to pollution associated with serious human health effects and adverse environmental consequences including ground-level ozone or "smog", particulate pollution, toxic air pollution, climate-disrupting pollution, and the haze that obscures scenic vistas in national parks and wilderness areas.

Sources of VOCs and NOx also produce significant amounts of methane which contributes to ground-level ozone pollution as well as climate change.[1] EPA has identified the oil and gas industry as the "single largest contributor to United States anthropogenic methane emissions."[2] The industry is responsible for over 40% of total U.S. methane emissions.[3] Emissions from oil and gas activities account for at least 125.5 million metric tons of CO_2 equivalent ("MmtCO_2e") in 2008 according to the most recent U.S. greenhouse gas inventory.[4] The methane emissions are comparable to the greenhouse gas emissions emitted from roughly 33 coal-fired power plants.[5] The actual emissions however, are likely much larger as emissions underreporting is well documented by EPA.

EPA estimates that as much as 300 billion cubic feet of natural gas (methane) is lost to the atmosphere in the United States each year. This equals over $1 billion in lost profits, assuming the relatively low average gas prices in April 2009.[6] EPA's proposed standards are designed to generate an estimated net savings of $30 million annually for industry due to increased recovery of methane, the main chemical component of shale gas. Conversely, oil and gas companies have *already* saved over $800 million through the implementation of over one hundred voluntary methane air pollution reduction technologies in the EPA's own Oil and Gas Energy Star Program.[7] Broad adoption of these technologies has the potential to further reduce current estimated methane emissions from oil and gas activities above and beyond the EPA estimated 26% that may be achieved by the proposed standards.[8]

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[1] Arlene M. Fiore et al., Characterizing the Tropospheric Ozone Response to Methane Emission Controls and the Benefits to Climate and Air Quality, Journal of Geophysical Research Vol. 113, at 1 (April 30 2008) (stating that "[I]n the presence of nitrogen oxides (NOx), tropospheric CH4 oxidation leads to the formation of O3);
Aaron S. Katzenstein et al., Extensive Regional Atmospheric Hydrocarbon Pollution in the Southwestern United States, 21 PNAS Vol. 100, 11975 ("The release of hydrocarbons into the atmosphere contributed to the photochemical ozone (O3) production, with related adverse health effects, reduction in plant growth, and climate change… Ch4 is by far the most abundant hydrocarbon in the atmosphere.")

[2] 76 Fed. Reg. 52,792 (citing U.S. EPA, 2011 U.S. GREENHOUSE GAS INVENTORY REPORT EXECUTIVE SUMMARY (2011), http://www.epa.gov/climateexchange/emissions/downloads11/US-GHGInventory-2011-Executive Summary.pdf).

[3] *See* 76 Fed. Reg. at 52,756, 52,791-92; *see also* EPA, Sources and Emissions/Methane, *available at* http://www.epa.gov/outreach/sources.html.

[4] EPA 2010 Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008 (March 2010), Table ES-2, http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[5] Calculated using EPA's GHG Equivalencies Calculator, http://www.epa.gov/RDEE/energy-resources/calculator.html#results.

[6] Nathanial Gronewold, Greenwire, "Industry Spotlighting Efforts to Curb Fugitive Emissions", May 19, 2009.

[7] U.S. EPA, Natural Gas STAR Program, available at http://www.epa.gov/gasstar/.

[8] U.S. EPA, Natural Gas STAR Program, available at http://www.epa.gov/gasstar/. Based on a thirty percent reduction from 2008 emission levels.

There is also an estimated reduction in VOC emissions of 540,000 tons; an estimated reduction in methane emissions by 3.4 million tons; and reductions in toxic air pollutants by 38,000 tons. Communities who are already suffering the effects of drilling from the more than 500,000 existing wells are depending on EPA for relief[9].

III. The Legal Basis for EPA to Regulate Existing Sources

The Legal basis for EPA to regulate Oil and Gas under the Clean Air Act:

A. NSPS

Section 111 of the Clean Air Act requires EPA to establish technology-based standards that limit the emissions of air pollutants from categories of stationary sources that "cause[s[, or contribute[s] significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare". 42 U.S.C. § 7411(b)(1)(A). From "time to time" EPA must revise this list. *Id*. Once EPA publishes a category of stationary sources, it must establish new source performance standards for air pollutants emitted from new and modified sources within the category (NSPS). 42 U.S.C. § 7411(a)(1). New source performance standards must reflect "best demonstrated technology" which is "the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction and any non-air quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated." 42 U.S.C. § 7411(a)(1).

EPA listed Crude Oil and Natural Gas Production on its "priority" list of categories that "cause[s], or contribute[s] significantly to, air pollution" which endangers human health and welfare in 1979. 42 U.S.C. § 7411(b)(1)(A); 44 Fed. Reg. 49222 (August 21, 1979) (codified at 40 C.F.R. § 60.16). Accordingly, EPA is obligated to promulgate new source performance standards for sources within this category. This source category consists of a wide range of equipment such as pneumatic devices, dehydrators, tanks, separation units, flanges, valves and other fittings, compressors, pumps, and heater-treaters located at and in-between wells, compressor stations and gas processing plants. Most importantly, these sources emit a range of pollutants including VOCs, methane, NOx, and sulfur dioxide ("SO2"). Despite the large number of sources within the source category, and the many pollutants they emit, EPA has only issued two performance standards for this category. These standards are inadequate because they apply only to a fraction of the sources located within the source category and only to two of the many types of air pollutants emitted from these sources.[10]

<u>The case for regulating existing sources under NSPS</u>:

[9] U.S. Energy Information Administration, Number of producing natural gas wells, available at: http://205.254.135.24/dnav/ng/ng_prod_wells_s1_a.htm

[10] EPA has also issued standards to reduce NOx from new gas powered engines spark ignition internal combustion engines with power ratings between 25 and 100 HP although this NSPS is not specific to the Crude Oil and Natural Gas Production source category. "Stationary Spark Ignition Internal Combustion Engines", 73 Fed. Reg. 3568 (Jan. 18, 2008).

Although existing sources create the largest portion of emissions from oil and gas, EPA is still has not created emission guidelines to reduce air pollution from existing sources. *See* 40 C.F.R. 60.30, Subpart C. The CAA requires EPA to issue emission guidelines for existing sources once it establishes new source performance standards for a category of new sources:

> "Concurrently upon or after proposal of standards of performance for the control of a designated pollutant from affected facilities, the Administrator will publish a draft guideline document containing information pertinent to control of the designated pollutant from designated facilities… and upon or after promulgation of standards of performance for control of a designated pollutant from affected facilities, a final guideline document will be published and notice of its availability will be published in the FEDERAL REGISTER."

40 C.F.R. § 60.22(a). *See also* 42 U.S.C. §7411(d) (requiring the Administrator to "establish a procedure…under which each State shall submit to the Administrator a plan which (A) establishes standards of performance for any existing source…". Emission guidelines must reflect "the application of the best system of emission reduction (considering the cost of such reduction) that has been adequately demonstrated." 40 C.F.R. § 60.22(b)(5). Accordingly, in tandem with the revision of the current NSPSs and promulgation of additional NSPSs, EPA must promulgate standards for the control of air pollution from existing sources.

B. NESHAPS

In addition to its duty to control air pollution from new and modified stationary sources under section 111, EPA must also issue standards to reduce HAPs from new and existing stationary sources. *See* 42 U.S.C. § 7412. Like section 111, section 112(c)(1) of the CAA requires EPA to publish a list of categories and subcategories of major and area sources of HAPs. 42 U.S.C. § 7412(c)(1). EPA must "from time to time, but no less often than every 8 years, revise, if appropriate, in response to public comment or new information" its list of categories. *Id*. It may also add additional categories or subcategories at any time. 42 U.S.C. § 7412(c)(5). Once EPA lists a category of sources of HAPs it must establish emissions standards that require the "maximum degree of reduction in emissions" of HAPs from new and existing sources. 42 U.S.C. § 7412(c)(2), (d).

EPA included the "Oil and Natural Gas Production" category in its initial list of major source categories of HAPs in 1992. 57 Fed. Reg. 31576 (July 16, 1992). EPA subsequently listed oil and natural gas production for regulation as part of its Urban Air Toxics Strategy in 1999 because TEG glycol dehydration units at oil and gas production facilities contributed nearly 50% of the national benzene emissions from area sources. 64 Fed. Reg. 38706 (July 19, 1999). In 1998 EPA added the Natural Gas Transmission and Storage major category to its list of major source categories of HAPs based on its finding that "natural gas transmission and storage facilities have the potential to be major HAP sources…[and] that there are major source TEG dehydration units in the natural gas transmission and storage source category." 63 Fed. Reg. 6288, 6290 (Feb. 6, 1998). These listings triggered the requirement for EPA to promulgate emission standards for major and area sources within the Oil and Natural Gas Production category and for major sources within the Natural Gas Transmission and Storage category. 42 U.S.C. § 7412(c)(2); 42 U.S.C. § 7412(k)(3)(B) (source categories identified as part of the Urban Air Toxics Strategy "are or will be listed pursuant to subsection (c) of section 112").

The existing NESHAPs apply to only three types of equipment used during the production, processing and transmission of oil and gas: 1) glycol dehydrators; 2) storage vessels with the potential for flash emissions (i.e., condensate and oil tanks); and 3) certain equipment located at gas processing plants. The limitations on these standards are only large glycol dehydrators, storage vessels and gas processing plants located at major sources are subject to MACT.[11] This leaves a large number of dehydrators, storage vessels and equipment at gas processing plants unregulated. *See* "National Emission Standards for Hazardous Air Pollutants: Oil and Natural Gas Production and Natural Gas Transmission and Storage", 64 Fed. Reg. 32610 (June 17, 1999) (showing that the rule only applies to 440 out of 100,00 to 250,000 production facilities and 7 out of 2,000 transmission and storage facilities). More importantly, the rules do not limit emissions from other sources such as wells, pneumatic devices, compressor seals, valves, or flanges or other production equipment located at oil and gas production facilities or natural gas storage and transmission facilities.

IV. Recommendations to EPA for Further Reductions

General recommendations:

- Existing and new oil wells that co-produce gas can be significant sources of pollution and lost product that can be cost-effectively captured by reduced emission completions. Earthworks' OGAP recommends the scope of the reduced emission completion requirement be clearly expanded to cover emissions from this type of well.

- On their face, EPA's proposed rules do not include a standard that reduces emissions from liquids unloading activities. Assuming that "liquids unloading" is a distinct practice from a well workover, liquids unloading is not covered under the proposed standards. As cost-effective technologies exist to reduce emissions during well unloading activities, we believe this is an important area for rule improvement in order to secure additional protections for human health and the environment from existing wells. EPA's most recent greenhouse gas inventory identified liquids unloading as one of the most significant sources of methane emissions from existing production activities in the natural gas sector, and therefore should be covered by the reduced emission completion requirement under the final new rules.

- The reduced emission completion requirement applies to workovers of gas wells that have been hydraulically fractured. However, the term "workover" is not defined. The final rule should add a protective definition of well workover that clearly describes which types of activities at existing wells are

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[11] The rule exempts dehydrators with an annual average natural gas flowrate less than 85 thousand m3/day or benzene emissions less than 0.90 Mg/yr. Similarly, only storage vessels that contain a hydrocarbon liquid with a storage tank gas to oil ratio equal to or greater than .31 m3/liter, an API gravity equal to or greater than 40 degrees, and an actual average throughput of hydrocarbon liquids equal to or greater than 79,500 liter/day are covered. Tanks located at facilities that exclusively process, handle or store black oil are also excluded.

subject to the REC requirement. Earthworks' OGAP is concerned that the standard could be carried out to exclude hydraulically fractured gas wells with very low VOC content. These wells can produce significant methane emissions during completion, re-completion and workovers. (We have attached separate comments regarding this issue, as it relates to CBM wells.) As written, the requirement to utilize RECs during completions, re-completions and workovers is an operational standard which applies to all hydraulically fractured wells during these activities irrespective of VOC emissions. However, EPA is soliciting comments on the appropriate applicability thresholds for the REC requirement. REC's are highly cost-effective for reducing both VOC and methane emissions. Accordingly, Earthworks' OGAP recommends the REC standard apply to all hydraulically fractured well completions, re-completions and workovers without exclusions.

- Existing pneumatic controllers account for a significant share of emissions. While replaced controllers must comply with the NSPS, additional pollution reductions are available by requiring all existing controllers to be low or no-bleed. Colorado requires existing, as well as new, pneumatic controllers located in areas out of compliance with the national health-based standard for ozone to be low bleed. EPA should follow Colorado's example by requiring additional pollution reductions from existing pneumatic devices. In addition, Wyoming requires the control of VOCs and HAPs from gas-operated pneumatic pumps by 98%. We recommend EPA adopt a similar national standard for pneumatic pumps.

- Wyoming requires 98% control of VOC and HAP emissions from storage vessels with the potential for flash emissions. Earthworks' OGAP recommends EPA adopt an equivalent level of control for storage vessels pursuant to the NSPS. Such protections would carry out the law and would secure additional health and environmental benefits. In addition, Earthworks' OGAP believes additional air quality benefits can and should be obtained from produced water tanks and vessels in both the Crude Oil and Natural Gas Production and Natural Gas Storage and Transmission source categories and storage vessels used in the Natural Gas Storage and Transmission source category as these are also significant pollution sources. Lastly, EPA should require reductions from existing storage vessels in order to fully carry out its obligations under the law.

- Under the proposal, seals on existing compressors are not subject to the requirement to use the best demonstrated technology. Fugitive emissions from existing sources will continue to represent a significant amount of pollution going forward. Earthworks' OGAP recommends EPA require existing compressors to replace wet seals with dry consistent with the law and as an important component in protecting human health and the environment.

- Earthworks' OGAP is concerned that reciprocating compressors in the production sector do not need to comply with the proposed standard. We recommend EPA strengthen the rule by broadening the scope of coverage to include compressors in this sector. Reciprocating compressors in the production sector are significant sources of methane, according to EPA's Mandatory Greenhouse Gas Reporting Rule. In addition, EPA has missed an important opportunity for additional cost-effective reductions by failing to reduce emissions from existing reciprocating compressors.

- Existing natural gas processing plants are not subject to the NSPS. Improved leak detection methods are equally available to detect VOC leaks at existing plants and should be required for older, existing plants as demonstrated by Colorado's rules to reduce VOCs at existing gas plants in ozone nonattainment areas. We recommend EPA include these protections in the final rule. Earthworks' OGAP also recommends EPA include additional SO2 reductions from existing plants in the final standards.

- Produced water ponds can be a significant source of VOC emissions, especially in arid parts of the country such as the Intermountain West. The state of Colorado has a permitting system in place to help reduce emissions from produced water ponds and has also developed ways to calculate emissions. Earthworks' OGAP supports the promulgation of a performance standard that reduces emissions from produced water ponds as well as implementation of the best available techniques to quantify emissions.

- EPA has proposed monitoring, recordkeeping and reporting requirements to ensure compliance with the NSPS. These requirements include the submission of initial notices that a source is subject to an NSPS, annual reports documenting compliance, and self-certification. EPA has proposed these compliance mechanisms in lieu of requiring compliance with Title V mechanisms. EPA is accepting comments on these alternative compliance requirements as well as the viability of requiring third-party verification of compliance. Compliance with the proposed standards is critical to ensuring the intended public health and environmental benefits are realized.

- For large glycol dehydrators in the Crude Oil and Natural Gas Production and Natural Gas Storage and Transmission source categories that are currently subject to existing MACT standards, EPA proposes to remove a compliance option that it determined does not adequately protect public health with an ample margin of safety. Specifically, EPA proposes to remove the one ton per year benzene compliance option and require all large dehydrators to reduce HAPs by 95%.

- Earthworks' OGAP supports EPA's decision to ensure that the MACT standards protect human health and the environment with a generous margin of safety, as required by the Clean Air Act. The current MACT standards only apply to storage vessels in the Crude Oil and Natural Gas Production source category with the potential for flash emissions. EPA's proposal expands the scope of the MACT standards to apply to production vessels that contribute to air pollution through breathing, working and standing losses. Specifically, the MACT standard requires 95% control of HAPs from all existing and new storage vessels located in the Crude Oil and Natural Gas Production source category. Earthworks' OGAP urges the EPA to broaden the scope of types of storage vessels covered under the NESHAP to include produced water tanks and also applying the standard to storage vessels in the Natural Gas Storage and Transmission source category. Earthworks' OGAP also recommends EPA consider a more stringent control requirement of 98% to capitalize on the additional air quality benefits that are possible.

- Earthworks' OGAP believes the EPA's proposed standards miss the mark in failing to reduce HAP emissions from equipment other than valves. Leak detection and corrective action saves valuable product and can be highly cost-effective. We recommend EPA expand and strengthen these important protections to address the pressing problem of leak detection and repair from *all* components and equipment located at natural gas processing plants.

Rationale for a Reduced Emissions Completion (REC) Requirement for Coalbed Methane Wells

Prepared by Lisa Sumi, MSc, Earthworks Science and Research Advisor

November 30, 2011

INTRODUCTION

Earthworks Oil and Gas Accountability Project (Earthworks) would like to state first and foremost that we strongly support the requirement for an operational standard to reduce emissions from unconventional gas well completions. Our comments are focused primarily on the question of whether or not coalbed methane (CBM) wells should be exempted from the requirements for 'subcategory 1 wells'.[1]

Section 1 of our comments lays out why Earthworks believes there is a need to control air emissions from CBM well completion operations.

