The Natural Gas Explosion: Boom or Bust for New York's Economy and Environment?

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I. Introduction

High volume "slickwater" hydraulic fracturing (also known as "hydrofracking" or "fracking") is a method of extracting natural gas from coal beds or shale rock formations such as the Marcellus Shale. To proponents of natural gas extraction, fracking and natural gas represent energy independence and a means of creating jobs in struggling communities. To opponents, the potential benefits of natural gas are outweighed by the environmental legacy of poisoned ground and surface water and the short and longterm socioeconomic impacts of fracking operations on local economies.

Regardless of the net benefit or harm to the environment and communities near hydrofracked natural gas wells, the natural gas industry is growing, and hydrofracking is on the rise. As the regulations governing hydrofracking in New York are finalized, and the level of interest in and political will behind developing the New York Marcellus Shale becomes clear, so too will the impacts on the state and local communities. One thing is already clear, however: the New York Marcellus Shale will undergo some level of development. As such, it is important to assess the likely economic and environmental impacts of the development, and proactively develop policies and practices to mitigate the harms and maximize the benefits of natural gas.

II. What is hydrofracking?

Hydrofracking is a stimulation technique used to increase the yield of natural gas wells.[1] In organically rich shale formations such as the Appalachian Marcellus Shale, natural gas occurs in three ways: within the pore spaces of the shale, within natural vertical fractures or joints in the shale, and adsorbed to mineral grains and organic materials within the shale.[2] Most of the

[1] *Marcellus Shale – Appalachian Basin Natural Gas Play*, GEOLOGY.COM, http://geology.com/articles/marcellus-shale.shtml (last accessed Dec. 12, 2011)
[2] *Id.*

recoverable gas is located in the pore spaces, but because the pores are tiny and insular, extracting gas from them is difficult.[3]

Because of shale's low permeability, the vertical wells traditionally drilled in the Marcellus Shale and others yielded gas at a slow rate.[4] Geologists noticed, however, that the most successful wells shared a common trait: a wellbore that intersects numerous fractures in the shale.[5] These fractures in turn intersect other fractures, and this network of intersecting fractures provides channels for gas to flow into the well.[6]

Modern hydrofracking procedures combine horizontal drilling techniques with extreme pressures to take advantage of the expedient nature of fractures and maximize yield. Horizontal wells intersect many more of the vertical fractures than a traditional vertical well, and injecting high volumes of fluid to create more fissures yields more gas than a non-fracked well.[7] Using these techniques together, some wells in the Marcellus Shale are able to yield millions of cubic feet of gas per day.[8]

Modern hydrofracking typically involves first drilling a vertical wellbore through the subsurface rock to reach the shale formation, typically nearly a mile or more below the surface, and subsequently turning the bore to drill horizontally.[9] Rock cuttings are removed during drilling by circulating high-pressure drilling fluid, and taken away for disposal.[10] The wellbore is typically lined with several layers of cement.[11] A special gun is then lowered into the horizontal portion of the bore, where it fires slugs into the rock to perforate the well and create

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[3] *Id.*
[4] *Id.*
[5] *Id.*
[6] *Id.*
[7] *Id.*
[8] *Id.*
[9] *Id.*
[10] York State Department of Environmental Conservation, Revised Draft Supplemental Generic Environmental Impact Statement on The Oil, Gas and Solution Mining Regulatory Program (2011), *available at* http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf.
[11] *Id.*

fissures in the shale.[12] Mechanical plugs are then inserted into the horizontal bore to create "stages" along the bore, and to control the pressure in the bore at each stage.[13] Figure 1, below, is an illustration of the wellbore at this point in the fracking process.[14]

