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Pennsylvania's Natural Gas Boom Economic & Environmental Impacts

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Introduction

The Marcellus Shale formation is believed to be the largest unconventional natural gas reservoir in America, and its exploration has been coined a modern-day gold rush. More than a mile underground, this once unreachable gas is now recoverable thanks to advancements in horizontal drilling and hydraulic fracturing technology.

Dozens of drilling companies are investing in Pennsylvania and boosting the economy by creating high-paying and permanent jobs. A Penn State University study estimated Marcellus Shale activity generated more than 44,000 jobs in 2009. Those who need jobs the most are being put to work, as much of the drilling activity is occurring in rural, economically depressed areas of Pennsylvania.

Unfortunately, all of these positive developments could be eroded if proposals to impose additional taxes and regulations are imposed by Harrisburg. Those who would hinder the Marcellus Shale development are misinforming legislators and the public about the drilling process and the state's environmental safeguards. Regulations in Pennsylvania are among the strictest in the nation. Within the last year, the Pennsylvania Department of Environmental Protection (DEP) has raised permitting fees to pay for greater oversight and enacted a host of new water regulations. Yet there has been little to no evidence to suggest that Pennsylvania's natural resources are seriously threatened by drilling.

A short-sighted proposal to garner more state revenue through a severance tax on natural gas would negatively impact the industry's development and stunt Pennsylvania's economic recovery and growth.

Economic Impact

Pennsylvania is positioned to greatly benefit from the booming gas industry. A Penn State study found Marcellus Shale activity in 2009 added over \$389 million in state and local tax revenue, in addition to 44,000 jobs to the Commonwealth. The study predicts the industry will generate over 111,000 jobs and \$987 million in state and local tax revenue by 2011, *if* Harrisburg doesn't impose higher taxes or more onerous regulations.¹ A study by the Center for Workforce Information & Analysis estimated that in 2008 the industry added 10,287 direct jobs statewide, and the average annual earnings per each of its workers was \$63,553.²

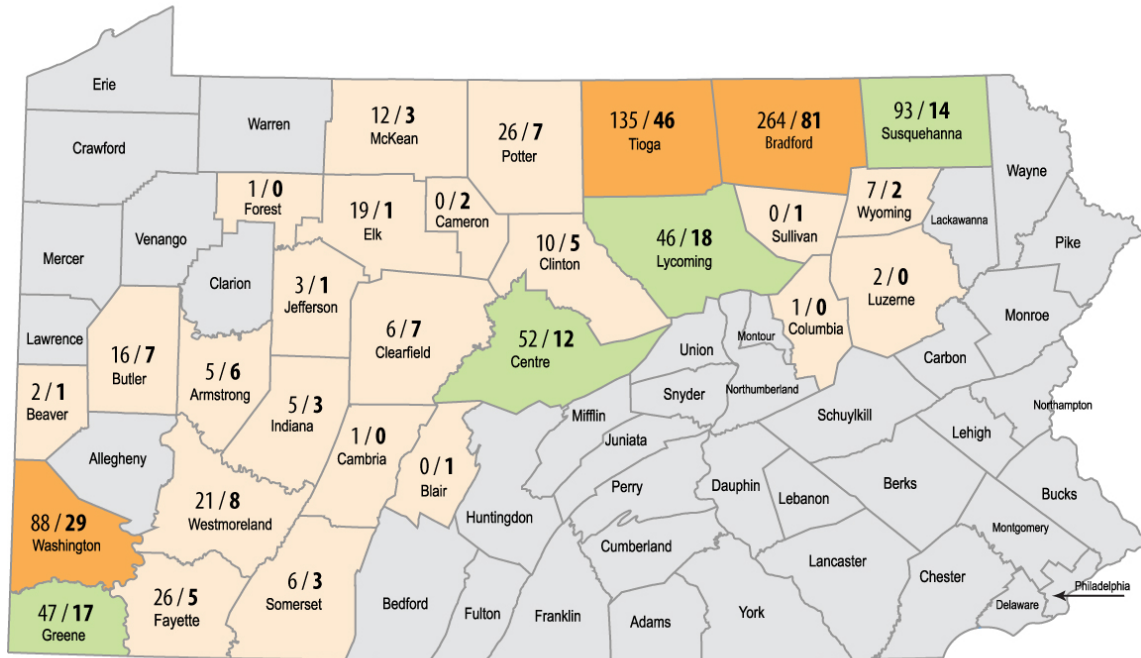
Many of the jobs being created are from the ripple effect of gas exploration. For example, last year the Reading and Northern Railroad Company was underutilized, but its president says it is now growing by transferring and storing the silica sand used for Marcellus Shale drilling.³