Section 2 of the comments addresses EPA's rationale for considering exempting CBM wells from the requirement to use reduced emissions completions (RECs), also referred to as "green completions." In the proposed rule, the U.S. Environmental Protection Agency (EPA) wrote:

> *. . .we learned that coalbed methane reservoirs may have low pressure, which would present a technical barrier for performing a REC because the well pressure may not be substantial enough to overcome gathering line pressure. In addition, we identified that coalbed methane wells often have low to almost no VOC emissions, even following the hydraulic fracturing process. We solicit comment on criteria and thresholds that could be used to exempt some well completion operations occurring in coalbed methane reservoirs from the requirements for subcategory 1 wells.*[2]

Our comments provide information to support our position that while technical barriers may have existed in the past, technologies now exist and are being used to perform RECs in low-pressure CBM reservoirs. We also provide information that shows that not all CBM basins contain natural gas with a low-VOC content, and that the potential reduction in VOC emissions from CBM operations is significant.

In Section 3 of these comments, Earthworks provides additional issues for EPA to consider – issues that we believe support our recommendation that CBM wells should NOT be exempted from subcategory 1 well requirements.

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[1] In the proposed rules, subcategory 1 wells are those for which EPA identified "green" completions, which EPA refers to as reduced emissions completions or REC, as an option for reducing VOC emissions during well completions. (**Source:** U.S. Environmental Protection Agency. August 23, 2011. *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review. Proposed Rule*. Paragraph 76 FR 52757. p**.** 52757. http://www.federalregister.gov/a/2011-19899/p-347

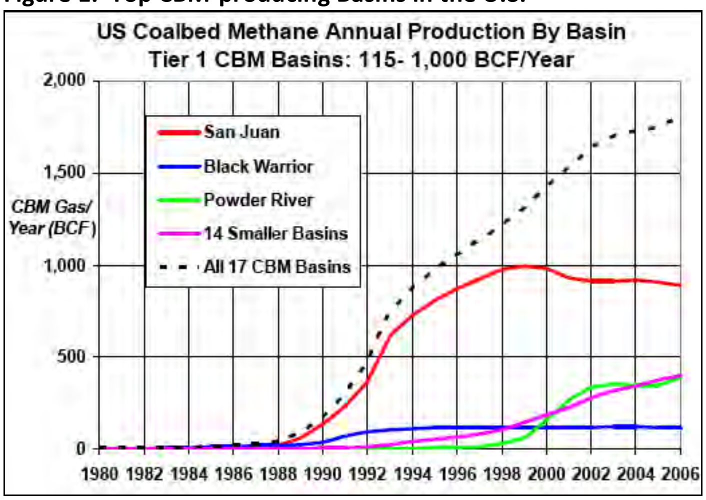
[2] U.S. Environmental Protection Agency. August 23, 2011. *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review. Proposed Rule*. Paragraph 76 FR 52758, p**.** 52758. http://www.federalregister.gov/articles/2011/08/23/2011-19899/oil-and-natural-gas-sector-new-source-performance-standards-and-national-emission-standards-for#p-352

We are not arguing that all coalbed methane will be able to use REC technology. As with other unconventional and conventionally fractured wells, there will be situations where the technology is not technically feasible or safe to use. What we are recommending is that CBM operators be treated the same as other unconventional gas operators - in other words, the EPA rules should not exempt CBM operators from the requirement to RECs, or the requirement to flare completion emissions when it is not feasible to capture flowback emissions.

1 THERE IS A NEED TO CONTROL AIR EMISSIONS FROM CBM WELLS

Much of this submission focuses on the San Juan Basin, located in northwest New Mexico and southwest Colorado, which is where Earthworks has the most experience regarding CBM development. Where possible, examples from other CBM basins are used.

Figure 1. Top CBM-producing Basins in the U.S.[3]



According to the Energy Information Administration (EIA), the San Juan Basin is the most prolific CBM basin in the country (see Figure 1).

The San Juan Basin also has the largest proved reserves of the U.S. CBM basins. In 2007, it was reported that the San Juan Basin held just less than half (43%) of the total U.S. proved CBM reserves (8,446 bcf).[4]

At the end of 2009 the United States still had more than 18,500 billion cubic feet (bcf) of proved CBM gas reserves.[5] In 2009, the U.S. produced 1,914 bcf of coalbed methane gas.[6] At that rate, there is close to another decade of CBM production left.

There are tens of thousands of CBM wells that may yet be drilled in the United States. In the San Juan Basin of Colorado there are approximately 1,800 more wells projected by

[3] U.S. Energy Information Administration. Nov. 2007. "Coalbed methane: the past, present and future." http://www.eia.doe.gov/oil_gas/rpd/cbmusa2.pdf

[4] U.S. Energy Information Administration. Nov. 2007. "Coalbed methane: the past, present and future." http://www.eia.doe.gov/oil_gas/rpd/cbmusa2.pdf

[5] U.S. Energy Information Administration. Dec. 30, 2010. "Coalbed Methane." http://www.eia.gov/dnav/ng/ng_enr_coalbed_dcu_NUS_a.htm

[6] U.S. Energy Information Administration. Dec. 30, 2010. "Coalbed Methane Production." http://www.eia.gov/dnav/ng/ng_prod_coalbed_s1_a.htm

just two companies (the Southern Ute Indian Tribe and BP[7]) while in the Wyoming portion of the Powder River Basin the potential number of additional wells is more than 50,000.[8] It's not known how many wells might be drilled in the other dozen or so CBM basins across the country. While the VOC emissions per well might be lower for CBM wells than other types of wells, the cumulative impact of developing CBM reserves is extremely high.

1.1. Potential CH_4 emissions from CBM well completions

In its 2011 Technical Supporting Document for EPA's Greenhouse Gas Emissions Reporting Requirements for the oil and natural gas industry, EPA estimated that unconventional wells vent 9,175 thousand cubic feet (Mcf)/well completion. This estimate included both CBM and shale gas wells.[9] In 2011, the U.S. Department of Energy (DOE) used a lower emission factor than EPA for CBM well completions, arguing:

> *While coal bed methane (CBM) wells are an unconventional source of natural gas, they have a low reservoir pressure and thus have relatively low emission rates from completions and workovers. The emission factor used for the completion and workover of CBM (low-pressure) wells is 49.57 Mcf* CH_4.[10]

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[7] **The Southern Ute Indian Tribe (SUIT):** in 2009, SUIT proposed the development of **770 additional CBM gas wells** in the San Juan Basin. (**Source:** Environ. August 2009. *Programmatic Environmental Assessment (PEA) for 80-acre Infill Oil & Gas Development on the Southern Ute Indian Reservation.* p. 1. http://www.suitdoe.com/Documents/Appendix_G_AirQualityTSD.pdf)
BP: In 2007, it was reported that BP had 1,000 wells yet to drill in the San Juan Basin of CO and NM. (**Source:** Leary, J., Pink, T. and Seyler, C. March 16, 2007. "Operator tests limits of coiled tubing drilling," E&P Magazine. http://www.epmag.com/archives/features/295.htm) BP did not drill any CBM wells in New Mexico between 2007 and 2011. (**Source:** New Mexico Oil Conservation Division. Well Search – Operator: BP, Pool: 71629. http://www.emnrd.state.nm.us/OCD/OCDPermitting/Data/Wells.aspx) In 2008, BP was granted a downspacing request, increasing the number of possible wells by 256, to **1,256.** (**Source:** Colorado Oil and Gas Conservation Commission. Order 112-215. Dec. 9, 2008. BP Request for four optional wells in certain 320-acre drilling and spacing unit. p. 129. http://ogccweblink.state.co.us/DownloadDocument.aspx?DocumentId=2062097)
Between 2007 and 2011 BP drilled approximately 223 wells in the Ignacio-Blanco Field of La Plata County, Colorado (**Source:** COGCC Well Search for BP, Field 38300, County Code 067; Sequence Code: 089xx and higher. The result was 223 wells drilled. http://cogcc.state.co.us/cogis/FacilitySearch.asp.) So BP still has more than 1,000 CBM wells that it can drill in the basin.

[8] In 2003, the U.S. DOE reported that more than 13,000 wells had been drilled in the Powder River CBM Basin, with "the potential for drilling up to 76,000 total wells in the basin to fully develop its CBM resources."
(**Source:** U.S. Department of Energy. 2003. Multi-Seam well completion technology: implications for Powder River Basin Coalbed Methane Production. http://www.adv-res.com/pdf/Multi-Seam%20Well%20Completion%20Technology%20-%20Powder%20River%20Basin.pdf)
According to the Wyoming Oil and Gas Commission, there were 13,305 producing and 10,470 shut in wells in Sept. 2011. So there is the potential to drill 76,000 – (13,305+10470) = 52,225 wells. (Source: Wyoming Oil and Gas Conservation Commission web site: "Coalbed production by month – PRB only." http://wogcc.state.wy.us/coalbedchart.cfm)

[9] U.S. Environmental Protection Agency. 2011. *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry Background Technical Support Document*. Washington, D.C.: U.S. Environmental Protection Agency, Climate Change Division. p. 86. http://www.epa.gov/climatechange/emissions/downloads10/Subpart-W_TSD.pdf

[10] *ibid.*

Table 1. Estimated and reported CH_4 emissions per CBM completion in the San Juan Basin.

	Estimated CH_4 emissions per completion (Mcf)	Reported CH_4 Reported emissions per completion (Mcf)	CH_4 Emissions per CBM completion (short tons)[11]
EPA (all CBM basins)	9,175		193
DOE (all CBM basins)	49.57		1
BP		300 to 600[12] 941[13]	6 to 12 20
ConocoPhillips[14]		2,000	42
La Plata CEAP[15]		1,875	39
Weatherford[16]		667	14
Southern Ute	5,000		105

The DOE converted the volumetric amount released during CBM completion venting (49.57 Mcf) into the mass of CH_4 released, calculating that 2,090 pounds (1.045 short tons) of methane would be released per completion for coal bed methane.[17]

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[11] Assumed a natural gas density of 0.042 lb/cf, and 2,000 lbs/short ton. After DOE. (**Source:** U.S. Department of Energy. Oct. 24, 2011. *Life Cycle Greenhouse Gas Inventory of Natural Gas Extraction, Delivery and Electricity Production*. p. A-9. http://www.netl.doe.gov/energy-analyses/pubs/NG-GHG-LCI.pdf)

[12] Based on a July 2007 presentation as part of EPA's Gas STAR program, BP's estimate of savings from green completions was slightly lower. The company reported that completion venting occurred over a period of approximately 3 days, and that 100 to 200 Mcf of gas were released per day, for a total **of 300 – 600 Mcf of gas** per well saved by using green completions. (**Source:** Nye, Bruce. (BP). July 2, 2007. "Greenhouse Gas Reduction Project." Presentation at the EPA Natural Gas STAR Producers Technology Transfer Workshop. Durango, Colorado. Sept 13, 2007. http://www.epa.gov/gasstar/documents/workshops/durango-2007/06_%20bp_rec_Greenhouse_gas_emision_reduction.pdf)

[13] In April 2008, BP's green completions in the San Juan Basin were preventing the emission of approximately 6,850 tons of CO2e per year. BP drilled 46 wells in the San Juan Basin that year, using green completions on about 40% (18) of those wells.[13] So each green completion operation prevented approximately **381 tons of CO2e (941 Mcf)** or 18 tons of CH4 from entering the atmosphere. Note: 6,580 tons of CO2e/18 wells = 380.56 tons CO2e. (**Source:** Burford, K. April 3, 2008. "BP touts emission-saving technique ,"*Durango Herald.* http://archive.durangoherald.com/asp-bin/article_generation.asp?article_type=earth&article_path=/earth/08/earth080403_1.htm)

[14] In an EPA Gas STAR presentation, ConocoPhillips reported that green completions allowed it to reduce emissions from its Fruitland Coalbed Methane wells (San Juan Basin) by approximately **2,000 Mcf** per well, or approximately **42 tons of methane** per well. (**Source:** Jonas, A., Gregoire, J. and Bertoglio, G. (ConocoPhillips). "SJBU – Completions. Gas Recover Cleanout System." Presentation at the EPA Natural Gas STAR Producers Technology Transfer Workshop. Farmington, NM. May 11, 2010. http://www.epa.gov/gasstar/documents/workshops/farmington-2010/03_conoco_phillips_gas_recovery_unit_epa_presentation.pdf)

[15] As part of the La Plata Climate and Energy Action Plan process, two members of the oil and gas working group (representatives from BP and Red Cedar, the Southern Ute Indian Tribe's gas production company), estimated that green completions in the San Juan Basin (SJB) of Colorado could reduce methane emissions by **1,875 Mcf (or 39 tons)** per well. Their estimates were based on actual industry data for green completions in the SJB. (**Source:** Hawk, A. (BP) and Hinkley, E. (Red Cedar). August 4, 2010. "Mitigation Option 1: Implementation of Reduced Emission Well Completions (Green Completions)," Oil & Gas Workgroup Final Report. *La Plata Climate and Energy Action Plan*. http://www.fourcore.org/docs/CEAP/actionplandetailsheets/O&G_LeakDet.pdf)

[16] In 2004, Weatherford reported successfully carrying out a pilot project in Fruitland coal formation in Durango, Colorado. Three wells captured **2 million cubic feet** of gas, which is the equivalent of 667 Mcf, or **14 tons** of methane per well. (**Source:** ExxonMobil Production Company, American Petroleum Institute and EPA's Natural Gas STAR Program. Sept. 21, 2004. "Weatherford Durango Experience." **In** *Green Completions – Lessons Learned from Natural Gas STAR*. Producers Technology Transfer Workshop. Slides 14 – 16. http://epa.gov/gasstar/documents/workshops/houston-2004-2/GreenCompletions.ppt)

[17] U.S. Department of Energy. Oct. 24, 2011. *Life Cycle Greenhouse Gas Inventory of Natural Gas Extraction, Delivery and Electricity Production*. p. A-9. http://www.netl.doe.gov/energy-analyses/pubs/NG-GHG-LCI.pdf

We agree with the DOE that the completion emissions from CBM are likely lower than for unconventional wells such as shale gas wells, but the data that are available on gas captured through RECs leads us to believe that the potential savings from CBM RECs are considerably higher than that estimated by DOE.

As seen in Table 1, BP and ConocoPhillips have reported capturing between 300 and 2,000 Mcf of gas per green completion, or between 6 and 42 tons of methane per completion. The Southern Ute Indian Tribe (SUIT) has estimated even higher completion emissions – 5,000 Mcf, which is the equivalent of 105 tons CH_4.[18]

The reason for the wide variation in the venting/completion emissions reported by the companies is that the San Juan Basin, like many hydrocarbon basins, is not uniform. There are some portions of the San Juan Basin Fruitland coals that are extremely prolific gas producers, and others that produce less gas.

In 2006, Meek and Levine reported regional characteristics of Fruitland Coalbed Methane wells based on actual production data.[19] Table 2, based on Meek and Levine data, show initial gas production rates (IP rates) from 150 to 1,000 Mcf per day.

Table 2. Regional variations in Fruitland Coalbed Methane wells (from Meek and Levine, 2006).

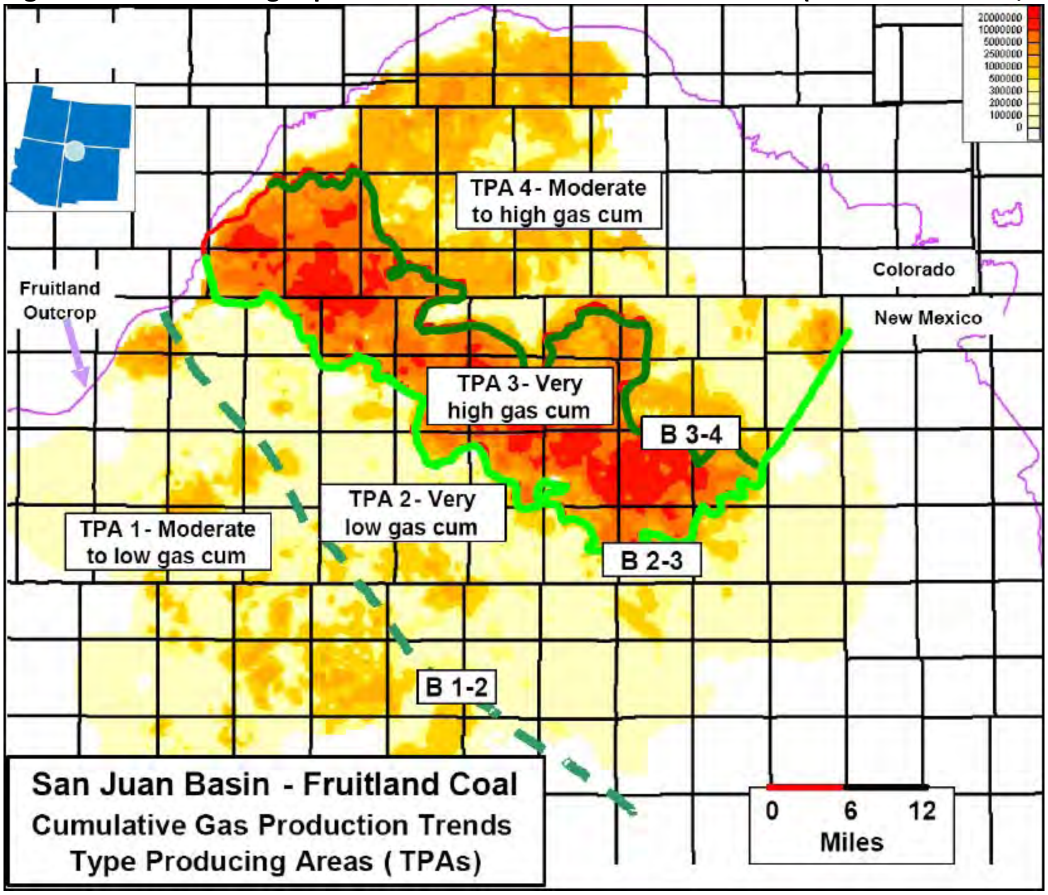
Zone	Initial Production (Mcf per day)	Peak gas rate (Mcf per day)	Gas Quality
TPA1	150	350	900-1100 British thermal units (Btu)
TPA2	200	75	1100-1300 Btu; low CO_2, some oil production
TPA3	1000	3,700	650-900 Btu, >10% CO_2
TPA4	200	700	900-1100 Btu

If the Southern Ute wells are in the area designated as TPA 3 (Figure 2), it is possible that their well completions, which can take up to seven days[18], could produce emissions of 5,000 Mcf or more.