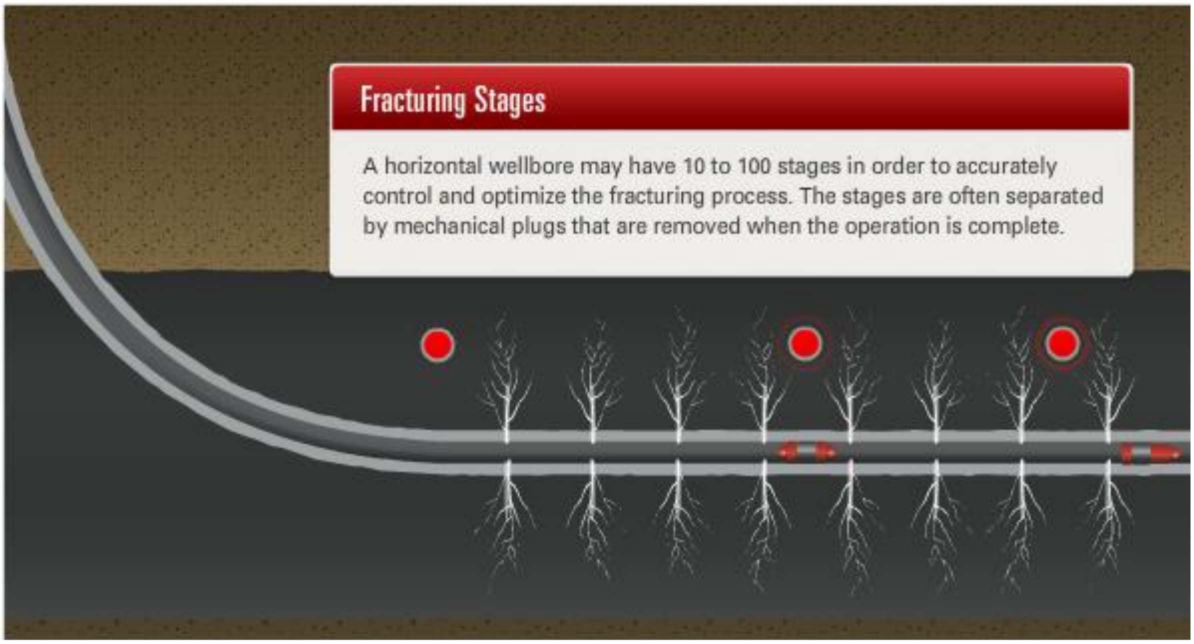

Figure 1 – The staging process.

Next, anywhere from 3 million to 9 million gallons of water and chemical agents are blasted into the wellbore at pressures up to 11,000 PSI.[15] The pressurized fluid creates fractures in the rock through which natural gas can escape. Sand or some man-made proppant such as ceramic spheres is injected along with the fluid.[16] Millions of grains of proppant make their way into the fissures to prop them open, while remaining porous enough to allow natural-gas-bearing fluid to flow into the well for recapture.[17] Acids and other chemicals included in the chemical slurry repair and prevent damage to the wellbore, etch the stone and prevent the fissures from

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[12] Halliburton, *Hydraulic Fracturing: A Look Back*, available at http://www.halliburton.com/public/projects/pubsdata/Hydraulic_Fracturing/fracturing_101.htm (last accessed Dec. 12, 2011).
[13] *Id.*
[14] *Id.*
[15] *See supra* note 10.
[16] *Id.*
[17] J. Daniel Arthur et al., *Hydraulic Fracturing Considerations for Natural Gas Wells*, available at http://www.dec.ny.gov/docs/materials_minerals_pdf/GWPCMarcellus.pdf

resealing, and inhibit microorganism growth.[18]

As the fissures form, natural gas is released from the rock. After the fracturing process is complete, typically after 3 to 10 days[19], the pump is deactivated and gas-bearing fracking fluid flows out of the well under the pressure of the released methane.[20] Up to a million or more gallons of this flowback water can be produced by a well in the first month of operation alone.[21] This water consists of the original fracking fluid, called "flowback," as well as water originally present in the formation, called "produced water," and the mixture may contain a number of naturally occurring salts, metals, and potentially corrosive and radioactive materials, called "total dissolved solids" (TDS).[22] Some of the fracking fluid, from 30 to as much as 80 percent, is estimated to remain underground.[23] The rest is captured and processed to extract the natural gas, and then disposed of as wastewater in the manner prescribed by applicable state and federal law.[24] The natural gas is stored in on-site tanks for pickup by trucks, or carried away via pipeline.[25]

III. <u>The Rise of Modern Hydrofracking</u>

Despite the recent uptick in hydrofracking, and the explosion of controversy surrounding the process, the extraction method is not a new invention: it was first used in 1947 at a well in Grant County, Kansas, when 3,000 gallons of fluid was pumped to a depth of 2,400 feet to increase natural gas production.[26] Two years later in 1949, Halliburton performed the first commercial fracking operation.[27] It was only after Halliburton further advanced the process in

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[18] *Id.*
[19] *See supra* note 10.
[20] *See supra* note 1.
[21] Tip of the Mitt Watershed Council and National Wildlife Federation, *Hydraulic Fracturing: Treatment and Disposal of Fracking Fluid Waste*, available at http://www.watershedcouncil.org/learn/hydraulicfracturing/files/hydraulic%20fraturing%20information%20sheets/hyraulic%20fracturing%20and%20fracking%20fluid%20waste%20disposal.pdf
[22] *Id.*
[23] Lustgarten, *In New Gas Wells, More Drilling Chemicals Remain Underground*, PROPUBLICA, Dec. 27 2009, http://www.propublica.org/article/new-gas-wells-leave-more-chemicals-in-ground-hydraulic-fracturing.
[24] *See* Daniel, *supra* note 17.
[25] *Id.*
[26] State of California Department of Conservation, *Hydraulic Fracturing,* http://www.consrv.ca.gov/dog/general_information/Pages/HydraulicFracturing.aspx
[27] *See supra* note 12.

2003 and combined it with horizontal drilling, however, that the use of hydraulic fracturing of natural gas plays began to skyrocket.[28] In 2003, slickwater hydrofracking development of the Barnett Shale formation began in Texas. Like most shale formations, the Barnett Shale is largely impermeable, and extractors must use stimulation techniques (primarily hydrofracking) to produce enough gas for wells to be economically viable.[29] Due largely to the development of hydrofracking, natural gas extraction in the Barnett Shale became economical, and hydrofracking has spread to other Shale formations.[30]

IV. <u>Hydrofracking the Marcellus Shale</u>

The Marcellus shale is a newcomer to the slate of viable natural gas plays. Until around 2003, natural gas extraction in the Marcellus was not considered economically viable: the great depth of the shale, typically a mile or more below the surface, means a well must yield a large quantity of gas if the driller is to recoup the drilling cost, often over a million dollars for conventional vertical wells, and much more for nonconventional horizontal and hydrofracked wells.[31] The cost of drilling, coupled with a former projected total potential yield of only 1.9 trillion cubic feet of gas, with only a small percentage of that recoverable, made the Marcellus Shale a largely unappealing prospect.[32]