A report by the Perryman Group estimates the Barnett Shale play in Texas accounts for \$8.2 billion in annual economic output and 83,823 jobs.⁴ Many experts believe Pennsylvania will outperform Texas in both those categories because the shale formation here is significantly larger. Since 2009, Pennsylvania's Bradford County has seen the largest job growth of any county in the state, adding 2,000 jobs related to the natural gas industry.⁵ This rapid growth is continuing—between January and April 2010, 81 wells were drilled in Bradford County, the largest growth in any county in the state.⁶

MARCELLUS SHALE PERMITS ISSUED & WELLS DRILLED

(January 2010–April 2010)

Permits Issued: 894 / Wells Drilled (as reported by operators): 364



Source: PA Department of Environmental Protection

With new jobs comes additional tax revenue for local and state governments. Natural gas companies are paying among the highest business taxes in the nation. In fact, most drilling companies pay Pennsylvania's Corporate Net Income Tax, Capital Stock and Franchise Tax, leasing fees, and royalty payments.⁷ The state has already received almost \$420 million in leasing fees and over \$250,000 in royalty payments for drilling on state lands.⁸

Apart from extensive job creation, natural gas drilling is directly benefiting residents who own the mineral rights to gas-rich property. Landowners, and in some cases coalitions of landowners, negotiate contracts specifying a percentage of the profits or a royalty payment for the production life of a well. Additionally, many companies are offering immediate signing or leasing bonuses. These arrangements have allowed many Pennsylvanians to retain their family farms. If a severance tax on natural gas is passed, landowners' royalties will also be taxed, reducing the benefit to these Pennsylvanians.

Contrary to the characterizations of severance tax proponents, the natural gas industry is marginally profitable. Toward the end of 2008, natural gas prices fell sharply and have yet to reach their \$9 per million Btu (MMBtu) high. Currently, prices are under \$5 per MMBtu, far below many companies' break-

even cost. It cost between \$3 million and \$5 million to construct a horizontal well, according to Range Resources,⁹ and drilling in Pennsylvania costs on average \$1 million more than in other states, in large part due to extensive permitting and environmental regulations. Drilling companies are making financial investments predicated heavily upon the regulatory and tax climate of the Commonwealth.

Environmental Impacts

Drilling has long been a part of Pennsylvania’s energy history. Since 1859, over 350,000 oil and gas wells have been drilled.¹⁰ Over one million wells using hydraulic fracturing have been drilled nationally since the technology was developed in the 1960s, and *not a single instance* of direct groundwater contamination has been tied to the process.¹¹

Yet certain special interest groups warn about water contamination, since hydraulic fracturing requires large quantities of slickwater—a mixture of water, sand, and naturally occurring chemicals or additives. The majority of the fluid, over 98%, is water and sand. The sand, typically silica sand, is used as the proppant and keeps the cracks in the shale open while additives keep the pipes clean by preventing rust and allowing the gas to travel freely.

Environmental concerns include:

Disposal of fracking fluid. In the Barnett Shale, deep-injection wells are widely used, but this solution is not economical for the Marcellus Shale due to Pennsylvania’s tightly formed underground geology. Recycling and reuse are the prevalent methods of disposal for wastewater—the industry as a whole reuses 60% of flow-back, leading to fewer water withdrawals.¹² Eventually, wastewater is transported to large treatment plants. By the time water is injected into streams, it meets Environmental Protection Agency (EPA) and DEP standards for cleanliness.