[18] "During well completion, some wells in the project area will flare natural gas, allowing operators to evaluate the well's performance. To conservatively estimate emissions from this flaring process, it was assumed that 5 million cubic feet of gas . . . would be burned in a pit flare at each well for a maximum of 7 days, 24 hours per day." (**Source:** Environ. August 2009. *Programmatic Environmental Assessment (PEA) for 80-acre Infill Oil & Gas Development on the Southern Ute Indian Reservation.* p. 44. http://www.suitdoe.com/Documents/Appendix_G_AirQualityTSD.pdf)

[19] Meek, R. and Levine, J. May 3, 2006. "Delineation of Four "Type Producing Areas" (TPAs) in the Fruitland Coal Bed Gas Field, New Mexico and Colorado, Using Production History Data." Paper modified from presentation at the AAPG Annual Convention, Calgary, Alberta. June 19-22, 2005. AAPG Search and Discovery Article #20031. http://www.searchanddiscovery.com/documents/2006/06025meek/images/meek.pdf

Figure 2. Cumulative gas production trends in the San Juan Basin (Meek and Levine, 2006)



1.2. Potential CH_4 reductions from Coalbed Methane RECs are significant

1.2.1. Potential CH_4 Reductions from CBM RECs in the San Juan Basin

In the proposed rule, EPA stated that:

> *We believe that the proposed rule regulates only significant emission sources for which controls are cost-effective. Nevertheless, we solicit comment and supporting data on appropriate thresholds (e.g., pressure, flowrate) that we should consider in specifying which well completions are subject to the REC requirements for subcategory 1 wells.*[20]

Earthworks argues that if EPA exempts CBM wells from the well completion requirements for subcategory 1 wells, it will have missed a cost-effective opportunity to

[20] U.S. Environmental Protection Agency. August 23, 2011. *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review. Proposed Rule*. Paragraph 76 FR 52759, p. 52759. http://www.federalregister.gov/a/2011-19899/p-356

control a significant emissions source.

Because we do not have access to well-by-well data on emissions saved by using RECs on CBM wells in the San Juan Basin (SJB), we do not have definitive numbers on the actual reduction in CH_4 emissions. Based on data that are available, however, we have tried to conservatively estimate the potential yearly reductions in CH_4 if RECs are used on all CBM well completions in the SJB.

BP and Red Cedar have estimated that 200 wells are drilled in the Colorado portion of the San Juan basin per year.[21] Data from the New Mexico Oil Conservation Division show that over the past five years an average of 200 Fruitland Coal CBM wells have been drilled per year, but in 2009 and 2010 only about 50 wells were drilled per year.[22]

A conservative estimate of 250 wells drilled annually with RECs, each saving 20 tons of CH_4 per well completion,[23] means that up to 5,000 tons of methane could be captured per year from CBM wells in the San Juan Basin alone. (Flaring would reduce the CH_4 emissions, but we did not explore the option of flaring a portion of the completion emissions due to lack of data.)[24]

While 5,000 tons of CH_4 per year pales in comparison to the estimated nationwide emissions reductions from using RECs on other unconventional gas wells (1.4 million tons CH_4 per year), the methane reduction that could result from RECs in the San Juan Basin approaches the savings that EPA has estimated for emissions controls for conventional well completions. It also exceeds the savings from controlling equipment leaks at processing plants and from reciprocating compressors at well pads, and approaches the savings by controlling emissions from high throughput storage vessels. (See Table 3)

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[21] Hawk, A. (BP) and Hinkley, E. (Red Cedar). August 4, 2010. "Mitigation Option 1: Implementation of Reduced Emission Well Completions (Green Completions)," Oil & Gas Workgroup Final Report. *La Plata Climate and Energy Action Plan*. http://www.fourcore.org/docs/CEAP/actionplandetailsheets/O&G_LeakDet.pdf

[22] A total of 1,214 wells were drilled in the Fruitland Coal "pool" between 2005 and 2010. In 2009 and 2010, 61 and 42 wells were drilled, respectively. (**Source:** New Mexico Oil Conservation Division. Well search - Status: Active wells, Pool Name: 71629, Well Type: Gas. Sort by spud date. http://www.emnrd.state.nm.us/OCD/OCDPermitting/Data/Wells.aspx)

[23] This is a very conservative estimate of CH_4 captured. As shown in Table 1, CBM producers in the San Juan Basin have reported or estimated capturing a range of 6 to 105 tons of CH_4 per completion.

[24] It is noted that some of the gas from CBM well completions will be flared, not vented. For example, the Southern Ute Indian Tribe reports flaring is used on "some" of its well completions. Thus, the actual CH_4 emissions if RECs are not used will be less than 5,000 tons. Based on data from EPA, the DOE assumes that 15% of gas from CBM operations is flared as opposed to being vented. Given the lack of data on flaring versus venting of San Juan Basin CBM well completion gases, there is no way to gauge the accuracy of this number.
(**Sources:** [1] Environ. August 2009. *Programmatic Environmental Assessment (PEA) for 80-acre Infill Oil & Gas Development on the Southern Ute Indian Reservation.* p. 44. http://www.suitdoe.com/Documents/Appendix_G_AirQualityTSD.pdf [2] U.S. Department of Energy. Oct. 24, 2011. Life Cycle Greenhouse Gas Inventory of Natural Gas Extraction, Delivery and Electricity Production. p. A-9. http://www.netl.doe.gov/energy-analyses/pubs/NG-GHG-LCI.pdf*)*
The Southern Ute Indian Tribe reports that flaring is used on "some" of its well completions.

The cost-effectiveness of using RECs on CBM wells in the San Juan Basin CBM appears to be better than the cost-effectiveness of controlling emissions from leaks at processing plants, reciprocating compressors at well pads, and high throughput storage vessels. As will be shown in Section 3.4, RECs on San Juan Basin CBM wells can be a break-even proposition or cost operators $6,000 per well completion (which would mean an annual cost to operators of $1.5 million per year, at most),[25] while some of the other air emissions controls proposed by EPA could cost the industry tens of millions of dollars. (Table 3)

Table 3. Comparison of potential CH_4 emissions reductions and costs for San Juan Basin CBM RECs versus other control requirements proposed by EPA.[26]

Emissions Control	Potential yearly CH4 emissions reduction (tons/year)	Annual Cost
RECs San Juan Basin CBM wells	5,000	0 to $1,500,000
Emissions Control	**Nationwide CH4 Emissions Reductions (tons/year)**	**Nationwide annualized costs (2008$)**
RECs on unconventional gas wells	1,399,139	-$20,235,748
Combustion of emissions from conventional well completions	5,875	$27,104,761
NSPS Subpart VV - equipment leaks at processing plants	1,411	$104,412,154
Annual monitoring and maintenance at reciprocating compressors at well pads	947	$21,984,763
95% control of high-throughput storage vessels	6,490	$4,234,856

1.2.2. Potential CH_4 Reductions from RECs in other CBM Basins

Data on CH_4 emissions per completion in other CBM basins are very limited. In fact, no data were found on the total amount of gas vented during completions in any U.S. CBM basin other than the San Juan Basin.

In the absence of well completion emissions data, we are using initial production (IP) data as a rough approximation of the potential methane emissions during well completions. (IP rate is typically the rate of gas flow at first production).

Earthworks recognizes that the IP rate of a well is not a perfect surrogate for the amount of gas that might be emitted during a well completion, as the gas stream tends to build up during flowback.[27] Consequently, emissions are typically lower the first few

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[25] Assuming ALL of the RECs cost $6,000: $6,000 x 250 well completions per year = $1,500,000 per year.

[26] U.S. Environmental Protection Agency. 2011. *Regulatory Impact Analysis. Proposed New Source Performance Standards and Amendments to the National Emissions Standards for Hazardous Air Pollutants for the Oil and Gas Industry*. Table 3-3. Estimated Nationwide Compliance Costs, Emissions Reductions, and VOC reduction Cost-Effectiveness by Emissions Sources and Points, NSPS, 2015. p. 3-16. http://www.epa.gov/ttnecas1/regdata/RIAs/oilnaturalgasfinalria.pdf

[27] Barcella, M., Gross, S. and Rajan, S.(IHS CERA). 2011. *Mismeasuring Methane. Estimating Greenhouse Gas Emissions from Upstream Natural Gas Development.* (Private Report). p. 9. Accessed Nov.17, 2011. http://heartland.org/sites/default/files/Mismeasuring%20Methane.pdf

hours or days of flowback or well clean-out, and increase as flowback fluid decreases and gas flow starts to increase. We have attempted to account for the variation in emissions throughout the flowback/clean-out/completion process in our estimates.

Table 4 shows IP rates that were found for a few CBM basins.

Table 4. Initial Production Rates for Selected CBM Basins.

CBM Basin	IP rate (Mcf/day)
Powder River Basin, WY[28]	Range: 0 – 1,732; Average: 82.2
Wilcox Basin, Central Gulf Coast[29]	Range: 2 – 371
Arkoma Basin, OK/AR[30]	Range: Trace – 600

The following is an extremely conservative estimate of potential emissions from CBM completions in the Powder River Basin.

In Wyoming, in 2009 there were 391 coalbed methane wells spudded in the Powder River Basin.[31] If we assume that approximately that many wells are completed per year, and assume conservatively that an average of 41 Mcf/well of CH_4 are vented per day (i.e., half of the IP rate in Table 4), and conservatively assume that wells take three days to complete,[32] then the emissions that could be prevented by RECs in the Powder River Basin would be 1,009 tons of CH_4 per year.[33]

[28] The Wyoming Oil and Gas Conservation Commission collects data on initial gas production rates for CBM wells. The initial production rate varies by well. For example, in one PRB area (Township 58N, Range 82W) the initial gas production rate, averaged over 140 wells, was 198 MCf/day.Due to time constraints it was not possible to calculate the average of all PRB CBM wells in the WOGCC database.But the average initial production rate for 989 wells **was 82.2 Mcf/day**. (Township/Range: 58N/80W; 58N/82W; 58N, 83W; and 58N/84W) (**Source:** Wyoming Oil and Gas Conservation Commission. Coalbed Methane Wells. "Initial Rates Logs." Township 58 N, Range 82 West. http://wogcc.state.wy.us/MaxGasTwpRge.cfm?RequestTimeout=9500&Twp=58&Rge=82)

[29] Penn Virginia Oil and Gas reported the initial production rates for17 of its wells in the Wilcox CBM basin. The rates ranged from 2 – 371 Mcf, with an average of **78 Mcf/day**. (**Source:** Penn Virginia Oil and Gas. Oct. 12, 2005. "Horizontal wells: a viable method for exploitation of coalbed methane form the Wilcox coals of the Central Gulf Coast?" Presentation to the U.S. Oil and Gas Association. http://usoga.com/events/presentations/Wilcox_lewis.pdf)

[30] Initial production rates for vertical coalbed methane wells in the Arkoma range from a trace to 595,000 cubic feet a day, with the average **72 Mcf** daily (**Source:** Shirley, K. March 2000. "Weekend work yields gas fields." AAPG Explorer. (American Association of Petroleum Geologists) http://www.aapg.org/explorer/2000/03mar/arkomacoal.cfm) Vectra has drilled horizontal wells in the Arkoma Basin that have initial production rates that exceed 500 Mcf/day. (**Source:** Fisher, J. Dec. 2005. "CBM is the place to be," *Oil and Gas Investor*. P. 6. http://www.oilandgasinvestor.com/pdf/CoalbedMethane.pdf) Lexington Resources recently announced an initial production rate on a vertical well of 500 – 600 Mcf/day. (**Source:** Young, D.P., and Pratt, T.J. (TICORA Geosciences). 2005. Coal Gas Reservoir Assessment – WIC Region. GasTIPS. http://media.godashboard.com/gti/4ReportsPubs/4_7GasTips/Winter05/CoalGasReservoirAssessment.pdf)

[31] Doll, T. 2010. Wyoming Oil and Gas Commission. Presentation at the 4th Annual CO2 Conference. http://www.uwyo.edu/eori/_files/co2conference10/Tom%20Doll%20EORI_30June2010_2009-2010.pdf

[32] The Natural Resources Law Center reports that it takes from 3 to 6 days to complete a PRB well. (**Source:** Natural Resources Law Center (University of Colorado School of Law). 2002. *Coalbed Methane in the Intermountain West: Primer*. p. 11. http://www.colorado.edu/law/centers/nrlc/publications/CBM_Primer.pdf)

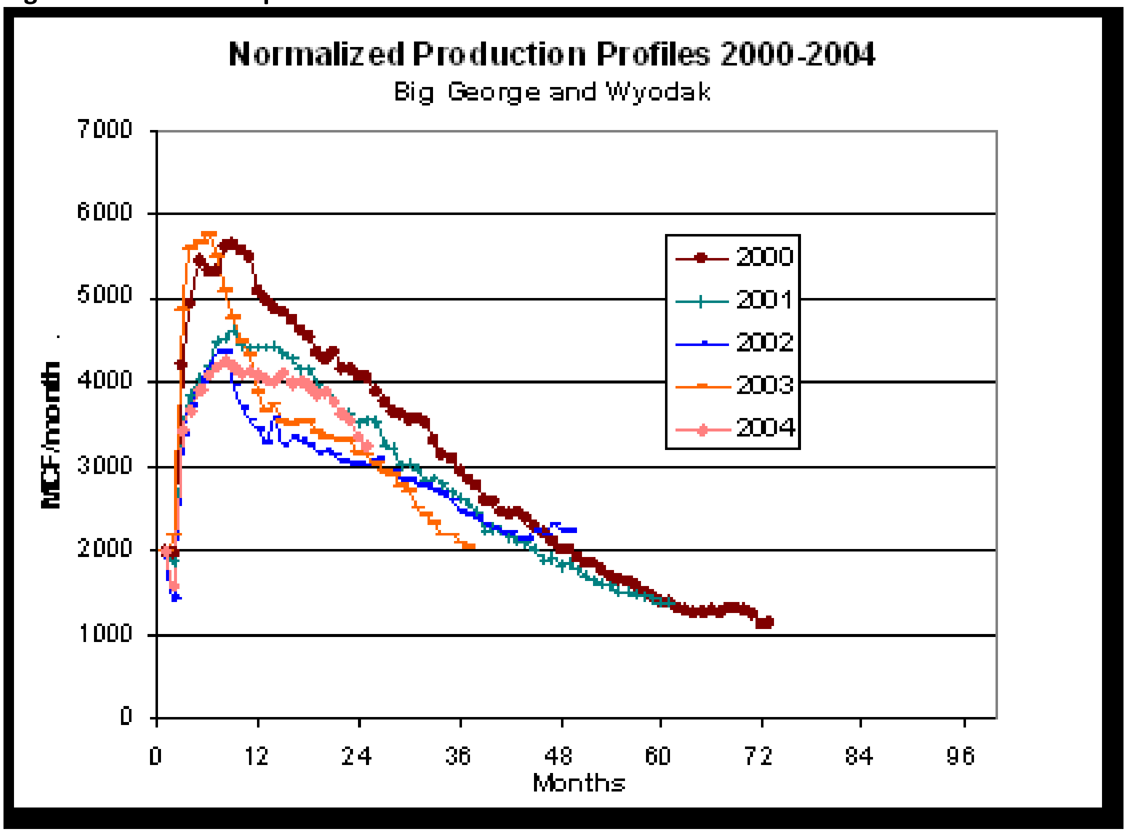
[33] 41 Mcf/day = 0.9 tons CH_4/day x 3 days to complete a well x 391 wells completed per year = 1,994 tons CH_4 per year.

Thus, between the San Juan and Powder River Basins the emission of more than 6,000 tons of CH_4 could be prevented per year. Methane emissions reductions from CBM wells nation-wide would obviously be higher than 6,000 tons, but we were not able to find enough data to calculate the potential annual CH_4 emissions from well completions in other U.S. CBM basins.