In 2008, however, a new projection that the formation might actually contain approximately 500 trillion cubic feet of gas, with 10% of that recoverable using hydrofracking, suddenly made a gas lease on the Marcellus a valuable commodity.[33] This discovery, coupled with advances in horizontal drilling and hydrofracturing technology and an upturn in the market price of natural gas made drilling in the Marcellus a viable option.[34]

Between 2003 and 2005 the first natural gas discoveries were made in the Marcellus

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[28] *Id.*
[29] *Water Use in the Barnett Shale*, Railroad Commission of Texas, Jan. 24, 2011, http://www.rrc.state.tx.us/barnettshale/wateruse_barnettshale.php (last accessed December 12, 2011).
[30] *Id.*
[31] *See supra* note 1.
[32] *Id.*
[33] *Id.*
[34] *Id.*

Shale in Pennsylvania.[35] By 2007, more than 375 gas wells had been permitted in Pennsylvania.[36] In 2011 alone, more than 4,347 new natural gas wells were drilled in Pennsylvania, comprising roughly 83% of all fossil fuel wells drilled in the state.[37] Drilling is beginning on the Marcellus in New York as well, with over 94 natural gas leases issued in 2010 alone.[38]

The meteoric rise of hydrofracking in Pennsylvania and the inception of the practice in New York have kindled a heated debate among environmental advocates, sociologists, economists, natural gas proponents, and others. At the crux of the debate are the competing interests of environmental protection and economic growth. Environmentalists are primarily concerned by hydrofracking's potential to poison ground and surface water. Natural gas proponents, on the other hand, point to the benefits to the state and local economy provided by a booming natural gas industry. The following sections of this paper will attempt to: (1) analyze the projected economic costs and benefits of a booming natural gas economy; (2) assess the likely environmental impacts of hydrofracking and natural gas, both positive and negative; and (3) suggest best practices for lawmakers and local communities to adopt to maximize the benefits and minimize the harms of hydrofracking.

V. <u>The Economic Impacts of Hydrofracking and Natural Gas</u>

Although the hydrofracking process is highly resource- and wastewater-intensive, from a production standpoint it is a vast improvement over traditional vertical drilling.[39] Fracking is credited with increasing natural gas production by up to 75 percent over extraction through traditional methods.[40] Over 600 trillion cubic feet of natural gas has been delivered to the market

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[35] *See supra* note 12.
[36] *Id.*
[37] Pennsylvania Department of Environmental Protection, Permits Issued By County By Well Type January thru November 2011, available at http://www.dep.state.pa.us/dep/deputate/minres/oilgas/DiscovererReports/Permits%20by%20County%20Total%202011.htm
[38] *See supra* note 10.
[39] *See supra* note 12.
[40] *See supra* note 1.

in the past 50 years, through more than 1.1 million separate hydrofracking operations.[41]

According to a study performed by the nonpartisan think tank, Ecology and Environment, Inc. for use by the New York State Department of Environmental Conservation in preparing its Revised Draft Supplemental Generic Environmental Impact Statement (SGEIS), at its peak the Marcellus Shale will produce anywhere from 3.26 million to 8.72 million cubic feet of natural gas per day in New York.[42] Because estimates on natural gas investment range widely, these projections are based on high, average, and low estimates of construction and production.[43] Natural gas activity is distributed on an arc spanning 60 years, with construction of new wells ceasing after 30 years.[44]

In turn, this glut of gas production will create new jobs.[45] Ecology and Environment, Inc. estimates that, at peak production during year 30, production employment is expected to range from 1,790 FTE (full-time equivalent) workers under the low development projection to 10,673 FTE workers under the high development projection.[46] In the peak construction year, building the wells is expected to require from 4,408 to 26,316 workers.[47] In addition, natural gas well development in expected to indirectly create jobs in a variety of sectors ancillary to the support of the natural gas industry: as new construction and production workers spend their income on goods and services in their local communities, and as natural gas companies buy equipment and materials to support operations, overall economic activity in New York will increase.[48] In response to the increased demand, retailers and service providers may increase their workforce by an estimated 7,293 to 43,521 workers.[49] At its peak year, between construction, production, and indirect jobs, the natural gas industry in New York is expected to require between 13,491

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[41] *See supra* note 12.
[42] Ecology and Environment, Inc., Economic Assessment Report for the Supplemental Generic Environmental Impact Statement on New York State's Oil, Gas, and Solution Mining Regulatory Program, August 2011, available at http://www.dec.ny.gov/docs/materials_minerals_pdf/rdsgeisecon0811.pdf
[43] *Id.* at 2-5.
[44] *Id.*
[45] *Id.* 2-4
[46] *Id.* at 4-20.
[47] *Id.*
[48] *Id.*
[49] *Id.*

and 80,510 FTE workers.[50] Moreover, New York employers may spend their increased income in New York, in a sense "multiplying" the benefits of natural gas for the state.[51] These multiplicative benefits will continue to reverberate through the state economy until all the original funds resulting from natural gas have been absorbed by taxes or savings, or spent on goods and services outside the state.[52] The New York State government would also see substantial revenue increases from hydrofracking due to increased sales tax, income tax, corporate tax due to the overall increase in statewide economic activity.[53]

Even based on the most conservative projections, it is clear that the natural gas industry will very likely result in a significant positive effect on the New York state economy. New natural gas wells will result in increased employment, earnings, and economic output throughout the state.[54] As such, many natural gas proponents view the Marcellus Shale play as the shot in the arm the ailing state economy needs.