As drilling continues, new treatment plants will be needed, but building new facilities will not be easy with new regulations more than doubling the cost of construction. New plants will need to charge upward of 18 to 30 cents per gallon compared to the current rate of 10 to 15 cents per gallon.¹³ These new regulations have been enacted despite evidence that agriculture and mine runoff have a much greater impact on water quality than natural gas drilling wastewater.¹⁴

Leakage of pits and tanks storing fracking fluid. Used fracking fluid is stored in large dug pits lined with industrial strength liners. Very specific regulations for erosion and sedimentation barriers, as well as buffer zones from water bodies, must be followed.

Contamination of drinking water due to hydraulic fracturing. While a legitimate concern, there is no conclusive evidence that hydraulic fracturing has caused the contamination of drinking water in Pennsylvania. In the last 15 years, 32,000 wells were drilled and there have been fewer than 80 cases (0.25%) of groundwater impacts from drilling (and no health impacts). In other words, 99.75% of all wells had zero groundwater impact.¹⁵ Furthermore, a study by the Center for Rural Pennsylvania found up to 41% of the private wells in the state fail to meet health-based standards for drinking water,¹⁶ suggesting other factors (e.g. agricultural runoff) are more influential on water quality.

Migration of methane gas. Naturally occurring methane travels from high- to low-pressure areas. Changes in pressure can be caused by a change in water levels, abandoned mines and wells, current mining and natural gas drilling. Methane contamination in drinking wells is easily remedied by ensuring proper ventilation. DEP regulations require pre-drilling inspections of water wells within 1,000 feet of a gas well. Pre-drilling tests gather information on methane activity, well construction, and water quality.¹⁷ Resi-

dents are strongly encouraged to have their water tested to ensure irresponsible enterprises are held fully accountable. If landowners suspect pollution they notify the DEP's Bureau of Oil and Gas Management within six months of drilling completion for remediation.

Habitat disturbances and water consumption. Construction of new gas wells is bound to disturb habitats in a limited area, but many measures are taken to lessen the impact. Water withdrawals in Pennsylvania are heavily regulated. A company must comply with DEP regulations and rules from interstate federal commissions. For perspective, the consumption of fresh water for electrical generation in the Susquehanna River Basin alone is nearly 150 million gallons per day, while the projected total demand for peak Marcellus Shale activity in the same area is 8.4 million gallons per day. Estimated water use for shale gas development will range from less than 0.1% to 0.8% of all water use in the Basin.¹⁸

After construction, each company is required to return the drilling site to its original form, including ground cover within nine months of completed drilling. Horizontal drilling allows six to eight wells on one well pad—accessing the same reservoir volume as sixteen vertical wells.¹⁹ In other words, gas companies are able to generate more natural gas with fewer wells, fewer pipelines, and fewer disturbances to the surrounding environment.

Countless studies have shown that properly drilled and operated wells significantly mitigate environmental threats. In 2004, an EPA study determined hydraulic fracturing posed no danger to water quality (the EPA is currently in the process of updating this study).²⁰ In 2009, the U.S. Department of Energy's Office of Fossil Energy conducted a study concluding, "State oil and gas regulations are adequately designed to directly protect water resources through the application of specific programmatic elements such as permitting, well construction, well plugging, and temporary abandonment requirements."²¹ Additionally, the Interstate Oil and Gas Compact Commission (IOGCC) found hydraulic fracturing non-threatening to the environment or public health.²²

Social and Infrastructure Costs

Heavy traffic is one unavoidable consequence of drilling. Water, sand, and additives used in the fracking process are hauled in and the wastewater that returns to the surface is transported to treatment facilities or another site to be recycled. Traffic, dust, and noise decrease significantly once drilling subsides.