1.3. Potential emissions reductions from recompletions may be considerable

In CBM reservoirs, the use of RECs during recompletion operations may have even greater CH_4 reductions than RECs during initial well completions because CBM production tends to increase for a period of time before starting to decline.[34]

Figure 3. Production profiles for CBM wells in the Powder River Basin.[35]



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[34] Generally, gas production rates increase as water is pumped from the CBM formations, because this releases pressure on the gas and allows it to desorb from the coal and flow to the wells. It can take years before enough water is pumped off to sufficiently reduce hydrostatic pressure and enable maximum gas desorption. (E.g., see the story Bleizeffer, D. April 4, 2010. "CBM hits record production with fewer wells," *Casper Tribune*. http://trib.com/news/state-and-regional/article_6dcf5c85-16f9-506b-a7c3-c8dc0d76d12a.html)

[35] Data represent flow rates of 6,600 wells producing from the Wyodak and Big George coal zones of the Powder River Basin. (**Source:** Swindell, G. 2007. "Powder River Basin Coalbed Methane – Reserves and Rates." Paper presented at the Society of Petroleum Engineers (SPE) Rocky Mountain Oil and Gas Technology Symposium, Denver, April 16-18, 2007. SPE paper 107308. http://garyswindell.com/sp107308.htm)

As seen in Figure 3, the initial CBM production from wells in the Big George and Wyodak coal zones of the Powder River Basin is lower than gas production in subsequent years. After about year four (48 months), production rates decline back to the initial production rate.

Using data in Figure 3 as an example, if a well recompletion operation were to occur 12 months after production, the potential completion emissions would be about three-and-a-half times the initial completion emissions (because the gas is flowing at 5,500 $Mcf/month_{month12}$ as opposed to 1,500 $Mcf/month_{month\ 0}$).

Thus, not only is it important for CBM wells to utilize RECs during initial completion, it also important to require the use of RECs during CBM well recompletions.

2 Addressing EPA's questions regarding CBM well completions

EPA's proposed rule suggested that some of the unique characteristics of CBM formations (e.g., low reservoir pressure, low VOC content) make CBM operations candidates for an exemption to the proposed REC requirement for hydraulically fractured wells. The sections below provide information on why Earthworks believes that no exemption is needed for CBM wells.

2.1. Arguments against RECs in CBM and low-pressure reservoirs – and how these problems have been overcome.

In its proposed rules, EPA stated that:

> *. . .we learned that coalbed methane reservoirs may have low pressure, which would present a technical barrier for performing a REC because the well pressure may not be substantial enough to overcome gathering line pressure. . . We solicit comment on criteria and thresholds that could be used to exempt some well completion operations occurring in coalbed methane reservoirs from the requirements for subcategory 1 wells.*[36]

It appears that the Texas Railroad Commission (RRC) was one of the sources of this information. In its August 23, 2011 comments to EPA, the RRC wrote that:

> ***. . .*** *green completions are not viable for reservoirs with low pressures. In order to overcome the back-pressure of the gathering line, the reservoir must have*

[36] U.S. Environmental Protection Agency. August 23, 2011. *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review. Proposed Rule*. Paragraph 76 FR 52758, p. 52758. http://www.federalregister.gov/articles/2011/08/23/2011-19899/oil-and-natural-gas-sector-new-source-performance-standards-and-national-emission-standards-for#p-352

sufficient pressure to lift fluids out of the wellbore and adequately clean-up the formation.[37]

As will be shown below, RECs are not only viable in low-pressure reservoirs, they are actually being carried out with great success.

In 2007, OGAP participated in the Four Corners Air Quality Task Force (FCAQTF), a group that included industry, government, and members of the public from northern New Mexico and Arizona, and southern Colorado and Utah.[38] During this process comments similar to those voiced by the Texas RRC were voiced such as:

> *Green completion techniques are only applicable where the reservoir pressure and flow is sufficient to clean-up a well bore after completion and still have sufficient pressure to enter the collection system/pipeline. With the depleted status of the conventional San Juan basin reservoirs and the characteristics of coal bed methane reservoirs, [green completions are] not an available option for the SJ basin area.*[39]

The statements made during the FCAQTF demonstrate that there is a lack of communication and technology-sharing between companies. As will be described in Section 2.1.1, in 2007, at the time that some San Juan Basin operators were illegitimatizing the use of green completions BP had already been using the technology for a number of years on its CBM wells in the basin.

Also, in 2007 ConocoPhillilps decided to try to do what others said could not be done. The company initiated a program to develop what it termed a "Gas Recovery Cleanout System," which is a type of reduced emissions completion. And they were successful. ConocoPhilllips was able to utilize its green completion technology in a variety of formations in the San Juan Basin including Fruitland Coal, Dakota sandstone and Mesa Verde sandstone. According to a 2008 article in the ConocoPhillips' *Spirit Magazine*, "This system allows gas that previously would have been flared during the post-fracture stimulation cleanup process to instead be sold."[40]

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[37] Railroad Commission of Texas. Comments on "Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews," 76 Fed. Reg. 52738 (August 23, 2011), Docket ID No. EPA-HQ-2010-0505. http://www.rrc.state.tx.us/forms/reports/notices/EPA-RRC-Letter-Comments-10-25-11.pdf

[38] Four Corners Air Quality Taskforce web site. http://www.nmenv.state.nm.us/aqb/4c/

[39] Four Corners Air Quality Taskforce. Nov. 2007. *Final Report.* "Oil and Gas Section Report of Mitigation Options." p. 110. http://www.nmenv.state.nm.us/aqb/4c/Docs/4CAQTF_Draft_Report_vers_7_OilGasExpProd.doc

[40] Lowry, J. 2008. "Lower 48 – a business in fast forward." ConocoPhillips' *Spirit Magazine.* 3rd Quarter, 2008. p. 4. No longer available on-line.

2.1.1. Overcoming the problem of low reservoir pressure

In 2010, Earthworks provided testimony at a New Mexico Environmental Improvement Board (EIB) hearing that was being held to consider enacting a statewide cap on greenhouse gas emissions.[41]

As part of the hearing, Darren Smith from Devon Energy presented testimony that, ". . . wells with insufficient bottomhole pressure will not be able to flowback into the gathering system and when this is the case, such as in mature fields, a well cannot be green completed."[42]

Yet, during the same hearing Bruce Gantner of ConocoPhillips testified that, "Another operator's experience shows increasing use of closed-loop [i.e., reduced emissions] completions, with 30% of its new wells drilled in 2009 using this technology and tying into existing gathering systems. **Where formation pressures are insufficient to overcome line pressure, compression is employed to boost the gas pressure.** This operator is currently on schedule to utilize this technology on 75% of the reduced drilling program in 2010."[emphasis added][43]

BP pioneered the use of green completions in low pressure or what they term "low energy" reservoirs. This innovation took place in coalbed methane wells in the San Juan Basin. The development of this system began in 2004, as a collaboration between BP and the oil and gas service company Weatherford. At the time, BP was encountering pore pressures of 80-psi in the Fruitland coal seams (San Juan Basin). According to Weatherford, this "required a different approach to cleaning out sand and fluids during well completions. Even with BP's low-pressure, 150-psi to 200-psi gathering systems, the wells didn't have the natural pressure to push gas into the sales line while they were flowing water and frac fluids."[44]

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[41] Randolph, D. (Earthworks). 2010. Rebuttal Testimony of Dan Randolph. *In the Matter of the Petition for Hearing to Adopt New Regulations and Amend Various Sections of 20.2.1, 20.2.2,20.2.70 and 20.2.72 NMAC, Statewide Cap on Greenhouse Gas Emissions. New* Energy Economy, Inc., Petitioner. EIB No. 08-19(R). http://www.earthworksaction.org/pubs/RandolphRebuttalTestimonyFINAL_NMghgNEE.pdf

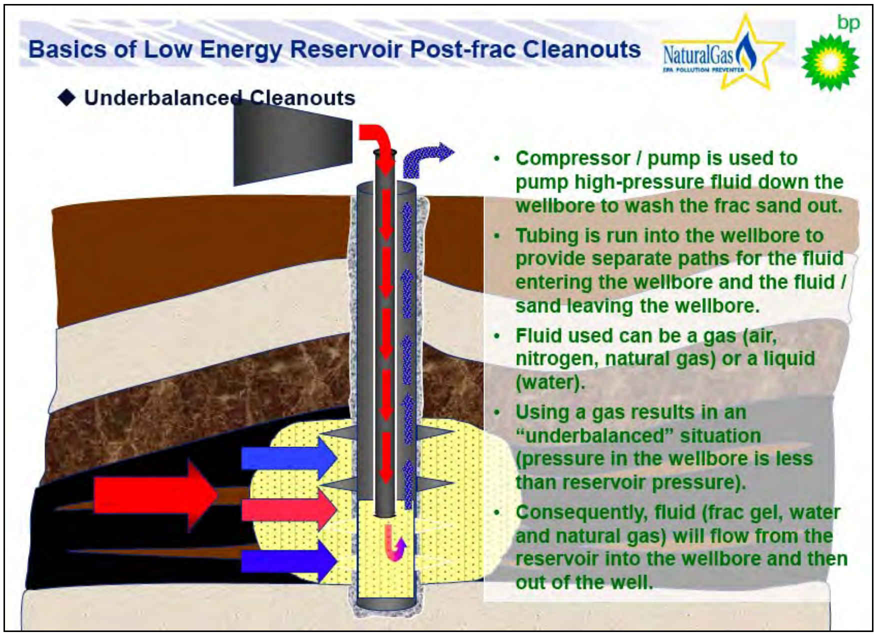
[42] New Mexico Environmental Improvement Board. Direct Testimony of Darren Smith. In the Matter of the Petition for Hearing to Adopt New Regulations and Amend Various Sections of 20.2.1, 20.2.2,20.2.70 AND 20.2.72 NMAC, *Statewide Cap on Greenhouse Gas Emissions New* Energy Economy, Inc., Petitioner. EIB No. 08-19(R). p. 10. Testimony available in pages 6 - 22, at: http://ftp.nmenv.state.nm.us/www/EIB/New%20material%20for%20GHG/EIB%2011-15%20&%2017/NOI's/NMOGA's%20NOI%20to%20Present%20Technical%20Testimony/NMOGA-Direct%20Testimony-Darren%20Smith.pdf

[43] New Mexico Environmental Improvement Board. Direct Testimony of Bruce A. Gantner, PE. *In the Matter of the Petition for Hearing to Adopt New Regulations and Amend Various Sections of 20.2.1, 20.2.2,20.2.70 and 20.2.72 NMAC, Statewide Cap on Greenhouse Gas Emissions. New Energy Economy, Inc., Petitioner.* EIB No. 08-19(R). ftp://ftp.nmenv.state.nm.us/www/EIB/June_21_2010_Meeting/EIB%2010-04/EIB%2010-04%20Pleading%20Documents%2035%20and%2036/Item%2035%20A%20Direct%20Testimony%20of%20Bruce%20A.%20Gantner.pdf

[44] 2004. "BP invites environmental solutions." *Weatherford W Magazine*. p. 18. http://www.weatherford.com/weatherford/groups/web/documents/weatherfordcorp/wft016133.pdf

Weatherford and BP overcame the pressure barrier. What they did was gather natural gas from BP's gathering system sales line, compress the gas and inject it downhole. The energy from the injection lifted flowback and formation fluids and sand to the surface, where a separator removed sand and fluids and routed the gas back into BP's sales line.

Figure 4. Description of RECs in low-pressure reservoirs.



As described in Figure 4, the injection of gas created an underbalanced situation where the pressure in the wellbore was less than the pressure in the low energy reservoir.

By reducing pressure within the well, the hydraulic fracturing fluids and gas from the formation were able to flow into the well and be cleaned out, clearing the way for methane to flow to the well.[45]

EPA and others refer to this type of clean-out process as "gas lift." According to EPA, "in low-pressure (i.e. low energy) reservoirs RECs are often carried out with the aid of compressors for gas lift. Gas lift is accomplished by withdrawing gas from the sales line, boosting its pressure, and routing it down the well casing to push the frac fluids up the tubing. The increased pressure facilitates flow into the separator and then the sales line where the lift gas becomes part of the normal flowback that can be recovered during an REC."[46]

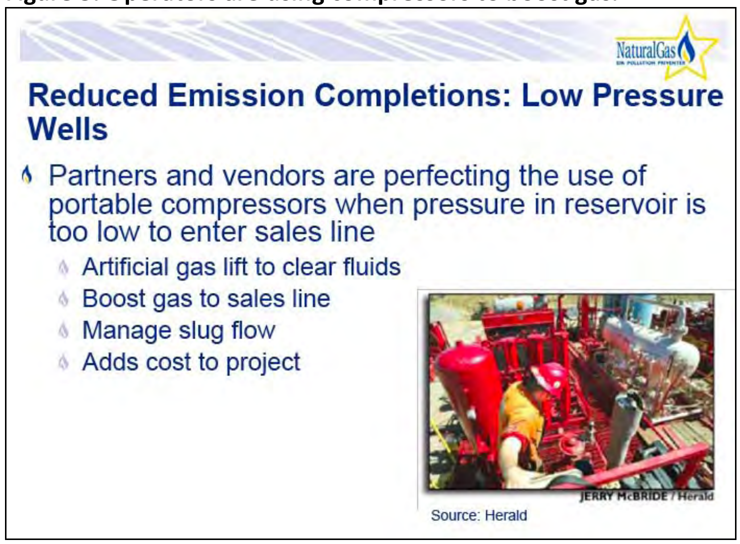
[45] Smith, R. (BP). 2011. Using Reduced Emission Completions (RECs) to minimize emissions during flow-back of hydraulically fractured gas wells." Presentation at the Global Methane Initiative All-Partnership Meeting, Oil and Gas Subcommittee – Technical and Policy Sessions. Krakow, Poland. Oct. 14, 2011. http://www.globalmethane.org/documents/events_oilgas_101411_tech_smith.pdf.

[46] U.S. Environmental Protection Agency Gas STAR Program. "Reduced Emissions Completions." Lessons Learned from Natural Gas STAR Partners. http://www.epa.gov/gasstar/documents/reduced_emissions_completions.pdf

2.1.2. Overcoming the sales line pressure

In addition to finding a way to carry out RECs in low-pressure reservoirs, companies have been able to overcome the problem of sales line pressure, as well as other perceived barriers to RECs (which will be discussed in Sections 3.1 and 3.2).

Figure 5. Operators are using compressors to boost gas.[49]



In some situations, the flowback or completion gas recovered in an REC separator is at a lower pressure than the sales line.[47] When this occurs, portable wet screw compressors can be used to boost the low-pressure gas into the sales line until normal reservoir flow and pressure are established.[48] The portable screw compressors can then be moved to the next REC site.

2.2. RECs will reduce emissions of VOCS from CBM wells

As part of EPA's rationale for the proposed NSPS for well completions, the agency wrote that:

> *. . .we identified that coalbed methane wells often have low to almost no VOC emissions, even following the hydraulic fracturing process. We solicit comment on criteria and thresholds that could be used to exempt some well completion operations occurring in coalbed methane reservoirs from the requirements for subcategory 1 wells.*[50]

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[47] *ibid.*

[48] Bylin, C. Robinson, D., Seastream, S., Gillis, B., Bocanegra, J. Ellwood, B., Richards, S., Cornejo, F., Ishkov, A., Akopova, G. and Boyarchuk, N. 2009. "Methane's role in promoting sustainable development in the oil and natural gas industry." Paper was originally published for the 24th World Gas Conference that took place in Buenos Aires, Argentina on 5-9 October 2009. http://www.epa.gov/gasstar/documents/best_paper_award.pdf.

[49] ConocoPhillips, New Mexico Environment Department and New Mexico Oil and Gas Association. May 11, 2010. "Reducing methane emissions from production wells: Reduced emission completions," EPA Natural Gas STAR Producers Technology Transfer Workshop, Farmington, New Mexico. http://epa.gov/gasstar/documents/workshops/farmington-2010/08_recs_farmington_nm_final.pdf

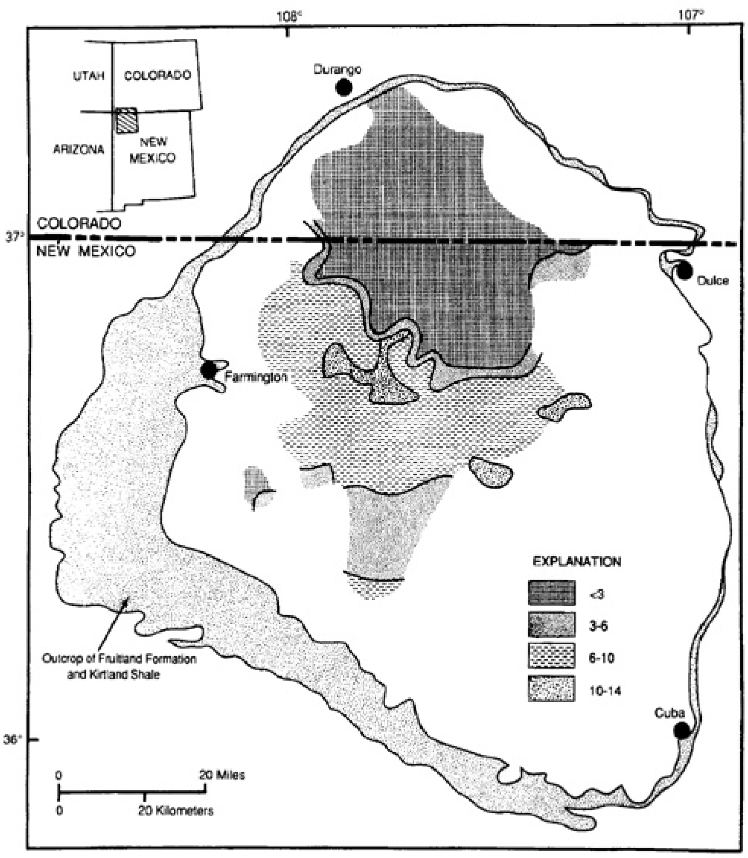
[50] U.S. Environmental Protection Agency. August 23, 2011. *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review. Proposed Rule.* Paragraph 76 FR 52758, p. 52758. http://www.federalregister.gov/articles/2011/08/23/2011-19899/oil-and-natural-gas-sector-new-source-performance-standards-and-national-emission-standards-for#p-352

2.2.1. CBM gas can have a high VOC content

Some coalbed methane basins and formations contain a very high percentage of methane and very low amounts of volatile organic compounds (VOCs). For example, it has been reported that typical Powder River Basin wells have a wet gas content of 0.1%, meaning that the "dry gas" or methane content is 99.9%. Fruitland CBM in Colorado has also been reported as having very high methane content (99.6%). (See Table 5)

According to Rice (2000), one reason for the high methane concentration is that aerobic microorganisms can thrive in shallow, wet coalbed formations like the Powder River and sections of the Fruitland formation in Colorado. Aerobic bacteria preferentially attack wet gas components, resulting in their conversion to lighter hydrocarbons and ultimately creating a higher concentration of methane gas.[51]

Figure 6. Wetness (C2+) of Fruitland Formation CBM gas.[52]



Other CBM formations or parts of CBM formations, however, contain considerable concentrations of wet gas.