A. Natural Gas Boom and Bust

While natural gas development will create statewide economic opportunities in New York, it also comes with potential pitfalls for local communities. Chief among these are the negative socioeconomic impacts on boomtown communities near active wells, the burden natural gas boom places on local governments, and the damage to communities caused by economic whiplash when a natural gas well plays out.[55]

i. The Boom: Too Much of a Good Thing

While rapid population and economic growth seems like an inherently positive change for any rural community, too much of it in too short a time can prove disastrous.[56] According to what has come to be known as the "boomtown model" or "social disruption model," boom rates

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[50] *Id.*
[51] *Id.*at 4-23
[52] *Id.*at 4-18.
[53] *Id.* at 4-116.
[54] *Id.*
[55] The Northwest Regional Center for Rural Development, *Energy Boomtowns & Natural Gas: Implications for Marcellus Shale Local Governments & Rural Communities*, available at http://nercrd.psu.edu/Publications/rdppapers/rdp43.pdf.
[56] *Id.*

of population growth create a vicious cycle of problems for the most often small, rural communities experiencing them.[57] As population booms, existing services in the community fall short of need, as school classrooms, retail inventories, housing, and the number of doctors in the community lag behind the growing population.[58] Recreational opportunities also do not meet people's needs, and the overall quality of life in the community is degraded.[59]

As quality of life degrades, there is little to attract people to the often isolated rural community, which has an inadequate indigenous population to meet the demands of the economic growth. Workers do not want to remain in these communities, and the workforce is often inadequate and dissatisfied. Employee turnover rates and absenteeism skyrocket, and it is difficult to maintain a satisfactory work force, be it for natural gas well construction or operation, to staff local businesses, or to maintain the county infrastructure. Industrial productivity and profits decline as a result.

Because of the declining productivity, or at least the absence of expected increases in productivity or profit, less money is available to finance needed public sector services.[60] The social upheaval and malaise drives of private investors and prevents investment in commerce, housing, or other private sector needs. The inadequacy of public and private sector services feeds back into the cycle, degrading the quality of life and destabilizing the workforce, which leads in turn to a reduction in services.[61]

The problems of boom growth are exacerbated by the fact that local governments in natural gas towns are often ill-equipped to handle the challenges posed by the burgeoning population.[62] This is due in part to the fact that rural communities often have antiquated infrastructures and governments unaccustomed to rapidly meeting new demands.[63] They seldom have adequate resources or the experienced staff required to research the issues that arise or

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[57] *Id.* at 7.
[58] *Id.*
[59] *Id.*
[60] *Id.*
[61] *Id.*
[62] *Id.* at 10-11.
[63] *Id.*

preventatively allocate resources to deal with expected problems before they occur.[64]Although there is no consensus concerning the growth threshold at which local governments become overwhelmed by new demand, and although communities react differently based on factors like their size and infrastructure capacity, 5% annual growth seems to be the limit before services begin to suffer.[65] At growth rates higher than 15%, "institutional breakdowns in the labor market, the housing market, and the system for financing local public facilities" are typical.[66]

The social and economic problems caused by natural gas boom might be easier for boomtowns to handle if they profited from natural gas development to the same degree as other parts of the state; their losses would be offset by the net gains to the state economy. However, the benefits to a boomtown of a natural gas boom are often short-lived, and the increased income and profits quickly leak out of the community into the broader regional economy, as the local economy is not set up to provide the specialized labor, materials or services necessitated by rapid industrialization.[67]

Furthermore, the increased need for labor in boomtowns to service the natural gas play is largely fulfilled by newcomers to the town, rather than longterm residents.[68] Many do not wish to change careers, lack the required expertise, or are deterred by unpaid training periods.[69] Therefore, most of them jobs created ancillary to natural gas wells are filled by workers from outside the local community.

In sum, while natural gas boom can be beneficial to the region or the state at large, the communities that host the operations see few of the benefits and bear most of the costs of rapid natural gas development.

ii. <u>The Bust: Going into Withdrawal</u>

The flipside of explosive growth due to the development of a depletable resource is, of

[64] *Id.*
[65] *Id.* at 11.
[66] *Id.*
[67] *Id.* at 14.
[68] *Id.* at 15.
[69] *Id.* at 16.

course, what happens when the town runs out of gas. The spike in employment and population during a boom leads to a commensurate spike in community investment in housing, infrastructure, and services.[70] These investments are often predicated upon projected growth rates that make the erroneous assumption that the initial natural gas well construction phase will continue indefinitely.[71] Consequently, these communities experience a dramatic economic downturn when the industrialization process leaves the construction and development phase and enters the much less labor-intensive production phase.[72] All of the natural gas boomtowns studied in the 1970s and 1980s experienced such a downturn, and absent some very proactive and farsighted planning by the local government, economic downturn is the natural end to any natural gas boom.[73]