In order to protect local roads, drilling companies are required by state law to post bonds for any roads with municipal weight limits. The drilling company pays for road conditions to be inspected before and after drilling occurs, and is responsible for fixing road damages. This ensures that no additional tax dollars are needed for necessary road repairs due to drilling activity.

Another possible social impact of Marcellus drilling is noise pollution. Landowners can work with companies to mitigate this nuisance. In cooperation with nearby residents, drilling companies in the Barnett Shale have installed sound barrier fences and placed thermal blankets over loud equipment to diminish the noise. Additionally, directional lighting and privacy fences can be installed.

Odor from pits storing wastewater can also impact communities. Under the Air Pollution Control Act, any entity producing odors can be fined up to \$25,000. Often those most affected are the landowners who voluntarily make the decision to lease their mineral rights.

Regulatory Burden

Shale exploration is regulated by federal and state laws, but it is the state agencies that monitor and enforce drilling activities in the Commonwealth. Marcellus Shale falls under eight federal and eleven Pennsylvania acts or laws which regulate the environmental and social impacts of drilling. Drilling activity is monitored by multiple state agencies (Table 1).²³

Table 1

| Federal Acts | Pennsylvania Acts and Laws | Monitoring Agencies |
|--|--|---|
| Clean Water Act (CWA) | Oil and Gas Act | Pennsylvania Department of Environmental Protection (DEP) |
| Safe Drinking Water Act (ADWA) | Oil and Gas Conservation Law | Fish and Boat Commission |
| Clean Air Act | Coal and Gas Resource Coordination Act | PA Department of Transportation |
| Endangered Species Act | Clean Streams Law | County Conservation Districts: |
| Resource Conservation and Recovery Act (RCRA) | Solid Waste Management Act | Susquehanna River Basin Commission (SRBC) |
| Comprehensive Environmental Response Compensation and Liability Act (CERCLA) | Dam Safety and Encroachment Act | Delaware River Basin Commission (DRBC) |
| Emergency Planning and Community Right to Know Act (EPCRA) | Safe Drinking Water Act | PA Department of Conservation and Natural Resources. |
| Occupational Safety and Health Act | Water Resources Planning Act | |
| | Worker and Community Right to Know Act | |
| | Vehicle Code | |
| | Municipalities and Planning Code | |

DEP is primarily responsible for issuing permits, monitoring well sites, responding to complaints, and fining violators. DEP inspectors routinely and randomly inspect drilling sites throughout the state.²⁴ Since 2005, 1,526 Marcellus Shale wells have been drilled in the state.²⁵ In 2009 alone, the Department carried out 14,544 drilling site inspections.²⁶ DEP has over 190 employees working full-time on oil and gas oversight.²⁷

Additionally, the Fish and Boat Commission, as well as County Conservation Districts, work with DEP to monitor effects on local ecosystems and aquatic life. Depending on the location, drilling operators must also receive permits from the Susquehanna River Basin Commission or the Delaware River Basin Commission.

The extensive regulatory oversight requires additional resources and funds, leading DEP to add over 100 new inspectors since 2009 and open a new office in Scranton funded by an increase in drilling permit fees. Last year, the cost for a permit rose from about \$100 to almost \$6,000. DEP Secretary John Hanger believes the increased fees will bring in \$11 million this year, compared to only \$700,000 in 2008-2009, an almost 1,600% increase.²⁸

Pennsylvania's Clean Streams Law prohibits discharging any pollutants from drilling into the state's water sources and requires that Best Management Practices (BMP) be used to limit land disturbance and runoff. DEP describes BMP as "minimizing earth disturbances, silt fences, mulch, diversion ditches, sediment traps, sediment basins, and the establishment of grasses for permanent stabilization."²⁹ Companies are required to have an Erosion, Sediment and Storm Control plan or permit (a permit is required when more than five acres is disturbed) showing how their BMPs protect water sources from erosion and runoff. Further, drillers are held responsible to correct any groundwater contamination within 1,000 feet of a well. Water withdrawal over 10,000 gallons per day for a 30-day period requires a permit, and drilling is prohibited within 100 feet from any body of water.³⁰ This law, in conjunction with the Solid Waste Management Act, establishes fines between \$10,000 to \$25,000 per day for each violation committed.³¹

State laws require companies to disclose all chemical compounds used in the fracking process, but not the specific quantities of each, as that information is considered proprietary. The complete list is available at DEP's website: <http://www.dep.state.pa.us/dep/deputate/minres/oilgas/FractListing.pdf>.