For example, in the southern part of the San Juan Basin, Fruitland coalbed methane, Rice reports that, "gases are generally wet (C_{2+} values generally greater than 6%)," (Figure 6) and oil is produced in association with the wet gases.[53]

[51] Rice, D. (U.S. Geological Survey). 2000. "Composition and origins of coalbed gas," Adapted from article of same title in *Hydrocarbons from Coal*. Association of American Petroleum Geologists. Studies in Geology No. 38. p. 174. http://www.searchanddiscovery.com/documents/rice/images/rice.pdf

[52] Rice (2000). See footnote 49. http://www.searchanddiscovery.com/documents/rice/images/fig18.htm

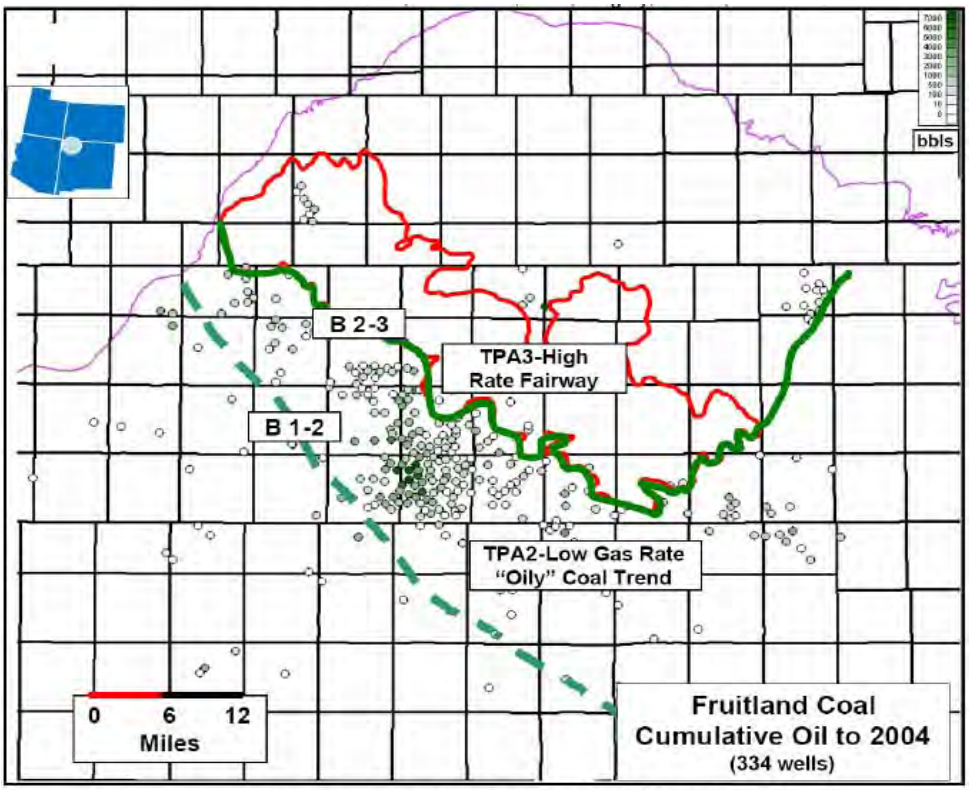
[53] Rice, D. (U.S. Geological Survey). 2000. See footnote 49. p. 174. http://www.searchanddiscovery.com/documents/rice/index.htm#11%20San%20Juan%20Basin,%20New%20Mexico%20and%20Colorado,%20USA

Figure 7 shows the region of the Fruitland Coalbed Methane Basin where wells produce oil. According to Meeks and Levine (2006):

> *South of B2/3 (within TPA2), the reservoir is underpressured, permeability and production rates are low, and wells produce wet gases (rich in C_{2+}) with little or no water. Most of the wells that report oil production from the Fruitland Coal are also located in this area.*[54]

In 2004, cumulative oil production from Fruitland CBM wells was more than 239,000 barrels.[55]

Figure 7. Fruitland Coalbed Methane wells that co-produce oil.[56]



Fruitland Coal: Cumulative oil to 2004 (334 wells).

Detailed information on gas composition from CBM Basins in the U.S. is limited. Table 5 includes partial gas composition data for several CBM basins/formations, and shows that there are several CBM basins where wells may contain appreciable concentrations of wet gas (e.g., Virginia, San Juan Basin, Piceance Basin, Arkoma Basin and Black

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[54] Meek, R. and Levine, J. May 3, 2006. "Delineation of Four "Type Producing Areas" (TPAs) in the Fruitland Coal Bed Gas Field, New Mexico and Colorado, Using Production History Data." Paper modified from presentation at the American Association of Petroleum Geologists (AAPG) Annual Convention, Calgary, Alberta. June 19-22, 2005. AAPG Article #20031. p. 6. http://www.searchanddiscovery.com/documents/2006/06025meek/images/meek.pdf

[55] *ibid.* p. 1.

[56] *ibid.* p. 5.

Warrior Basin). If completion emissions are vented (or flared) wells in these areas will release VOCs to the atmosphere.

Table 5. Average gas profiles (% composition) for some CBM formations.

Basin	N_2	CO_2	CH_4	Ethane	Propane	Butane	Pentane	Hexane	Wetness (C2+)
Fruitland Coal, CO[57]			99.6	0.34	0.03	0.01	0.01	0.03	
Mary Lee Seam, Warrior Basin[58]	3.4	0.1	96.2	0.01					0.71
D Coal Seam, Piceance Basin, CO[59]		6.38	90.3	2.66					0.71
Virginia[60]		0.5	97						2.5
Greene County, PA[61]	Part of 6%	Part of 6%	94	Part of 6%	Part of 6%	Part of 6%	Part of 6%		
Powder River Basin, MT and WY[62]		1.4 - 3.2							0 – 0.1
San Juan Basin, CO and NM[63]		0 - 13.5							0 - 23
Piceance Basin, CO[62]		0 - 25.4							0.1 - 17.8
Arkoma Basin, OK[62]		0.1 – 1.6							0.1 – 4.3
Black Warrior Basin, AB, MS[62]		0.1 – 0.2							0 - 4

Unfortunately, no data were found on the actual VOC emissions from CBM wells completed in areas that contain wet gas. Consequently, it is not possible to determine the potential emissions or cost-effectiveness of controlling a ton of VOC emissions from wet gas CBM wells in particular.

2.2.2. VOCs from dry gas

Based on gas composition and other well completion data acquired via an industry

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[57] ENVIRON. August 2009. Programmatic Environmental Assessment (PEA) for 80-acre Infill Oil & Gas Development on the Southern Ute Indian Reservation. Appendix A. "Emission Inventory." Table A-7. VOC Speciation for venting, flaring, pneumatic devices and fugitive emissions from CBM wells in Colorado. P. 44. http://www.suitdoe.com/Documents/Appendix_G_AirQualityTSD.pdf

[58] Hewitt, J.L.: "Geologic Overview, Coal, and Coalbed Methane Resources of the Warrior Basin-Alabama and Mississippi," in C.T. Rightmire, G.E. Eddy, and J.N. Kirr (eds.), *Coalbed Methane Resources of the United States: American Association of Petroleum Geologists Studies in Geology,* (1984) 17, 73-104. **Cited in:** Halliburton. June 2007. *Coalbed Methane: Principles and Practice*. Chapter 1. p.20. http://www.halliburton.com/public/pe/contents/Books_and_Catalogs/web/CBM/H06263_Chap_01.pdf

[59] *Unconventional Natural Gas*, M. Satriana (ed.), Noyes Data Corp., Park Ridge, New Jersey (1980). **Cited in:** Halliburton, 2007. p. 20. See footnote 56.

[60] Rice, D. 1995. "Geologic framework and description of coal-bed gas plays." National Assessment of United States Oil and Gas Resources. **Cited in:** Lyons, P. "Coalbed methane potential in the Appalachian states of Pennsylvania, West Virginia, Maryland, Ohio, Virginia, Kentucky, and Tennessee--An overview." Open-File Report 96-735. U.S. Department of Interior and US Geological Survey. http://pubs.usgs.gov/of/1996/of96-735/cbm_comp.htm

[61] Bruner, K.R., Oldham, A.V., Repine, T.E., Markowski, A.K., and Harper, J.A. 1995. "Geological aspects of coalbed methane in the northern Appalachian coal basin, southwestern Pennsylvania and north-central West Virginia." Gas Research Institute. **Cited in:** Lyons, P. "Coalbed methane potential in the Appalachian states of Pennsylvania,West Virginia, Maryland, Ohio, Virginia, Kentucky, and Tennessee--An overview." Open-File Report 96-735. U.S. Department of Interior and US Geological Survey. http://pubs.usgs.gov/of/1996/of96-735/cbm_comp.htm

[62] Rice, D. (U.S. Geological Survey). 2000. "Composition and origins of coalbed gas," Adapted from article of same title in *Hydrocarbons from Coal*. Association of American Petroleum Geologists. Studies in Geology No. 38. Table 1. pp. 164, 165. http://www.searchanddiscovery.com/documents/rice/images/rice.pdf

[63] *Ibid.* p. 174.

survey, ENVIRON calculated VOC emissions from well completions in the Powder River Basin.[64] In 2006, the highest well completion VOC emissions were found in the following counties:

- Campbell County: 561 tons (initial completions) and 798 tons (recompletions), and
- Johnson County: 72 tons (initial completions) and 102 tons (recompletions)

Wyoming counties in the Powder River Basin produce a mix of CBM, oil and conventional gas. Thus, some of the VOC completions emissions cited above came from oil and gas well completions. Unfortunately, the ENVIRON study (and associated data tables) did not show VOC emissions from CBM well completions versus other types of wells (i.e., oil, conventional gas).

Looking at the major CBM-producing counties in the Powder River Basin (Table 6), those with the highest number of CBM well completions in 2006 also had the highest VOC emissions from well completions. This suggests that CBM wells do indeed contribute some VOCs during well completion. (No data were found on the number of wells that were recompleted in 2006.)

Table 6. VOC emissions during well completion compared to the number of CBM, oil and conventional well completions (2006).[65]

County	VOCs from well completions (tons/yr)	Number of well completions		
		CBM	Oil	Conv. Gas
Campbell	561	1271	73	1
Johnson	72	1010	11	0
Natrona	29	0	72	7
Converse	6	19	9	0
Weston	4	0	38	0
Big Horn	3	0	8	0
Crook	1	0	519	0

Because there were some oil and conventional gas well completions in the counties listed in Table 6, it was not possible to establish the exact contribution of CBM well completions to the VOC emissions. But a rough estimate can be made for Campbell County in 2006:

> **Oil well emissions:** EPA has suggested that the VOC emissions from the completion of conventional (non-fractured) gas and oil wells is low – 0.007 tons

[64] ENVIRON International Corp. Sept. 2011. *Development of Baseline 2006 Emissions from Oil and Gas Activity in the Powder River Basin. Final Report.* http://www.wrapair2.org/pdf/2006_Baseline_Emiss_Powder_River_Basin_092311.pdf

[65] **VOC emissions data from:** ENVIRON. Sept. 2011. Powder River Basin - 2006 Baseline Data Summary Spreadsheet. http://www.wrapair2.org/pdf/2006PowderRiver_Basin_OG_EI_091911_webdist.zip
Well completion data from: Wyoming Oil and Gas Conservation Commission. Data by County. Completions for 2006. Data can be searched at: http://wogcc.state.wy.us/CompCntyMenu.cfm?oops=1

per completion.[66] In other words, 73 oils wells would emit approximately 0.5 tons of VOCs.[67]

Gas well emissions: Assuming that conventional gas wells in the Powder River Basin undergo hydraulic fracturing, VOC emissions from gas wells in Campbell County (2006) would be approximately 22 tons.[68]

CBM well emissions: would be equal to 561 tons VOC (all well completions) - 0.5 tons from oil wells – 22 tons from the conventional gas well = 538.5 tons of VOCs. Given that there were 1,271 CBM well completions in Campbell county, the per-well-completion reduction is 0.42 tons (84 pounds) of VOCs per well.

If approximately 390 CBM wells are drilled in the Powder River Basin per year (see Section 1.2.2), the requirement to use RECs on CBM would have a considerable effect on reducing VOCs in that region (i.e., it would reduce emissions by 164 tons of VOCs).

Table 7. Comparison of potential VOC emissions reductions and costs for Powder River Basin CBM RECs versus other control requirements proposed by EPA.[69]

Emissions Control	Potential yearly VOC emissions reduction (tons/year)
RECS in the Powder River Basin (390 wells)	164
Emissions Control	**Nationwide VOC Emissions Reductions (tons/year)**
Flaring of oil well (completion)	83
Flaring of oil well (re-completion)	44
NSPS Subpart VV - equipment leaks at transmission compressor stations	261
Annual monitoring and maintenance (AMM) at reciprocating compressors well pads	263
AMM at reciprocating compressors transmission compressor stations	12
AMM at reciprocating compressors underground storage facilities	2
Dry seals at centrifugal compressors transmission compressor stations	43
Pneumatic controllers (low bleed) at natural gas transmission and storage	6

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66 U.S. Environmental Protection Agency. August 23, 2011. *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review. Proposed Rule*. Paragraph 76 FR 52759, p**.** 52759. http://www.federalregister.gov/a/2011-19899/p-362

67 73 oil well completions x 0.007 tons VOC per completion = 0.511 tons VOC in Campbell County (2006)

68 EPA has estimated that an REC would reduce VOC emissions from a non-CBM, hydraulically fractured gas well by 22 tons . (**Source:** U.S. Environmental Protection Agency. August 23, 2011. *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Review. Proposed Rule*. Paragraph 76 FR 52758, p**.** 52758. http://www.federalregister.gov/a/2011-19899/p-362http://www.federalregister.gov/a/2011-19899/p-349)

69 U.S. Environmental Protection Agency. 2011. *Regulatory Impact Analysis. Proposed New Source Performance Standards and Amendments to the National Emissions Standards for Hazardous Air Pollutants for the Oil and Gas Industry*. Table 3-3. Estimated Nationwide Compliance Costs, Emissions Reductions, and VOC reduction Cost-Effectiveness by Emissions Sources and Points, NSPS, 2015. p. 3-16. http://www.epa.gov/ttnecas1/regdata/RIAs/oilnaturalgasfinalria.pdf

As seen in Table 7, this level of reduction is in the same ballpark as a number of the "nationwide emissions reductions" for other air emissions controls proposed by EPA.

2.2.3. VOCs from flaring

One estimate of VOC emissions specific to CBM well completion flaring was found. The 2009 Programmatic Environmental Assessment for the Southern Ute Indian Tribe CBM infill project reported that during well completion "some wells in the project area will flare natural gas." [70] It was also revealed that 32 pounds of VOCs would be emitted during the flaring of Fruitland CBM completion gas (Table 8).

Table 8. Computed flaring emission rates (From Environ, 2009. Table A-16).[71]

Pollutant	Gas burned per well (10^6 Btu)	Emissions per well (lbs/10^6 Btu)	Emissions (lbs/well)
$PM_{2.5}$	5,000	0.0062	31
PM_{10}	5,000	0.0062	31
SO_2	5,000	0	0
NO_x	5,000	0.068	340
CO	5,000	0.37	1,850
VOC	5,000	0.0063	32

Based on the SUIT data, flared emissions, i.e., controlled emission, of CBM well completion gas in the Colorado portion of the San Juan Basin, release 32 pounds of VOCs, so the uncontrolled (vented) emissions of VOCs would be considerably higher.

If RECs are used on CBM well completions, the majority of emissions associated with completion venting and flaring, including the VOCs, will be prevented.