B. Practices to Mitigate the Economic Harms of Natural Gas Boom and Bust

It is apparent that both the up cycle of natural gas development, the boom, and the down cycle, or bust, impose burdens upon local governments. However, research suggests that sound tax policy in gas producing states can ensure long-term economic development in regions affected by resource depleting industries like natural gas.[74] This section will examine such a severance tax, whether it can mitigate the economic burdens of boom and the downturn following a bust, and whether severance taxes cause industry de-investment in taxed regions.

i. The Benefits of a Severance Tax

A severance tax is a tax charged to industries that extract nonrenewable resources to be used outside of the state where they were extracted.[75] The tax is typically calculated as a percentage of the value of the gas extracted, the volume, or some combination of the two.[76]

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[70] *Id.* at 24.
[71] *Id.*
[72] *Id.*
[73] *Id.*
[74] Susan Christopherson et al., Cornell University Department of City & Regional Planning, *The Economic Consequences of Marcellus Shale Gas Extraction: Key Issues*, CARDI REPORTS, Sept. 2011.
[75] *Id.*
[76] Oil and Gas Mineral Services, *Gas Severence Tax*, http://www.mineralweb.com/owners-guide/leased-and-producing/royalty-taxes/gas-severance-tax/

There is no standard severance tax, and each state develops its own formula.[77] In addition to the extractor, landowners pay a portion of their royalties from well leases under the tax.[78]

The purpose of the tax is to help state, local, and municipal governments cover the costs on regions and communities associated with increased population due to natural gas boom.[79] These costs include planning and zoning and other administrative services, increased road traffic and reconstruction, and heightened demands on schools, social services, and public safety.[80] On the other side of the coin, when the local natural gas play goes bust, communities are left with a decreased population and tax base.[81] A sound severance tax policy will aid communities in both dealing with the burgeoning population and economic change during the boom, and the dearth of workers and revenue during the bust. The tax will also ensure that municipal and county governments see more of the economic benefits of local natural gas operations, which otherwise tends to leak out into the broader regional economy while leaving the locals to shoulder the costs.[82]

ii. Will a Severance Tax Inhibit Industry Investment?

A key point of debate over severance taxes is the degree to which they reduce industry investment in a tax state.[83] The answer, based on studies and upon the experience with other states which charge severance taxes, is very little.[84] By way of example, in the 1990s, Montana chose to decrease its severance tax rate, while Wyoming increased it.[85] A decade later, Wyoming's severance tax rate was about 50 percent higher than Montana's, yet both states experienced a surge in natural gas drilling.[86] Wyoming's production value (the product of price

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[77] *Id.*
[78] *Id.*
[79] *See* Christopherson, *supra* note 74 at 16.
[80] *Id.*
[81] *Id.*
[82] [82] See § V(A)(i), *supra* at 10.
[83] *See* Christopherson, *supra* note 74 at 16.
[84] Id; see also The Pennsylvania Budget and Policy Center, Nat. Gas Drilling Tax, http://pennbpc.org/gas-drilling-tax.
[85] *See* Christopherson, *supra* note 74 at 16.
[86] *Id.*

times volume), however, is five times that of Montana.[87] This suggests in Wyoming's case, a relatively high severance tax did nothing to reduce industry investment.

Moreover, all natural gas producing states besides New York and Pennsylvania currently charge a severance tax.[88] It is estimated that 96% of natural gas is produced in states that have severance taxes.[89] Studies in Wyoming, Utah, and other states have shown that severance taxes have little impact on natural gas production.[90] Furthermore, state severance taxes are deductible against federal income and corporate tax liabilities, so their impact on a company's bottom line is minimal.[91] Instead of severance taxes, it seems that the location and level of reserves, as well as the expected price of natural gas have the greatest impact on industry investment in a given state or region.[92] Other factors, such as labor costs and access to markets play a significant role in industry investment.[93]

Given the importance of such factors to industry investment, the high desirability to the natural gas industry of the Marcellus Shale, the relatively high population and market density of the Northeast and New England, as well as the expected increase in natural gas prices will likely drive investment.[94] Therefore, a severance tax will likely pose minimal threat to natural gas development in New York, while providing state and local governments the revenue needed to handle the localized burdens of natural gas development.

VI. The Environmental Legacy of Natural Gas

The key concern over the rise of hydrofracking, shared by environmental advocates and much of the public, is the devastating effect the practice can have on ground and surface drinking water.[95] There are also concerns over the adverse impacts of: the treatment and disposal of millions of gallons of potentially radioactive and corrosive wastewater; the disposal of

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[87] *Id.*
[88] *Id.*
[89] The Pennsylvania Budget and Policy Center, Nat. Gas Drilling Tax, http://pennbpc.org/gas-drilling-tax
[90] *Id.*; see also Susan Christopherson, supra note 76 at 16.
[91] Christopherson, supra note 76.
[92] *See supra* note 89; Christopherson, *supra* note 76 at 16.
[93] *See* Christopherson, *supra* note 74 at 16..
[94] *See* § IV, *supra* at 5-6.
[95] Christopherson, *supra* note 76 at 16; *see supra* note 10 at 3.

potentially radioactive rock cuttings; increased emissions due to truck traffic and pump stations; and others. This section will describe the chief environmental risk posed by hydraulic fracturing, water contamination, will address the harms already experienced in states where hydrofracking is common, and some proposed solutions to the environmental impacts of hydrofracking.