Congress is considering a federal takeover of fracking oversight, which would only lessen Pennsylvania's environmental protection. S. 1215, the Fracturing Responsibility and Awareness of Chemicals (FRAC) Act, would require the hydraulic fracturing process to be monitored by the federal government under the Safe Drinking Water Act.

S. 1215 is unwarranted. Fracking occurs thousands of feet beneath aquifers, and there is no indication it causes contamination. According to DEP's Bureau of Oil and Gas Management director, "there has never been any evidence of fracking ever causing direct contamination of fresh groundwater in Pennsylvania or anywhere else."²²

Besides being unnecessary, the FRAC Act is poor policy, as it shifts responsibility away from local authorities who are better equipped to handle local situations. Pennsylvania's regulatory agencies have made sure no water contamination in the state has occurred and should be supported as the correct regulatory bodies for protecting the state's waterways.

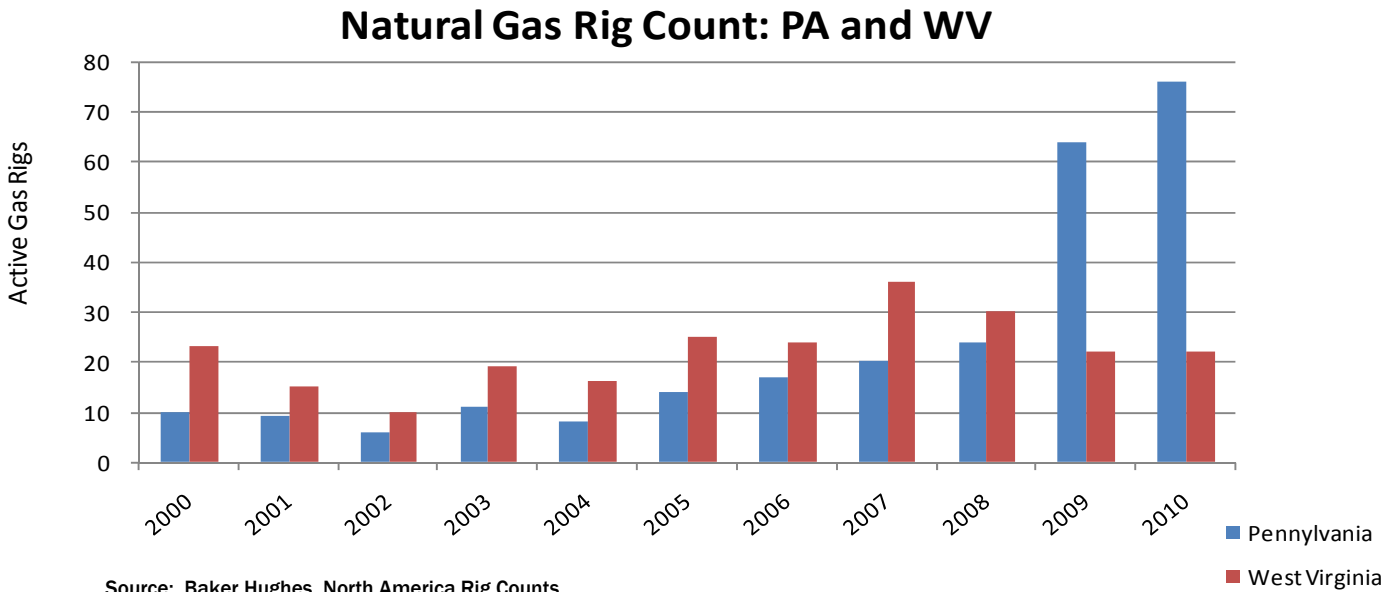
Natural Gas Severance Taxes

Governor Rendell has proposed a severance tax on natural gas extraction. If passed, natural gas will be the only energy source whose extraction is taxed in Pennsylvania. House Bill 1489 would impose a severance tax of 5% on the value of natural gas, plus \$.047 per thousand cubic feet, with an exemption for marginal wells producing less than 60,000 cubic feet per day. This proposal would send almost 90% of the revenue to the state General Fund. The latest proposal, H.B 325, would impose a tax of 8%, plus \$.07 per thousand cubic feet—sending 80% of the revenue to the General Fund.

Advocates for the tax claim that it is designed to resemble West Virginia's severance tax and would not discourage in-state drilling. Yet, West Virginia has seen a 20% increase in drilling activity in the last 10 years, while Pennsylvania, with no severance tax, has seen a 400% increase during the same period.

Since, the beginning of 2009, West Virginia has added two additional drilling rigs, while Pennsylvania has added 56.³³ See Chart 1, below.

Chart 1



Politicians argue Pennsylvania is the only major gas-producing state not to impose this type of tax, and therefore should have one. This statement neglects important economic facts. First, no other industry in the state pays an excise tax to “sever” natural resources. The majority of other states that have a severance tax on natural gas also tax the extraction of stone, salt, timber, oil, etc. Second, states with a natural gas tax often delay implementation, offer tax exemptions or credits, or discount the tax in hard-to-drill areas to encourage drilling. Texas and Arkansas reduced their severance tax for high-cost gas wells by nearly 80%. See Table 2, page 8.