3 Additional information to support the requirement for CBM RECs

3.1. Overcoming the problem of air and inert gases

It has been suggested that, "green completions are not feasible with when air, carbon dioxide or nitrogen is used as the stimulation fluid because any gases produced from the wellbore must meet pipeline specifications after simple separation operations, which do not work for air and other inert gases."[72]

[70] Environ. August 2009. *Programmatic Environmental Assessment (PEA) for 80-acre Infill Oil & Gas Development on the Southern Ute Indian Reservation.* Appendix A. "Emission Inventory." p. 44. http://www.suitdoe.com/Documents/Appendix_G_AirQualityTSD.pdf

[71] *ibid.*

[72] *Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews*," 76 Fed. Reg. 52738 (August 23, 2011), Docket ID No. EPA-HQ-2010-0505. "Comments of the Railroad Commission of Texas." http://www.rrc.state.tx.us/forms/reports/notices/EPA-RRC-Letter-Comments-10-25-11.pdf

As will be demonstrated below, it is feasible to conduct RECs on wells that use inert gases by venting some of the gas until it meets pipeline specifications. A preferable option, however, is to remove or replace oxygen, CO_2 and/or N_2 so that venting does not have to take place.

3.1.1. Overcoming the problem of oxygen in gas

During the Four Corners Air Quality Taskforce, it was suggested that, "many operators [in the San Juan Basin] use compressed air to fracture coal wells. Air mixed with natural gas cannot be shipped to a pipeline due to the high potential for spontaneous combustion under typical pipeline temperatures and pressures. Additionally, oxygen contamination of natural gas causes additional corrosion risks to gathering lines. Separation of air from natural gas is presently not feasible nor part of the process equipment used in "green completions."[73]

As mentioned previously, despite what others viewed as impossible conditions, BP developed a way to perform green completions in coalbed methane reservoirs in the Colorado portion of the San Juan Basin. Instead of worrying about removing oxygen (O_2) from CBM gas, BP changed its completion process. BP overcame the explosion hazard of oxygen by replacing compressed air with compressed methane (pipeline gas) during its well clean-outs.

If other operators do not want to use methane to clean-out/complete wells, there are units that can reduce the O_2 content of gas. For example, Newpoint has designed and built a plant to remove oxygen from coalbed methane in Utah.[74] Newpoint has also developed "skid-mounted systems for oxygen removal in all natural gas streams. The X-O2™ systems are designed to handle gas at any volume and various types of contaminants including sulfur and chlorine compounds at minimal operational cost."[75]

While the use of portable O_2-removal units are not yet included in the typical suite of green completion equipment, it seems feasible to add this technology to the process.

3.1.2. Overcoming the problem of N_2 in gas

Inert gases such as CO_2 or nitrogen are sometimes used during hydraulic fracturing operations in what are known as "energized fracturing" operations.

Based on EPA Natural Gas STAR partner experiences, it's been reported that RECs can be performed in combination with CO_2 and N_2 energized fracturing. "The process is generally the same with the additional consideration of the composition of the flowback

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[73] Four Corners Air Quality Taskforce. Nov. 2007. *Final Report.* "Oil and Gas Section Report of Mitigation Options." p. 32. http://www.nmenv.state.nm.us/aqb/4c/Docs/4CAQTF_Draft_Report_vers_7_OilGasExpProd.doc

[74] Newpoint Gas web site: "2 MMscfd X-O2 plant." http://www.newpointgas.com/project_detail.php?id=128

[75] Newpoint Gas web site: "X-O2™ - Oxygen (O2 removal from natural gas." http://www.newpointgas.com/naturalgas_oxygen.php

gas. The percent of inert gases in the flowback gas is, at first, unsuitable for delivery into the sales line. As the fraction of inerts decreases, the gas can be recovered economically."[76]

At the New Mexico Environmental Improvement Board hearing in 2010, ConocoPhillips testified that, "gatherers in the San Juan Basin will not accept gas for sale until the nitrogen content has reached a suitable level and no oxygen is present. One gatherer has a 10% nitrogen allowance which means the well clean-out phase must continue to be vented to atmosphere until that level is reached. Another gatherer in the basin has a 20% nitrogen content threshold so **a well can be placed on closed-loop recovery earlier** than in the preceding case."[77][emphasis added]

In the San Juan Basin, ConocoPhillips has been developing a "Gas Recovery Cleanout System." In Phase 1 and 2 of their project, ConocoPhillips performed fracturing jobs with cross-linked gel and slickwater "to eliminate the N_2 issues." During Phase 3 of their Gas Recovery Cleanout program, however, the company incorporated N_2-energized fracs, and reported that they developed a process "to get the N_2 % down to meet pipeline specs."[78] Unfortunately, the presentation did not describe how ConocoPhillips was able to reduce N_2 to pipeline specifications.

One possibility is that ConocoPhillips used a portable nitrogen-rejection unit (NRU) to separate out the N_2. According to an EPA Gas STAR presentation, 16% of U.S. gas reserves contain large volumes of nitrogen and must be treated to meet heat content specifications (approximately 4% N_2 by volume). "Unacceptable levels of N_2 can be removed with a nitrogen rejection unit."[79]

The EPA presentation focused on NRUs at gas processing plants. But there are several companies that claim to be able to remove N_2 from wellhead and well completion gases with portable NRUs. For example:

- Guild Associates' Molecular Gate™ adsorption systems for upgrading

[76] U.S. Environmental Protection Agency Gas STAR Program. "Reduced Emissions Completions." Lessons Learned from Natural Gas STAR Partners. http://www.epa.gov/gasstar/documents/reduced_emissions_completions.pdf

[77] New Mexico Environmental Improvement Board. Direct Testimony of Bruce A. Gantner, PE. In the Matter of the Petition for Hearing to Adopt New Regulations and Amend Various Sections of 20.2.1, 20.2.2,20.2.70 and 20.2.72 NMAC, *Statewide Cap on Greenhouse Gas Emissions. New* Energy Economy, Inc., Petitioner. EIB No. 08-19(R). pp. 9, 10. ftp://ftp.nmenv.state.nm.us/www/EIB/June_21_2010_Meeting/EIB%2010-04/EIB%2010-04%20Pleading%20Documents%2035%20and%2036/Item%2035%20A%20Direct%20Testimony%20of%20Bruce%20A.%20Gantner.pdf

[78] Jonas, A., Gregoire, J. and Bertoglio, G. (ConocoPhillips). "SJBU – Completions. Gas Recover Cleanout System." Presentation at the EPA Natural Gas STAR Producers Technology Transfer Workshop. Farmington, NM. May 11, 2010. http://www.epa.gov/gasstar/documents/workshops/farmington-2010/03_conoco_phillips_gas_recovery_unit_epa_presentation.pdf

[79] Devon Energy, Enogex, Dynegy Midstream Services and EPA's Natural Gas STAR Program. April 22, 2005. Optimizing Nitrogen Rejection Units. Presentation at the EPA Gas STAR Processor's Technology Transfer Workshop. Oklahoma City, OK. http://www.epa.gov/gasstar/documents/rejection_units.ppt

contaminated natural gas include systems for the removal of N_2, CO_2 or removal of a mixture of the two. As of January 2009, 30 units were in use, and 12 had been supplied for coalbed methane or coal mine methane upgrading.[80] According to the company, " The portability of the system also makes it applicable to purifying associated gas after frac projects."[81]

- The Kansas Geological Survey and American Energies Corporation have developed a micros-scale NRU. It was initially constructed as a means to upgrade low-Btu gas diluted with N_2 in central Kansas. In 2009 field tests the micro-scale NRU was able to upgrade low-pressure (<100 psig) and low-volume (≈ 100 Mcfd) low-btu gas to pipeline quality. The cost of the unit is $120,000.[82] According to the developers, the plant can be used in other types of upgrading applications such as N_2 removal from landfill and frac gases.[83] The unit is designed as skid-mounted modular units so that the plant is mobile and scalable as per changing feed volumes.[84]
- IACX Energy's Nitrogen Sponge cleans nitrogen-contaminated natural gas at low-pressures and volumes. According to the company, Nitrogen Sponge allows for economic, small scale processing at the well head or compressor station.[85] "IACX's innovative mobile nitrogen rejection unit allows natural gas drillers using nitrogen fracs to treat the initial flows of natural gas and send that gas to pipelines, rather than release the methane to the atmosphere."[86]
- Membrane Technology Research has a NitroSep™ system, which the company says can produce pipeline-quality or pipeline-acceptable gas and a nitrogen-rich fuel from raw natural gas with N2 content of 4 – 50%. The system uses proprietary membranes that are more permeable to methane, ethane, and other hydrocarbons than to nitrogen. The skid-mounted system can be installed in 1-2 days and "is easily moved from one location to another."[87]

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[80] Mitariten, M. 2005. (Updated January 2009). "Molecular Gate adsorption system for the removal of carbon dioxide and/or nitrogen from coalbed and coal mine methane," Paper presented at the Western States Coal Mine Methane Recovery and Use Workshop. Grand Junction, CO, April 19-20, 2005. http://www.moleculargate.com/nitrogen-rejection-N2-removal/Coal-Bed-Coal-Mine-Methane-Upgrading.pdf

[81] Guild Associates, Inc. web site: "Molecular Gate SPEC Plant for N_2 removal from smaller flow rates." http://www.moleculargate.com/nitrogen-rejection-N2-removal/Molecular-Gate-SPEC-Plant-N2-Removal.html

[82] Bhattacharya, S., Newell, K., Watney, W. and Sigel, M. Oct. 26, 2009. "Field tests prove microscale NRU to upgrade low-btu gas." *Oil and Gas Journal*. Vol. 107, Issue 40. http://www.ogj.com/articles/print/volume-107/issue-40/Processing/field-tests-prove-microscale-nru-to-upgrade-low-btu-gas.html Accessed Nov. 22, 2011.

[83] Bhattacharya, S., Newell, K., Watney, W. and Sigel, M. 2009. "A cost-effective solution for upgrading low-pressure, low-BTU natural gas: an experiment with a micro-scale pressure-swing adsorption plant in central Kansas." AAPG Search and Discover Article #90097. Tulsa Geological Society, Tulsa, Oklahoma. http://www.searchanddiscovery.com/abstracts/html/2009/midcon/abstracts/bhattacharya.htm

[84] Bhattacharya, S., Watney, W., Newell, K., Magnuson, M. May 2009. *Demonstration of a Low-Cost 2-Tower microscale N2 Rejection System to Upgrade Low-BTU Gas from Stripper Wells*. Report to U.S. Department of Energy. DOE Award No: DE-FC26-04NT42098. p. 16. http://www.kgs.ku.edu/PRS/Microscale/Reports/42098_final.pdf

[85] IACX Energy web site: "Nitrogen Sponge." http://www.iacx.com/nitrogensponge/

[86] Haddinton Ventures, LLC. web site: "Environmental Impact." http://www.hvllc.com/en/cms/172/

[87] Membrane Technology Research web site: "Nitrogen removal from natural gas: NITROSEP™. http://www.mtrinc.com/nitrogen_removal.html

It appears that the technology already exists to reduce N_2 concentrations in fracturing flowback/well completion gases. We believe that ConocoPhillips and other companies can and will continue to improve these technologies and bring down the costs.

3.1.3. Overcoming the problem of CO_2 in gas

While it is true that natural gas with high CO_2 cannot go immediately into a natural gas sales pipeline,[88] it can be routed through gathering lines to a facility that can remove the CO_2.[89] In the San Juan Basin, CBM gas contains up to 18% CO_2. Much of this gas is eventually removed at natural gas processing plants. (See Section 3.5)

CO_2 can also be removed at the well site. Natural gas containing CO_2 is co-produced in oil fields that use CO_2-enhanced to increase oil production. At these sites "produced fluids are separated and the produced gas stream, which may include amounts of CO_2 as the injected gas begins to break through at producing well locations, must be further processed."[90] CO_2 membrane technology exists to remove CO_2 from gas recovered from these wells.[91]

CO_2 used during the hydraulic fracturing process can also be recovered at the well site. According to Ron Schendel, this technology was being used as long ago as 1986. "Immediately following a CO_2 frac, membranes may be used to remove CO_2 from methane in the associated gas and as the CO_2 content comes back down, the membranes may be removed and used elsewhere. Separex reports at least two portable membrane systems are in use for this application, and one of these has already been used at three sites."[92]

EPA Natural Gas STAR has also mentioned that portable membrane acid gas separation units can increase the amount of methane recovered for sales after a CO_2 energized fracture.[93]

Noble Energy has reported using membrane technology to remove CO_2 following 10

[88] Most interstate pipelines require less than 4% CO2, and sometimes less than 2%. (**Source:** Foss, M. 2004. *Interstate Natural Gas – Quality specifications & interchangeability*. See Table: Snapshot of Selected U.S./Canada Natural Gas Transmission Pipeline's General Terms and Conditions on Gas Quality and OFO's. p. 15. http://www.beg.utexas.edu/energyecon/lng/documents/CEE_Interstate_Natural_Gas_Quality_Specifications_and_Interchangeability.pdf)

[89] See Figure 2 **In**: Moritis, G. May 2001. "Future of EOR & IOR." *Oil and Gas Journal Special Report*. http://www.kindermorgan.com/business/co2/article_052001.pdf

[90] U.S. Department of Energy. March 2010. *Carbon Dioxide Enhanced Oil Recovery*. p. 6. http://www.netl.doe.gov/technologies/oil-gas/publications/EP/small_CO2_eor_primer.pdf

[91] For example, Cameron's CYNARA CO2 Separation System. http://www.c-a-m.com/Forms/Product.aspx?prodid=e20af1ea-0c38-4934-8d1d-f120aeb891a7

[92] Schendel, R. "Separation of Acid Gases and Hydrocarbons," Priestly Conference, Leeds, England, September 16 - 18, 1986. p. 4. Article available at: http://www.rschendel.com/PUBLICATIONS.htm

[93] U.S. Environmental Protection Agency Gas STAR Program. "Reduced Emissions Completions." Lessons Learned from Natural Gas STAR Partners. http://www.epa.gov/gasstar/documents/reduced_emissions_completions.pdf

flowback operations.[94] According to Noble, typically well completion gas would be sent to flare for several days until the CO_2 levels in the flowback gas were reduced to pipeline quality and/or became suitable for blending. To decrease methane emissions and increase the volume of gas sold, Noble Energy conducted a pilot project using portable (skid-mounted) CO_2 membrane technology. The company reported that the membrane technology prevented the release of 170 MMcf of CH_4. Previously, this gas would have been flared until CO_2 levels were down to acceptable levels). The cost of the membrane unit was $325,000 (including equipment rental and labor). Using an assumed gas sales price of $3.12/million BTU, Noble's net profit was $340,000, or an average of $34,000 per well.[95]

3.2. Well-developed pipeline infrastructure enables RECs in CBM basins

As CBM basins are developed, infill drilling or downspacing occurs. Some CBM basins are already well developed, and so the remaining wells to be drilled are infill wells. For example, the when development first started in the San Juan Basin (1988) wells were spaced at one per 320 acres. This was reduced (down-spaced) to 160 acres in 2000. Beginning in 2005 companies began requesting and being granted 80-acre spacing.[96] What this means is that these companies have access to either their own or third-party pipelines (gathering/sales lines).

During the New Mexico Environmental Improvement Board (EIB) hearing, Devon Energy testified that access to third-party gathering lines is seen as a barrier to use of RECs for operators that do not own their own gathering systems:

> *Without the line, you cannot perform a green completion. In order for an Operator to be able to perform green completions on wells they would have to rely on the third party gathering company to make adjustments to their right of way and permitting work to track an Operator's constantly changing drilling schedule, take on the capital risk that the well will be commercial before it is tested, and predict the correct line size before a well is tested or the development in an area is known. It is these risks and uncertainties make third party green completions impractical.*[97]

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[94] Wadas, J. (Noble Energy). Nov. 3, 2010. "Reduced vented flowback emissions from CO_2 fractured gas wells using membrane technology." Presentation at the 17th Annual Natural Gas STAR Implementation Workshop. http://www.epa.gov/gasstar/documents/workshops/2010-annual-conf/01wadas.pdf.

[95] Noble Energy. Spring 2011. EPA Natural Gas STAR Partner Update. Pp. 2, 3. http://www.epa.gov/gasstar/documents/ngspartnerup_spring11.pdf

[96] Lindblom, S. and Spray, K. 2009. Colorado Oil and Gas Conservation Commission. Sept. 25, 2009. "Coalbed methane production, San Juan Basin." p. 13. http://cogcc.state.co.us/Library/Presentations/PagosaSprings_Hearing_Sept25_09/9-25-09_Hearing_SJBasin_staffpres.pdf

[97] New Mexico Environmental Improvement Board. Direct Testimony of Darren Smith. In the Matter of the Petition for Hearing to Adopt New Regulations and Amend Various Sections of 20.2.1, 20.2.2,20.2.70 AND 20.2.72 NMAC, *Statewide Cap on Greenhouse Gas Emissions New* Energy Economy, Inc., Petitioner. EIB No. 08-19(R). p. 12. Testimony

Yet ConocoPhillips has demonstrated that they have been able to work with third party gatherers when performing RECs to overcome the "impracticalities" of tying into their systems. Part of ConocoPhillips' strategy for working with third party gatherers, which they shared in an EPA Gas STAR presentation, is "to continue letting the pipeline companies know when we are using a gas recovery cleanout many wells in advance."[98]

Clearly, some of the barriers perceived by some companies can be overcome without much hassle or expense.