A. What is the Risk to Ground and Surface Drinking Water?

Chief among the concerns over hydrofracking's environmental impacts is its potential to contaminate ground and surface drinking water.[96] These concerns are a natural reaction to a process that involves blasting up to several millions of gallons of additive-laced water deep underground, and which results in millions of gallons of contaminated flowback.[97] There is considerable debate, however, over the level of threat fracking actually poses ground and surface water. Natural gas proponents and industry members assert that the chemical additives used in fracking fluid are entirely safe, and sometimes compare them to the ingredients in various food and cosmetic products.[98] Moreover, they assure fracking critics that the likelihood of ground or surface water contamination is vanishingly small, due to both the vast distance between the fracturing operation and any groundwater, as well as the various safeguards employed by natural gas companies.[99]

Fracking opponents, on the other hand, argue the risk posed to drinking water is unacceptably high.[100] They cite the risk posed to ground and surface water by hazardous chemicals found in both the fracking fluid itself, as well as the produced water and its contamination with TSDs.[101] Fracking critics express concern over the potential for fracking

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[96] *See supra* note 10 at 3.
[97] *See supra* note 21.
[98] *See supra* note 17 at 11.
[99] *See supra* note 12; see also Adam Begley, *Hydrofracking problems are rare and preventable*, ROCHESTER CITY NEWSPAPEr, Dec. 7, 2011, available at http://www.rochestercitynewspaper.com/news/letters/2010/12/ENVIRONMENT-Hydrofracking-problems-are-rare-and-preventable/
[100] *See* Christopherson, *supra* note 74 at 7.
[101] *See* § II, *supra* at 4.

fluid to migrate from fractures in the shale to shallow freshwater zones.[102] Critics also point to the potential for fluid and produced water to migrate into groundwater supplies due to substandard well completion practices.[103] Additionally, wastewater disposal and the potential for spills is also an area of concern.[104] The following sections will examine a sampling of the available evidence to determine the likelihood of each occurrence, and will pose solutions to mitigate and prevent harm to drinking water.

i. Fracking Fluid: Deadly Chemical Cocktail, or Benign Expedient?

Considerable debate and mystery surrounds the fluid used in the fracking process. The uncertainty surrounding the composition of the fluid is due largely to the fact that fluid injected into the ground during the hydraulic fracturing process has been exempted from federal oversight under the Clean Drinking Water Act.[105] This exemption was amended to the Act due largely to a 2004 EPA study which found the fluid poses "little to no threat" to drinking water.[106] Many in the natural gas industry have made much of this finding in arguing that fracking fluid is safe, although it has been criticized as scientifically unsound by commentators such as Weston Wilson, an EPA scientist who spent more than three decades with the EPA.[107] Hyrdrofracking also enjoys exemption from the 1986 Emergency Planning and Community Right-to-Know Act, which mandates disclosure of information to the public on hazardous chemicals used at individual industrial facilities, their uses, and releases into the environment.[108] Moreover, natural gas companies expend considerable resources developing their proprietary blends, and seek to

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[102] Ernest J. Moniz et al., *The Future of Natural Gas: An Interdisciplinary MIT Study Executive Summary*, Massachusetts Institute of Technology (2011) at 7, available at http://web.mit.edu/mitei/research/studies/documents/natural-gas-2011/NaturalGas_ExecutiveSummary.pdf
[103] *Id.*
[104] *See* Christopherson, *supra* note 74 at 7.
[105] Sarah Collins & Tom Kenworthy, *Energy Industry Fights Chemical Disclosure Natural Gas Companies Want to Prevent Oversight of Fracking*, Center for American Progress, available at http://www.americanprogress.org/issues/2010/04/fracking.html
[106] *Id.*
[107] *Id.*
[108] *Id.*

protect their formulas as trade secrets.[109] Under New York's proposed natural gas regulations, companies will be able to apply to the Department of Environmental Conservation for trade secret protection, though the companies will still be required to disclose the ingredients of their fracking fluid to the DEC to obtain a permit.[110]

Because of their exemption from public disclosure requirements, natural gas companies have been somewhat successful at controlling public knowledge concerning fracking fluid additives.[111] Companies often emphasize that fracking fluid is composed of roughly 99 percent water and sand or other proppant, and gloss over other additives.[112] Companies also emphasize that many of their additives are used in food processing or cosmetic products in an effort to raise the public's comfort level with the additives.[113]

Despite industry efforts at raising public confidence and the exemption from disclosure requirements, studies have shown that at least 65 of the chemicals contained in some fracking fluid used in Colorado to date are listed or regulated as hazardous substances under six federal statues including the Clean Air Act, Clean Water Act, and Superfund.[114] Benzene is among the chemicals shown to have been added to fracking fluid, as well as produced by condensate, a liquid produced along with natural gas.[115] Benzene is a known carcinogen, and linked to nervous system disorders.[116] The maximum safe concentration of benzene in drinking water is just 5 parts per billion.[117] Thus, while many of the chemical additives in fracking fluid may be benign, it has been found to contain chemical additives that are unsafe even at vanishingly small