Pennsylvania’s Marcellus Shale is an unconventional energy source and requires additional effort and cost to extract the natural gas. Therefore, it is more accurate to compare taxation in states with comparable shale formations. Such states often offer a moratorium on any sort of severance tax until the industry recovers its investment and becomes profitable. See Table 3, page 9.

Conclusion

Three important factors should be acknowledged when considering a severance tax on natural gas:

1. The cost to drill in Pennsylvania is already more expensive than in other states due to topography and regulations.
2. The price of natural gas has plummeted, limiting companies’ available capital for drilling investment.
3. Most other states rely on a natural gas tax to lower other business taxes. In contrast, Pennsylvania already imposes one of the highest tax burdens on gas companies, and has the highest corporate income tax rate in the world when combined with high corporate income tax rate at the federal level.

Table 2

Top Natural Gas Producing States

| Top Natural Gas Producing States in 2007 | State | Severance Tax on Natural Gas | Severance Tax Exemptions and Incentives for Unconventional Wells | Top Corporate Net Income Tax | State & Local Tax Burden as a Percentage of State Income/National Rank (Tax Foundation 2010) |
|--|---------------|---|---|------------------------------|--|
| 1 | Texas | 7.5% of market value | Rate reduction appr. 2% for up to 10 years | 0% | 8.4% / 43 |
| 2 | Wyoming | 6% of taxable value (gross sales minus certain processing and transportation costs) | Gas transportation costs are significant and are subtracted from the taxable value | 0% | 7% / 48 |
| 3 | Oklahoma | 7% plus 0.095% excise tax | Exempt from severance tax for four years or until gas production pays for the cost of the well | 6% | 9.8% / 19 |
| 4 | New Mexico | 3.75% | | 7.60% | 8.6% / 39 |
| 5 | Louisiana | \$0.03 - 0.13 per MCF | Severance tax suspension on horizontally drilled well for 2 years or until payback | 8% | 8.4% / 42 |
| 6 | Colorado | 2% to 5% based on gross income | Allows producers to deduct 87.5% of their property taxes paid to gov. from severance tax to state. | 4.63% | 9% / 34 |
| 7 | Alaska | 25% to 50% net value | Reduction for all drilling in Cook Inlet basin and when gas is used in state; result minimal tax (appr. 1%). State also gives certain tax credits for exploration | 6.50% | 6.4% / 50 |
| 8 | Utah | 3% - 5% | 6 months exemption for development wells | 5% | 9.6% / 22 |
| 9 | Kansas | 8% on gross value severed from earth | There is 3.67% tax credit for ad valorem taxes paid, effectively reducing the severance tax to 4.33% | 7.05% | 9.6% / 21 |
| 10 | California | Less than 0.01 per mcf | | 8.84% | 10.5% / 6 |
| 11 | Alabama | 4-8% of gross value | | 6.50% | 8.6% / 38 |
| 12 | Arkansas | 5% | 1.5% on new discovery wells for 24 months and on high cost wells for 36 months (can get extension) | 6.50% | 10% / 14 |
| 13 | Michigan | 5% | | 4.95% | 9.4% / 27 |
| 14 | West Virginia | 5% plus \$0.047 per MCF | | 8.50% | 9.3% / 29 |
| 15 | Pennsylvania | No Tax | | 9.99% | 10.2% / 11 |