3.3. RECs are a proven technology for CBM wells in the San Juan Basin

In a report published by IHS CERA regarding EPA's proposed regulations, the consulting firm was critical of EPA, saying that the agency overestimated the amount of gas being vented during well completions. At the same time, however, the IHS CERA acknowledged that:

> *. . .many operators already follow the practices that the standard requires. Common industry practice is to capture gas for sale as soon as it is technically feasible. . . The proposed standards have the potential to codify good operating practice in the gas drilling industry*."[99]

La Plata County, in the San Juan Basin of Colorado, has not codified a requirement to use green completions, but it has taken steps to encourage CBM operators to utilize this good operating practice. Between 2005 and 2009, ten companies signed Memorandums of Understanding (MOUs) with La Plata County that included the stipulation that:

> *"[Operator] agrees to utilize reasonable efforts to minimize methane emissions by using "green completion" techniques, and the installation of "low bleed" pneumatic instrumentation, when feasible.*[100]

In the San Juan Basin, dozens of green completions have been carried out over the past few years. While there are no data indicating how many RECs have been conducted by

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available in pages 6 - 22, at: http://ftp.nmenv.state.nm.us/www/EIB/New%20material%20for%20GHG/EIB%2011-15%20&%2017/NOI's/NMOGA's%20NOI%20to%20Present%20Technical%20Testimony/NMOGA-Direct%20Testimony-Darren%20Smith.pdf

[98] Jonas, A., Gregoire, J. and Bertoglio, G. (ConocoPhillips). "SJBU – Completions. Gas Recover Cleanout System." Presentation at the EPA Natural Gas STAR Producers Technology Transfer Workshop. Farmington, NM. May 11, 2010. http://www.epa.gov/gasstar/documents/workshops/farmington-2010/03_conoco_phillips_gas_recovery_unit_epa_presentation.pdf

[99] Barcella, M., Gross, S. and Rajan, S. (IHS CERA). *Mismeasuring Methane. Estimating Greenhouse Gas Emissions from Upstream Natural Gas Development.* (Private Report). p. 10. Accessed Nov.17, 2011. http://heartland.org/sites/default/files/Mismeasuring%20Methane.pdf

[100] La Plata County, Colorado web site: "Memorandums of Understanding & Infill Information." http://co.laplata.co.us/departments_elected_officials/planning/natural_resources_oil_gas/mou

the ten companies that signed the MOU with La Plata County,[101] it is clear that the technology is being used by several companies in the region (e.g., BP, ConocoPhillips, Weatherford).

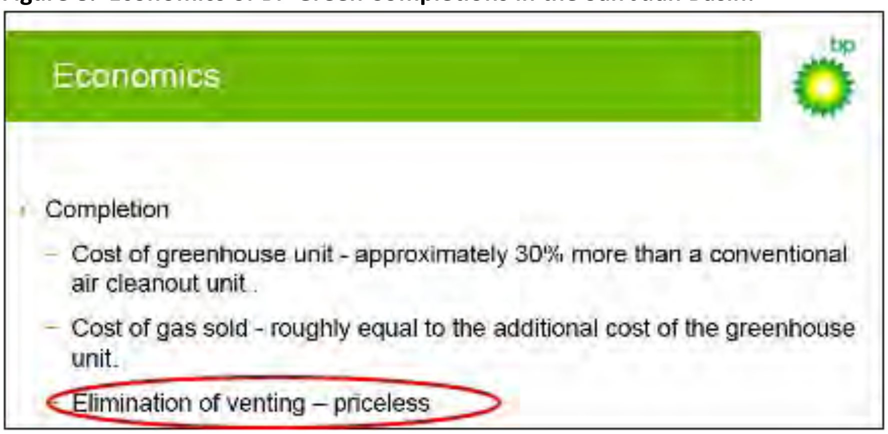
Table 9. Ten companies that have agreed to use green completions in La Plata County.

Year	Companies signing MOU
2005	BP America, Samson
2006	BP America, ConocoPhillips, Elm Ridge, Four Star (Chevron), Maralex, Petrogulf, XTO Energy
2007	BP America, Energen
2008	BP America (4th Infill), McElvain, Four Star (West Animas Indian Creek)
2009	Four Star (Southeast Infill), Four Star (La Posta Rd), McElvain

3.4. REC's are cost-effective for producers in the San Juan Basin

Based on available data from producers in the San Juan Basin, RECs are cost-effective.

Figure 8. Economics of BP Green Completions in the San Juan Basin.[102]



As seen in Figure 8, which is a slide from an EPA Gas STAR presentation by BP in 2007, the cost of greenhouse unit (used for RECs in CBM wells in the San Juan Basin) worked out to be approximately 30% more than a conventional air cleanout unit, but the cost of gas sold was roughly equal to the additional cost of the greenhouse unit. The elimination of venting, as pointed out by BP (emphasis added) was considered to be "priceless."

In a 2010 ConocoPhillips Gas STAR presentation the cost of the green completion equipment for CBM wells in the San Juan Basin was reported to be $4,000 per day and

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[101] La Plata County was not clear on how many companies had used green completions because the county does not track that information. (**Source**: Pers. Comm. Nov. 21, 2011. Courtney Krueger, Oil and Gas Liaison, La Plata County and Lisa Sumi, Earthworks.)

[102] Nye, Bruce. (BP). July 2, 2007. "Greenhouse Gas Reduction Project." Presentation at the EPA Natural Gas STAR Producers Technology Transfer Workshop. Durango, Colorado. Sept 13, 2007. http://www.epa.gov/gasstar/documents/workshops/durango-2007/06_%20bp_rec_Greenhouse_gas_emision_reduction.pdf

recover 2 million cubic feet of gas per well.[103]

The economics, of course, are affected by the price of natural gas. If it is assumed that completions take three days (as they do for BP wells), it would cost $12,000 to perform an REC. By selling the 2 MMcf of gas recovered from their CBM green completions, some of the cost of the REC could be recouped. It would take $6/Mcf wellhead price for ConocoPhillips to break even on their RECs. At a price of $3/Mcf, which is lower than the average wellhead price from 2004 – 2011,[104] the REC ends up costing the company $6,000.[105]

3.5. Controlling CH_4 will help to offset high CO_2 emissions from the oil and gas industry in some regions

Compared to many conventional and unconventional gas reservoirs, coalbed methane in the San Juan Basin contains a high percentage of carbon dioxide (CO_2). The CO_2 that is entrained in the gas is removed using acid gas removal units at natural gas processing facilities, and then vented to the atmosphere.[106] Thus, on top of the methane emissions from leaks, well completions, and other sources, CBM wells in the San Juan Basin release CO_2.

In the San Juan Basin of New Mexico, it has been reported that CBM gas may contain up to 18% CO_2.[107]

In part of the San Juan Basin of Colorado (i.e., La Plata County), data provided by industry suggests that the gas produced in La Plata County "varies in CO_2 concentration across the basin but all measured streams were less than the 17%."[108] It has also been reported, however, that the CO_2 content "is likely to increase due to the fact that the coal seam preferentially releases methane as compared to CO_2. This means that as the methane in the field is drawn down, the coal seam will start to release more CO_2, which will be vented."[109]

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[103] Jonas, A., Gregoire, J. and Bertoglio, G. (ConocoPhillips). 2010. See footnote 90.

[104] U.S. Energy Information Administration web site. "U.S. natural gas wellhead price (dollars per thousand cubic feet). Data for 1973 -2011. http://www.eia.gov/dnav/ng/hist/n9190us3m.htm

[105] 2,000,000 cubic feet = 2,000 Mcf x $3/Mcf = $6,000 worth of gas sold. $12,000 (cost of REC) - $6,000 = $6,000 total cost of REC after selling the recovered gas.

[106] Testimony of Michael Schneider. New Mexico Environmental Improvement Board Hearing. "In the matter of proposed new regulation 20.2.350 NMAC. Greenhouse Gas Cap and Trade Provisions. EIB 10-04. pp. 1, 6 and 12. ftp://ftp.nmenv.state.nm.us/www/EIB/June_21_2010_Meeting/EIB%2010-04/EIB%2010-04%20Pleading%20Document%2018%20NMED%20NOI/NMED%20Notice%20of%20Intent%20EIB%2010-04%20R/Schneider%20Testimony.pdf

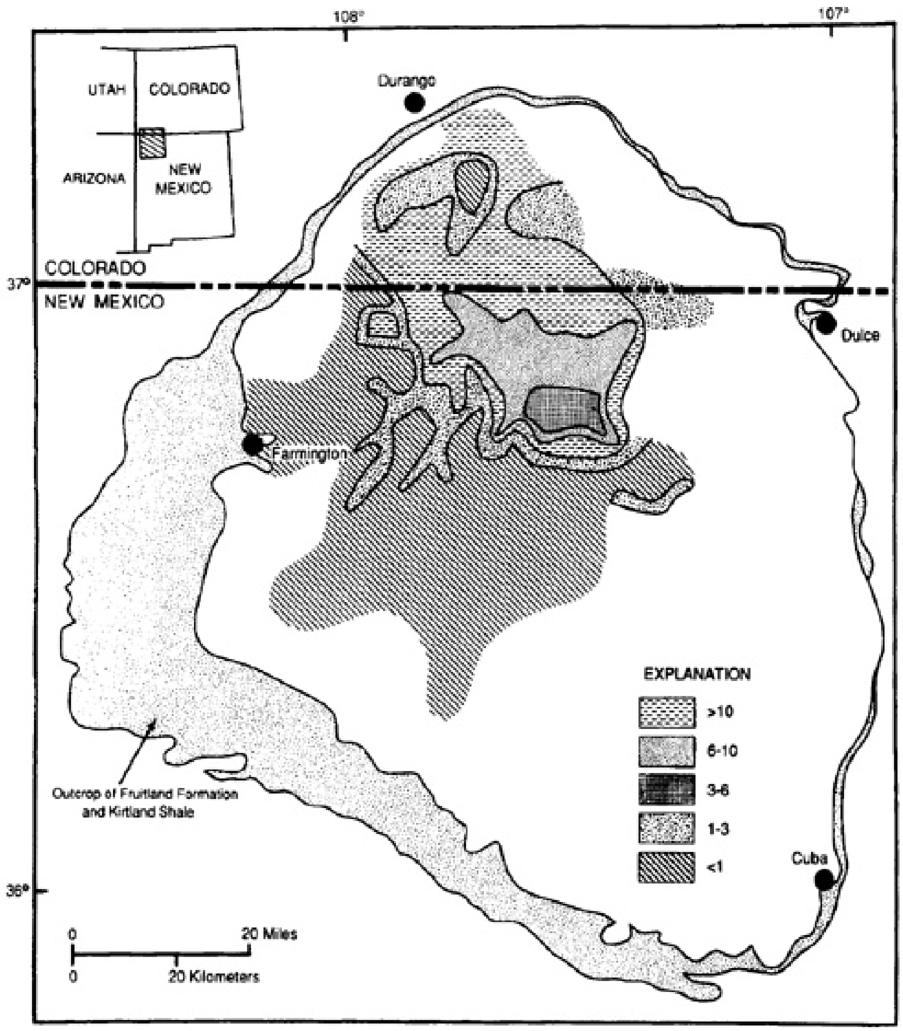
[107] Dixon, D. 2007. *The Economics of New Mexico Natural Gas Methane Emissions Reduction.* p. 11. http://www.unm.edu/~ddixon/papers/Final%20Report-Appendix%20G.pdf

[108] Climate and Energy Action Plan. June 28, 2009. *La Plata County Emissions Inventory Revisions Report.* Draft distributed for public review and comment. p. 3. http://www.fourcore.org/docs/CEAP/PDF_Draft_Emissions_Inventory_Revisions_Report.pdf

[109] *ibid.*

Figure 9 shows how CO_2 content varies over the San Juan Basin.

Figure 9. Carbon dioxide content of Upper Cretaceous Fruitland CBM.[110]



3.5.1. CO_2 emissions from CBM in the San Juan Basin are significant

Based on data from the Oil Conservation Division and the New Mexico Oil and Gas Association, coalbed methane from the Fruitland formation, which accounts for less than a third of New Mexico gas production, is thought to be the most significant source of entrained CO_2 in the State.[111] In 2007, it was reported that 26% of oil and gas sector greenhouse gas emissions in New Mexico were from "venting of carbon dioxide removed from coalbed methane," while CO_2 emissions from combustion (e.g., engines)

[110] Rice, 2000. See footnote 60. http://www.searchanddiscovery.com/documents/rice/images/fig19.htm

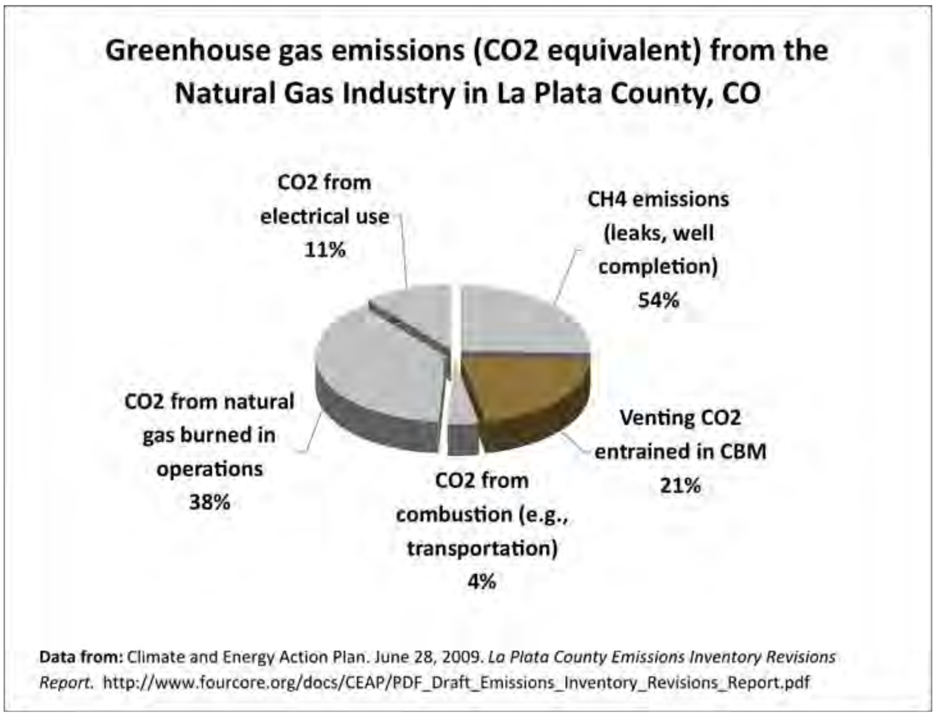
[111] New Mexico Environment Department. Dec. 31, 2007. *Oil and Gas Greenhouse Gas Emissions Reductions.* Final Report. Appendices. Attachment D-2. Fossil Fuel Industry Emissions. p. D-36. http://www.nmenv.state.nm.us/aqb/projects/documents/OandGERFinalReport-Appendices.pdf

contributed about 40% and methane emissions accounted for about one third of the oil and gas industry's emissions.[112]

In 2008, major oil and gas facilities in New Mexico (i.e., those releasing more than 25 metric tonnes of CO_2), were required to report their CO_2 emissions to the NMED. Oil and gas companies reported that 30% of their CO_2 emissions (i.e., just over 2.2 million tonnes) were from carbon dioxide removed from natural gas.[113]

Over the border, in La Plata County (San Juan Basin) vented emissions from CO_2 entrained in CBM gas were calculated to be 1.07 million tons in 2005.[114] As seen in Figure 10, these emissions represented 21% of natural gas industry greenhouse gas emissions in the county.

Figure 10. Greenhouse gas emissions including entrained CO_2 in La Plata County, CO (2009).



[112] New Mexico Environment Department. Dec. 31, 2007. Oil and Gas Greenhouse Gas Emissions Reductions. Final Report. p. 1. http://www.nmenv.state.nm.us/aqb/projects/documents/OilandGasEmissionsReductions-FinalReport.pdf

[113] It was reported that the oil and gas industry emitted 7.8 million tonnes of CO2. 30% of 7.8 million = 2.2 million tonnes from venting of entrained CO2. (**Source:** Testimony of Michael Schneider. New Mexico Environmental Improvement Board Hearing. "In the matter of proposed new regulation 20.2.350 NMAC. Greenhouse Gas Cap and Trade Provisions. EIB 10-04. pp. 1, 6 and 12. ftp://ftp.nmenv.state.nm.us/www/EIB/June_21_2010_Meeting/EIB%2010-04/EIB%2010-04%20Pleading%20Document%2018%20NMED%20NOI/NMED%20Notice%20of%20Intent%20EIB%2010-04%20R/Schneider%20Testimony.pdf

[114] Climate and Energy Action Plan. June 28, 2009. *La Plata County Emissions Inventory Revisions Report.* Draft distributed for public review and comment. p. 3. http://www.fourcore.org/docs/CEAP/PDF_Draft_Emissions_Inventory_Revisions_Report.pdf

In New Mexico and Colorado, CO_2 is typically removed from the gas at gas processing plants, and vented directly to the atmosphere. At the present time, there is no way to economically capture and sequester the CO_2, so this greenhouse gas is simply vented to the atmosphere.