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[109] International Law Office, *States move forward with hydraulic fracturing disclosure regulations*, November 14 2011, available at http://www.internationallawoffice.com/newsletters/detail.aspx?g=13462e2d-bacc-40d3-97d7-ad2bb1a5a26f#7
[110] *Id.*
[111] *See* Collins, *supra* note 105.
[112] *See supra* note 12.
[113] *See* Daniel, *supra* note 17.
[114] The Endocrine Disruption Exchange, Analysis of Products Used for Drilling Crosby 25-3 Well – Windsor Energy, Park County, Wyoming, available at http://www.endocrinedisruption.com/files/Crosby25-3wellsummary4-20-09Final.pdf
[115] Environmental Working Group, Statement of Dusty Horwitt, JD, December 2008, available at http://www.ewg.org/node/27441
[116] *Id.*
[117] *Id.*

concentrations. The presence of these chemicals makes fracking fluid a threat to human beings, should the fluid find its way into drinking water.

ii. Natural Gas Migration into Drinking Water

A second key area of debate surrounds the likelihood or possibility of fracking fluid and natural gas migrating from a natural gas well to a ground or surface drinking water source.[118] It is the natural gas industry's standpoint that escape of fracking fluid or natural gas from the wellbore into drinking water is extremely unlikely.[119] It is thought that the several layers of concrete and steel casing that sheathe a wellbore, which is especially thick closer to the surface where groundwater is typically located, preclude such an escape.[120] Independent studies have confirmed this theory, and suggested that fluid migration from a properly completed well is unlikely and has not been observed.[121]

However, there is evidence of natural gas migration due to improper well completion by certain operators.[122] A recent study of natural gas operations on the Marcellus and Utica Shale formations in Pennsylvania and upstate New York found direct systematic evidence of methane contamination in drinking water.[123] The level of contamination in drinking water sources was inversely proportional to the distance of the sources from natural gas wells, and was often high enough to constitute an explosion hazard.[124]

In what is surely one of the more dramatic examples of methane migration from a well to a drinking water supply, in 2008 natural gas in an Ohio family's well caused their house to explode.[125] Although the two residents at home at the time were not injured, their house was

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118 *See* Moniz, *supra* note 102.
119 *See supra* note 12.
120 *Id.*
121 *See* Moniz, *supra* note 102 at 7.
122 *Id.*
123 Stephen G. Osborn et al., *Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing*, Cary Institute of Ecosystem Studies, April 14, 2011, available at http://www.pnas.org/content/early/2011/05/02/1100682108.
124 *Id.*
125 Ohio Department of Natural Resources, Report on the Investigation of the Natural Gas Invasion of Aquifers in Bainbridge Township of Geauga County, Ohio, September 1, 2008 at 3, available at http://www.dnr.state.oh.us/Portals/11/bainbridge/report.pdf

significantly damaged.[126]A report by the Ohio Department of Natural Resources concluded there were three primary factors in the drilling and completion of the well which led to the explosion: first, inadequate cementing of the wellbore casing; second, the decision to proceed with hydrofracking despite the inadequate cement behind the casing; third, the well operators decision to allow 31 days to pass after fracking the well, during which time dangerous pressure levels built up inside the sealed well.[127] Thus, it is apparent from independent and government studies that migration of natural gas from a well to drinking water is an entirely possible, if not frequent occurrence.

iii. <u>Fracking Fluid Migration into Drinking Water</u>

Perhaps the most hotly debated area of concern surrounding the environmental impacts of fracking is the potential for fracking fluid itself – and the chemical additives therein – to migrate into drinking water.[128] The natural gas industry has firmly denied the possibility of water contamination by fracking fluid, citing the multiple layers of wellbore casings and the thousands of feet of impermeable rock between the fracturing operation and most aquifers.[129] The industry has also cited the dearth of evidence of drinking water contamination by fracking fluid; although anecdotal evidence of such contamination abounds, there had been no official finding that fracking fluid was behind poisoned drinking water.[130]

That all changed on December 8, 2011, however, when the EPA released a draft report on its investigation into contaminated groundwater near Pavilion, Wyoming.[131] The report conclusively found, for the first time, that contamination in groundwater likely seeped up from gas wells, and contained at least 10 chemical compounds used in fracking fluid.[132] The report's

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[126] *Id.*
[127] *Id.* at 5.
[128] *See* Moniz, *supra* note 102 at 7.
[129] *See supra* note 12.
[130] Jad Mouawad & Clifford Krauss, *Dark Side of a Natural Gas Boom*, THE NEW YORK TIMES, December 7, 2009, available at http://www.nytimes.com/2009/12/08/business/energy-environment/08fracking.html?pagewanted=all
[131] Abrahm Lustgarten & Nicholas Kusnetz, *Feds Link Water Contamination to Fracking for the First Time*, ProPublica, Dec. 8, 2011, available at http://www.propublica.org/article/feds-link-water-contamination-to-fracking-for-first-time
[132] *Id.*

findings contradict many of the natural gas industry's arguments concerning why hydrofracking is safe, such as the thick, impermeable layer of rock between fractures and groundwater;[133] the theory that hydrologic pressure would naturally force fluids down, away from groundwater; and the argument that problems with wellbore casings are endemic to all gas wells, not just fracked ones.[134] Thus, based on the EPA's findings, it is entirely possible for contaminants from fracking fluids to migrate into drinking water supplies.[135] It has happened at least once before, and in reality, the phenomenon has probably not been isolated to Pavilion; the Dec. 8 EPA report is merely the only instance of an account of fracking contamination being officially verified.

iv. Mitigation Efforts to Prevent Impacts on Drinking Water Supplies

If even a fraction of the anecdotal evidence of drinking water contamination by fracking fluid is true, poisoned groundwater due to fracking is a significant public health problem in the United States. The problem is only likely to become worse over the next several decades as natural gas development skyrockets in the Marcellus Shale and elsewhere, unless significant steps are taken to prevent the worst effects. The next sections will address some potential solutions to the environmental threats posed by natural gas development.