A Penn State University study estimated Gov. Rendell's proposed tax would reduce in-state drilling activity by at least 30% and result in an 11% decline in rate of return.³⁴ This reduced activity would cost Pennsylvania \$880 million in lost state and local taxes by 2020. Pennsylvania's natural gas reserve, while large and close to destination markets, only remains an attractive investment if costs are carefully controlled and expenses minimized.

Politics and the desire for more revenue are driving the severance tax. Despite claims that environmental and social concerns are the motivators for supporting a tax, Gov. Rendell's proposal would send 90% of the revenue to the General Fund, which is not dedicated to mitigating impacts from natural gas drilling and operations.

Any severance tax should be dedicated to environmental and local community impacts; however, there is no indication a tax is needed for this purpose at this time. Instead of creating a new tax for environmental clean-up—which is highly unlikely as government often raids funds for other purposes, i.e., the M-Care fund—environmental concerns should be met by the state's current laws and regulations.

Table 3

Unconventional Gas Shale Play

| State | Shale Name | Highest Marginal Rate on Natural Gas | Severance Tax Exemptions for Unconventional Wells | Corporate Net Income Tax | State and Local Tax Burden as a Percentage of State Income (Tax Foundation 2010) | Change in drilling activity between 2008-2010 |
|---------------|---------------------------------------|--------------------------------------|--|--------------------------|--|---|
| Texas | Barnett Shale, Haynesville Shale | 7.5% of market value | Reduction to 2% for up to 10 years | 0% | 8.4% | 21.4% reduction |
| Arkansas | Fayetteville Shale, Haynesville Shale | 5% | 1.5% on new discovery wells for 24 months and on high cost wells for 36 months (can get extension) | 6.50% | 10.0% | 22.6% reduction |
| Louisiana | Haynesville Shale | \$0.03 - 0.13 per MCF | Severance tax suspension on horizontally drilled well for 2 years or until payback | 8% | 8.4% | 44.2% increase |
| West Virginia | Marcellus Shale | 5% plus \$0.047 per MCF | | 8.50% | 9.3% | 26.7% reduction |
| Pennsylvania | Marcellus Shale | No Tax | | 9.99% | 10.2% | 225% increase |