Emissions of CO_2 entrained in coalbed methane gas are going to occur whether or not companies are required to use RECs. But if CBM producers in the San Juan Basin and other regions were required to use RECs, the methane reductions would help offset the currently uncontrolled release of CO_2 from CBM wells and processing plants in the San Juan Basin, thereby reducing the overall GHG impact from these wells.

3.5.2. CO_2 emissions from other CBM basins may be significant

In other parts of the country CBM may also contain high concentrations of CO_2 that could be offset by capturing methane during CBM completions, but data on CO_2 content of CBM gas in other regions is less available.

- Marshall Miller & Associates have reported coalbed methane seams in Appalachia that have CO_2 content higher than **20%**.[115]
- Other reports have found up to **10%** CO_2 content in CBM in the Appalachian Basin.[116]
- Halliburton reports that the D Coalseam of the Piceance Basin of Colorado has a CO_2 content of **6.38%**,[117] while Rice reports CO2 content in the Piceance Basin ranging from 0 – **25.4%**.[118]
- Halliburton reports that the Mary Lee seam of Alabama's Warrior Basin contains just **0.1%** CO_2.[119]
- The 2007 report *Montana GHG Inventory and Reference Case Projection (1999-2020)* acknowledged that CO_2 could be vented from CBM, but did not include any information on CO_2 content of the gas.[120]
- Black Diamond Energy reports that coalbed methane produced from low rank sub-bituminous coal in Wyoming's Powder River Basin (PRB) Coal Field contains 1.5 to

[115] E.g., Sewickley – 25.02, and Pittsburgh – 24.09%. (**Source:** McClure, M.G. (Marshall Miller & Associates.) Sept. 16, 2007. CBM gas composition trends – Central & Northern Appalachian Basins. Presentation to the AAPG Eastern Section, Lexington Kentucky. http://www.mma1.com/company/pdf/papers/CBM%20Gas%20Composition%20Trends.pdf)

[116] Rice, D. 1995. **Cited in**: Lyons, P. "Coalbed methane potential in the Appalachian states of Pennsylvania,West Virginia, Maryland, Ohio, Virginia, Kentucky, and Tennessee--An overview." Open-File Report 96-735. US Department of Interior and US Geological Survey. http://pubs.usgs.gov/of/1996/of96-735/cbm_comp.htm

[117] Halliburton. June 2007. Coalbed Methane: Principles and Practice. Chapter 1. P. 20. http://www.halliburton.com/public/pe/contents/Books_and_Catalogs/web/CBM/H06263_Chap_01.pdf

[118] Rice, D. (U.S. Geological Survey). 2000. "Composition and origins of coalbed gas," Adapted from article of same title in *Hydrocarbons from Coal*. Association of American Petroleum Geologists. Studies in Geology No. 38. Table 1. pp. 164, 165. http://www.searchanddiscovery.com/documents/rice/images/rice.pdf

[119] Halliburton. June 2007. Coalbed Methane: Principles and Practice. Chapter 1. P. 20. http://www.halliburton.com/public/pe/contents/Books_and_Catalogs/web/CBM/H06263_Chap_01.pdf

[120] Bailie, A., Roe, S., Lindquist, H. and Jamison, A. (Climate Strategies). Sept. 2007. *Montana GHG Inventory and Reference Case Projection (1990-2020). Prepared for Montana Department of Environmental Quality. http://www.mtclimatechange.us/ewebeditpro/items/O127F13145.pdf*

2% CO_2,[121] while Swindell reports the gas composition of PRB coalbed methane as containing **2 – 8 mole%** CO_2.[122]

- Penn Virginia Oil and Gas reports that Wilcox Coals in Mississippi contain **1 – 2%** CO_2.[123]

As mentioned previously, it has been reported that in La Plata county CO_2 concentrations in CBM gas vary across the basin. So it's highly likely that the concentrations cited above are not reflective of the entire basins (i.e., there may be areas that have higher or lower CO_2 content than the reported values). Also, as with CO_2 concentrations in CBM gas in the San Juan Basin, it is possible that the concentrations of CO_2 in gas from other CBM basins will increase with time.

Given that wells in CBM basins other than the San Juan Basin are likely to vent CO_2, it makes sense for operators to reduce the greenhouse gas emissions to offset these emissions, and at the present time RECs provide an avenue to achieve significant greenhouse gas reductions by reducing the venting of CH_4 from CBM wells.

3.6. CBM RECs can help prevent release of hydrogen sulfide

A 1991 report to the Gas Research Institute stated that 80% of raw gas that is over specification in carbon dioxide also contains hydrogen sulfide.[124] The same report found that about 13% of presently known and predicted natural gas reserves in the United States (conventional and unconventional) are prone to hydrogen sulfide contamination.[125]

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[121] Black Diamond Energy web site: De Bruin, R., Lyman, R., Jones, R. and Cook, L. "Coalbed methane in Wyoming." http://blackdiamondenergy.com/coalbed.html

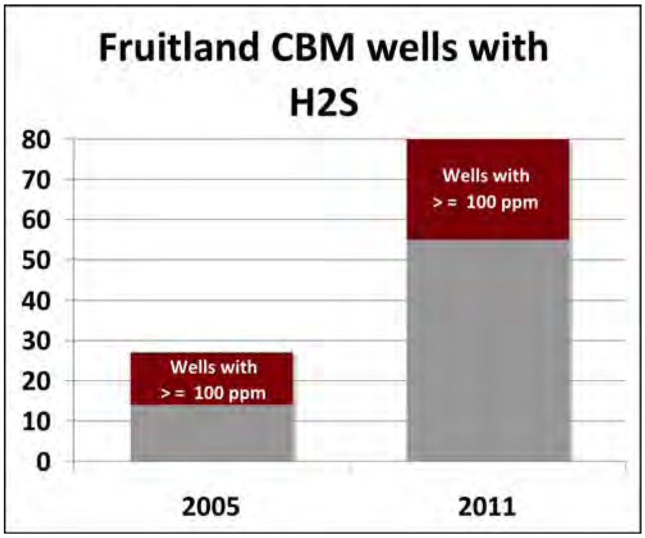
[122] Swindell, G. 2007. "Powder River Basin Coalbed Methane – Reserves and Rates." Paper presented at the Society of Petroleum Engineers (SPE) Rocky Mountain Oil and Gas Technology Symposium, Denver, April 16-18, 2007. SPE paper 107308. http://garyswindell.com/sp107308.htm

[123] Penn Virginia Oil and Gas. Oct. 12, 2005. "Horizontal wells: a viable method for exploitation of coalbed methane form the Wilcox coals of the Central Gulf Coast?" Presentation to the US Oil and Gas Association. p. 5. http://usoga.com/events/presentations/Wilcox_lewis.pdf

[124] A. Dalrymple, F.D. Skinner, and N.P. Maserole (Radian Corporation), "Investigation of U.S. Natural Gas Reserve Demographics and Gas Treatment Processes," Final Report to the Gas Research Institute, Report No. GRI-91/0019 (January 1991). **Cited In:** Lokhandwala, K., Ringer, M., Wijmans, H. and Baker, R. 1998. "Low-quality natural gas sulfur removal/recovery system." Final Report for U.S. Department of Energy. Contract No. DE-AC21-92MC28133-01. http://www.osti.gov/bridge/servlets/purl/775213-ekYSrf/webviewable/

[125] R.H. Hugman, E.H. Vidas, and P.S. Springer (Energy and Environmental Analysis, Inc.), "Chemical Composition of Discovered and Undiscovered Natural Gas in the Lower-48 United States—Project Summary," Final Report to the Gas Research Institute, Report No. GRI-90/0248, NTIS No. PB91-144600 (November 1990). **Cited in:** Lokhandwala, K., Ringer, M., Wijmans, H. and Baker, R. 1998. "Low-quality natural gas sulfur removal/recovery system." Final Report for U.S. Department of Energy. Contract No. DE-AC21-92MC28133-01. http://www.osti.gov/bridge/servlets/purl/775213-ekYSrf/webviewable/

Figure 11. New Mexico Fruitland CBM wells with H_2S.



In 2005, the Bureau of Land Management (BLM) released maps and data showing that there were 375 gas wells the New Mexico portion of the San Juan Basin (SJB), from at least five different producing formations, that contained hydrogen sulfide.[126] Twenty-seven were Fruitland CBM wells, 13 of which contained H_2S above 100 parts per million (ppm). Five wells had concentrations equal to or greater than 500 ppm.[127]

2011 BLM data show 666 H_2S wells in the SJB, 80 Fruitland CBM wells, and 25 Fruitland wells with concentrations at or above 100 ppm. Seven of the Fruitland CBM wells had concentrations equal to or greater than 500 ppm.[128]

The potential that H_2S could be vented at concentrations above 100 ppm in the San Juan Basin is cause for great concern with respect to the health and safety of workers and nearby residents. According to the Occupational Health and Safety Administration, a level of H_2S gas at or above 100 ppm is "Immediately Dangerous to Life and Health."[129] And EPA has reported that "Levels in the range of 500 to 1,000 ppm are life-threatening and can cause immediate unconsciousness followed by serious and debilitating neurologic and respiratory sequelae."[130]

Less information is known about H_2S concentrations in other CBM basins. The BLM reports that in 1987, the Rawhide Butte subdivision within the Powder River Basin had to be abandoned because of hydrogen sulfide and methane gas seeping into the

[126] Hewitt, J. (Bureau of Land Management). 2005. "H2S Occurrences San Juan Basin," a presentation at Hydrogen Sulfide: Issues and Answers Workshop. http://octane.nmt.edu/sw-pttc/proceedings/H2S_05/BLM_H2S_SanJuanBasin.pdf

[127] U.S. Bureau of Land Management. H_2S Wells in San Juan Basin - BLM Data. Posted with Proceedings of PTTC Workshop "H_2S in the San Juan Basin: Issues and Answers." Dec. 2005. San Juan College, Farmington, NM. http://octane.nmt.edu/sw-pttc/proceedings/H2S_05/H2SFarmington.asp

[128] Data requested by San Juan Citizens Alliance, received from Farmington Field Office/BLM lands office Oct. 3, 2011. Data not available on-line.

[129] Occupations Health and Safety Administration. Oct. 2005. Fact Sheet. "Hydrogen Sulfide. H2S." http://www.osha.gov/OshDoc/data_Hurricane_Facts/hydrogen_sulfide_fact.pdf

[130] U.S. Environmental Protection Agency. 2003. *Toxicological Review of Hydrogen Sulfide. CAS No. 7783-06-4*. p. 51. http://www.epa.gov/iris/toxreviews/0061tr.pdf

basements of homes that were built on a coalbed.[131] A 2002 water quality study conducted by the US Geological Survey detected H_2S in ground-water samples c from coalbed methane and adjacent aquifers in the PRB. The same study reported that others have detected H_2S in coalbed gas in the Fort Union Formation in the PRB (Wyoming and Montana).[132] But no data were provided on H_2S concentrations in the CBM gas.

If a newly drilled well contains H_2S, it will be released during completion venting. This is another reason to capture CBM gas rather than venting it. Once a well begins flowing into a pipeline, H_2S within the gas stream can be removed along with CO_2 at gas processing plants (in the acid gas removal units).

Flaring raw gas during well completions will convert some of the H_2S to sulfur dioxide (SO_2), but pit flares are not highly efficient. According to the Wyoming Department of Environmental Quality (DEQ):

> *Flare Combustion Efficiency: Pit flares are not engineered flares. They are simply open ended pipes. Combustion efficiency is a function of the mixture being burned. If there is moisture in the mixture, the efficiency obviously decreases. Since it would be impossible to determine overall efficiency during an entire well completion and since smoke is often observed from the flares, an overall efficiency well below 100% should be used."*[133]

Wyoming DEQ estimates that pit flares are 60% efficient, unless a different efficiency is "known and certifiable."[134]

Thus, some pure H_2S will be vented during completions. And the release of SO_2 is not exactly desirable either. According to EPA, "Current scientific evidence links short-term exposures to SO_2, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects including bronchoconstriction and increased asthma symptoms."[135] Flaring of completion gas can continue for hours or days at a time, so if the gas contains

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[131] U.S. Bureau of Land Management web site: "Coalbed methane - past to present." http://www.blm.gov/wy/st/en/field_offices/Buffalo/cbm.html

[132] Bartos, T. and Ogle, K. (US Geological Survey). 2002. *Water Quality and Environmental Isotopic Analyses of Ground-Water Samples Collected from the Wasatch and Fort Union Formations in Areas of Coalbed Methane Development—Implications to Recharge and Ground- Water Flow, Eastern Powder River Basin, Wyoming*. Prepared in cooperation with the Wyoming State Engineer's Office and the Bureau of Land Management. http://pubs.usgs.gov/wri/wri024045/

[133] Wyoming Department of Environmental Quality web site: Oil and Gas Forms. "CDA Well Completions Emissions Worksheet." (08/2011) Sheet 2 of the Excel Workbook. http://deq.state.wy.us/aqd/Oil%20and%20Gas/COMPLETION_EMISSIONS_8-11-2011.xlsx

[134] Wyoming Department of Environmental Quality web site: Oil and Gas Forms. "CDA Well Completions Emissions Worksheet." (08/2011) Sheet1 of the Excel Workbook. http://deq.state.wy.us/aqd/Oil%20and%20Gas/COMPLETION_EMISSIONS_8-11-2011.xlsx

[135] U.S. Environmental Protection Agency web site: Sulfur Dioxide. "Health." http://www.epa.gov/air/sulfurdioxide/health.html

H_2S the emissions of SO_2 could be problematic, especially for more vulnerable populations.

3.7. Reducing completion emissions from CBM will also help global and regional air quality

The reduction of methane not only reduces greenhouse gases in the atmosphere, it also affects air quality. According to the Global Methane Initiative, of which U.S. EPA is a member, "Studies have shown that reducing global methane emissions can lower tropospheric ozone formation and reduce associated mortalities."[136]

> *When methane is chemically destroyed in the atmosphere in the presence of sufficient nitrogen oxide, ozone is produced. In the United States, ozone in surface air is regulated as a pollutant under the Clean Air Act due to its detrimental impacts on human health and vegetation. . . Until recently, methane was considered irrelevant for addressing surface ozone pollution because its long atmospheric lifetime (8-9 years) prevents it from contributing to the rapid photochemical production which leads to high ozone episodes. Rather, methane plays a role in contributing to background tropospheric ozone. Increases in methane will thus raise the baseline ozone level in air globally, including at the surface. Ozone episodes, fueled by the traditional short-lived ozone precursors that are regulated in the United States (nitrogen oxides and non-methane hydrocarbons), then build on top of this baseline.*[137]

BP, which is a major coalbed methane operator in the San Juan Basin, considers methane to be a volatile organic compound (VOC), and recognizes the impact that methane can have on air quality. According to the BP web site:

> *Major health impacts of local air pollution may result from an increase in low-level ozone concentration and the formation of smogs. These are caused by the reactions between sunlight, nitrogen oxides (NOx) and volatile organic compounds (VOCs), and are often influenced by local weather conditions and topography. NOx and VOCs come from natural, community and industrial sources, the latter of which includes fuels, solvents, coatings, chemical feedstocks, and refrigerants.* ***BP considers that methane, which is a VOC, is a contributor to low-level ozone*** [emphasis added]*, especially in non-urban areas – where our facilities are more likely to be situated.* ***We therefore report our methane emissions as part of our emissions affecting air quality as well as in***

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[136] Global Methane Initiative web site. "Other environmental co-benefits of reducing methane." http://www.globalmethane.org/about/methane.aspx#fn7 **Citing**: West et al. 2006. Global Health Benefits of Mitigating Ozone Pollution With Methane Emission Controls. Proceedings of the National Academy of Sciences (PNAS). March 14, 2006 Vol. 103 No. 11 3988-3993. http://www.pnas.org/content/103/11/3988.full.pdf+html

[137] Geophysical Fluid Dynamics Laboratory. 2006."Linking climate and air pollution: methane emission controls yield a double dividend." http://www.oar.noaa.gov/spotlite/2006/spot_methane.html

our greenhouse gas emissions.[138] [emphasis added]

3.8. Conclusions

Based on the above comments, Earthworks recommends that EPA require the use of RECs for coalbed methane wells. In summary:

- There is the potential to drill tens of thousands of CBM wells over the next decade or more.
- The amount of natural gas released during CBM well completions varies between and within CBM basins, but can be hundreds or thousands of cubic feet per well completion. Thus, the potential CH_4 reductions from RECs are significant.
- VOC content in CBM gas varies, but even when VOC content is low there can be emissions of more than 80 pounds of VOCs per well. The cumulative impact on regional air quality of drilling hundreds of wells is significant.
- RECs have been used successfully on CBM wells in the San Juan Basin for years, on low-producing (e.g., 100 Mcf/day) and high producing (e.g., 2,000 Mcf/day) wells.
- Oil and gas companies have successfully developed technology to utilize RECs in low-pressure reservoirs, in situations where sales line pressure is higher than the pressure of the gas coming out of the separator, when there are high concentrations of inert gases, when they do not own their own gathering lines.
- RECs for CBM wells are as cost-effective (or moreso) than reducing CH_4 and VOC emissions from other types of natural gas systems.
- A requirement to use RECs on CBM wells will have the added benefit of reducing other air pollutants such as CO_2, H_2S, thus improving local, regional and global air quality.

[138] BP web site. "Emissions affecting air quality." Accessed Nov. 25, 2011. http://www.bp.com/sectiongenericarticle800.do?categoryId=9036528&contentId=7067446