Researchers at Cornell University have posed a framework for assessing the threat to drinking water, and several suggestions respecting public policy and natural gas regulation in New York.[136] The model distinguishes between two types of impacts on drinking water: first, impacts which are certain and can be planned for, such as water withdrawal and waste disposal, and impacts that are uncertain, such as spills, leaks, and contaminant migration, which must be addressed through risk assessment, preventative practices, and reporting and monitoring structures.[137] Expected impacts can be managed and regulated to minimize or avoid impacts on surface and groundwater, and to control and monitor the scale and pace of development.

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[133] *See supra* note 12.
[134] *See* Lustgarten, *supra* note 130.
[135] *Id.*
[136] *See* Christopherson, *supra* note 74 at 7.
[137] *Id.*

Unexpected impacts, conversely, cannot be specifically planned for or proactively monitored, but can be "minimized by targeted regulation, encouragement of preventative management practices, establishment of timely and accurate reporting guidelines, and emergency response planning."[138]

Several specific policy and regulatory suggestions are posed to help mitigate both expected and unexpected impacts: first, a water withdrawal permitting system with data collection and monitoring requirements, to allow for agency oversight of expected water withdrawal impacts on drinking water sources.[139] Legislation on this suggestion is pending in New York.[140] Second, use of private water treatment facilities rather than municipal facilities for hazardous and complex flowback and produced water should be mandated.[141] This will reduce damage to municipal water treatment facilities not designed to process the kind of contaminants found in fracking wastewater. Third, stringent regulations should be adopted governing on-site containment practices to prevent drinking water impacts caused by spills and leaks.[142] Fourth, a fast and transparent reporting system needs to be developed to ensure effective responses to unplanned events by emergency personnel and regulatory agencies.[143] Fifth, drinking water wells near natural gas drilling sites should be tested both before and regularly after drilling to allow a link to be established between drilling activity and drinking water contamination.[144] Lack of baseline well water quality data has frequently been the cause of an inability to establish a connection between drilling and water contamination; ensuring testing before and after drilling will remedy this problem.[145] Finally, State Pollutant Discharge Elimination System (SPDES) permitting requirements, which govern wastewater discharge in New York, and other enforceable requirements for containment, monitoring, and compliance measures by well operators should be introduced.[146] These measures, if adopted and vigorously enforced, will help to curb the worst

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[138] *Id.*
[139] *Id.*
[140] *Id.*
[141] *Id.*
[142] *Id.*
[143] *Id.*
[144] Id.
[145] *See*, Horwitt, *supra* note 115.
[146] *See* Christopherson, *supra* note 74.

environmental effects of natural gas boom on the Marcellus Shale. Provisions such as these would give the proposed natural gas regulations in New York considerably greater power to ensure the safety of ground and surface drinking water.

While New York can and should impose measures through regulations to prevent damage to drinking water resources, the push to prevent environmental impacts cannot come exclusively from regulatory bodies. The majority of environmental impacts such as natural gas and fracking fluid migrations are caused by substandard well drilling and completion practices.[147] Therefore, it is incumbent upon natural gas developers to develop and faithfully espouse industry best practices at every stage of well development. Ensuring proper monitoring of the subsurface prior to and during fracking, as well as proper completion of the well and casings will reduce the likelihood of unplanned impacts on water resources, and justifiably increase public confidence in fracking technology through safe operation, rather than misinformation.

VII. Conclusion

Natural gas development of the Marcellus Shale has the potential to provide substantial economic benefits to New York state. Development is certain to result in job creation, and is almost certain to result in a net economic benefit to the state at large. Care needs to be taken, however, to avoid disproportionately burdening natural gas boomtowns with the costs of explosive development while they see little of the benefits. New York state should follow the lead of every other natural gas producing state besides Pennsylvania and adopt a severance tax to ensure both short-term and long-term economic growth in natural gas boomtowns.

While development of the Marcellus Shale presents a likely net benefit to the New York economy, it poses a strong possibility of negative impacts on the state's drinking water resources. This trend has been observed and proven in other natural gas producing states. To prevent environmental impacts of fracking and ensure the economic benefits of natural gas are not outweighed by its environmental costs, New York needs to strengthen its regulatory scheme. Finally, the natural gas

[147] See § VI(A)(ii), (iii) *supra* at 17-19.

industry must self-regulate, espousing best practices to ensure environmental impacts like those in other states do not occur in New York. If the right policies are adopted and consistently enforced, New York can reap the benefits of a burgeoning natural gas economy, with few costs to its communities or environment.