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APPENDIX

Fracturing Fluid Additives, Main Compounds, and Common Uses

| Additive Types | Main Compound(s) | Purpose | Common Use of Main Compound |
|---------------------|------------------------------------|---|--|
| Diluted Acid (15%) | Hydrochloric acid or muriatic acid | Help dissolve minerals and initiate cracks in the rocks | Swimming pool chemical and cleaner |
| Biocide | Glutaraldehyde | Eliminates bacteria in the water that produce corrosive byproducts | Disinfectant; sterilize medical and dental equipment |
| Breaker | Ammonium persulfate | Allows a delayed break down of the get polymer chains | Bleaching agent in detergent and hair cosmetics, manufacture of household plastics |
| Corrosion Inhibitor | N,n-dimethyl formamide | Prevents the corrosion of the pipe | Used in pharmaceuticals, acrylic fibers, plastics |
| Crosslinker | Borate salts | Maintains fluid viscosity as temperature increases | Laundry detergents, hand soaps, and cosmetics |
| Friction Reducer | Polyacrylamide | Minimizes friction between the fluid and the pipe | Water treatment, soil conditioner |
| | Mineral oil | | Make-up remover, laxatives, and candy |
| Gel | Guar gum or hydroxyethyl cellulose | Thickens the water in order to suspend the sand | Cosmetics, toothpaste, sauces, baked goods, ice cream |
| Iron Control | Citric acid | Prevents precipitation of metal oxides | Food additive, flavoring in food and beverages; Lemon Juice ~7% Citric Acid |
| KCL | Potassium chloride | Creates a brine carrier fluid | Low sodium table salt substitute |
| Oxygen Scavenger | Ammonium bisulfite | Removes oxtgen from the water to protect the pipe from corrosion | Cosmetics, food and beverage processing, water treatment |
| pH Adjusting Agent | Sodium or potassium carbonate | Maintains the effectiveness of other components, such as crosslinkers | Washing soda, detergents, soap, water softener, glass and ceramics |
| Proppant | Silica, quartz sand | Allows the fractures to remain open so the gas can escape | Drinking water filtration, play sand, concrete, brick mortar |
| Scale Inhibitor | Ethylene glycol | Prevents scale deposits in the pipe | Automotive antifreeze, household cleansers, and deicing agent |
| Surfactant | Isopropanol | Used to increase the viscosity of the fracture fluid | Glass cleaner, antiperspirant, and hair color |

Note: The specific compounds used in a given fracturing operation will vary depending on company preference, source water quality and site-specific characteristics of the target formation. The compounds shown above are representative of the major compounds used in hydraulic fracturing of gas shales.

Source: Modern Shale Gas In the United States: A Primer, Ground Water Protection Council and ALL Consulting, April 2009. http://fossil.energy.gov/programs/oilgas/publications/naturalgas_general/Shale_Gas_Primer_2009.pdf

Current Produced Water Management by Shale Gas Basin

| Shale Gas Basin | Water Management Technology | Availability | Comments |
|--------------------|-----------------------------|---|--|
| Barnett Shale | Class II injection wells | Commercial and noncommercial | Disposal into the Barnett and underlying Ellenberger Group |
| | Recycling | On-site treatment and recycling | For reuse in subsequent fracturing jobs |
| Fayetteville Shale | Class II injection wells | Non-commercial | Water is transported to two injection wells owned and operated by a single |
| | Recycling | On-site recycling | For reuse in subsequent fracturing jobs |
| Haynesville Shale | Class II injection wells | Commercial and noncommercial | |
| Marcellus Shale | Class II injection wells | Commercial and noncommercial | Limited use of Class II injection wells |
| | Treatment and discharge | Municipal waste water treatment facilities, commercial facilities | Primarily in Pennsylvania |
| | Recycling | On-site recycling | For reuse in subsequent fracturing jobs |
| Woodford Shale | Class II injection wells | Commercial and noncommercial | Disposal into multiple confining formations |
| | Land Applications | | Permit required through the Oklahoma Corporation Commission |
| | Recycling | Non-commercial | Water recycling and storage facilities at a central location |
| Antrim Shale | Class II injection wells | Commercial and noncommercial | |
| New Albany Shale | Class II injection wells | Commercial and noncommercial | |

Source: Modern Shale Gas In the United States: A Primer, Ground Water Protection Council and ALL Consulting, April 2009. http://fossil.energy.gov/programs/oilgas/publications/naturalgas_general/Shale_Gas_Primer_2009.pdf

ABOUT THE AUTHOR AND THE COMMONWEALTH FOUNDATION

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