The Physical and Legal Implications of Continued Fracking in the Marcellus Shale Gas Basin

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Abstract:

In this paper we make a set of physical and legal arguments that call into question the wisdom of harvesting shale gas as a means of reducing our carbon footprint associated with the generation of electricity. From the legal and regulatory views it is clear that extant law has little applicability to shale gas mining operations despite the significant potential of harmful effects to nearby land owners, water quality in the relevant water sheds, and to the consumer. There is already substantial anecdotal evidence of direct harmful effects on area livestock and ground water contamination. Furthermore the lack of strong regulatory statutes allows for drilling to occur at almost any location, independent of the physical nature of the material which is being drilled. There are significant porosity variations in these shale deposits so that some locations can drill and frack in very “leaky” environments. In these cases, more methane may be leaking to the atmosphere than is captured by the well head infrastructure. Furthermore, given the limited supply of available shale gas, relative to current demand, it seems wiser to invest in non-GHG generation technologies. We explicitly demonstrate this by building an infrastructure model to develop 200 GW (an increase of 20% from the current value for the US) of new nameplate generation capacity by the year 2020 and compare wind energy vs. shale gas against that target. The major feature of this model is that the rapid rate of decline in individual well-head production requires a very large commitment to building new wells to make up for these losses. More specifically, we fit raw well-head production data to a simple annual exponential decline which results in a well-head useful lifetime of 3 years before it needs to be replaced (or possibly refreshed with additional fracking). This framework shows that sustainability of yield (in PA) requires building approximately 6000 new well heads a year at the expense of producing 750 square miles of abandoned well-head wasteland each year. For wind, we require 70,000 2.5-3 MW wind turbines to be built out to 2020. Each of these non-GHG producing turbines can provide energy for 25 years whereas NG fired electricity, from a cumulative build out of 50,000 new well heads, would produce 14 gigatons of CO_2 emission over this time period and wasteland 15% of the state of Pennsylvania. Thus harvesting of shale gas as a source of electricity generation is neither scalable nor sustainable and the external consequences of continuing on this course, as a matter of US energy policy, are severe.

I. **Introduction**

In this article we critically examine the overall impact of harvesting shale gas located in the Marcellus Shale Basin as the principal means of reducing US greenhouse gas (GHG) emission associated with the generation of electricity. We perform this examination from both a physical and legal/regulatory point of view. From the physical point of view, we construct a straw model based on aggressively increasing US nameplate electrical generation capacity by 20% from its 2010 value by the year 2020 and then directly compare the harvesting of shale gas and the associated infrastructure deployment to that which is required to meet this nameplate capacity goal through build out of wind energy which does not produce GHG emission. The discussed legal and regulatory aspects of hydraulic fracking include local land use law, mineral rights, water rights, and applicable federal law including EPA regulations and tax incentives.

In November of 2011, for the first month ever, coal fired electricity fell to less than 40% of total US generation due to gains made in NG fired electricity. That statistic, however, only creates the illusion of a decarbonized electrical grid. Although NG emits 50% less GHG per MW generated than coal, our total GHG emission continues to grow due to increasing consumption. Rather than using NG for capacity additions, a far more sensible approach is to use NG as a **direct replacement** for coal (e.g. Nelson etal 2012). This echoes a salient policy statement made by the Environmental Defense council in March 2012:

> *Our nation's top energy priority must be the rapid expansion of energy efficiency and renewable energy resources. These are the quickest, cleanest, and most sustainable*

> *solutions to meeting our energy needs, while curbing global warming and other serious pollution problems*

We argue in this paper that exploiting these newly discovered shale gas deposits as a source of new electricity generation are unsustainable and, as utilized, will increase the GHG emission budget of the US – in stark contrast with the above policy statement.

II. Some Physical Scenarios

a) Coal vs. Natural Gas and associated GHG emissions

We begin by setting the numerical context of electricity generation in the US and the role of natural gas (NG) in that generation. Total generator nameplate capacity is a direct measure of total investment in infrastructure. In 2008, US nameplate capacity was 1.104 Terawatts[1] (TW); by 2010 this had risen to 1.139 TW through capacity additions (primarily NG and wind) of 35,000 MW. In 2010, coal nameplate was 342 GW while NG was 467 GW[2]. In 1990 those nameplates capacities were 330 GW coal compared to 153 GW NG. Currently NG is operating strictly as a capacity addition and not as a **directreplacement** for coal which therefore increases total US GHG emission. To show this we normalize 330 GW of coal to 2 coal units of emission; 153 GW NG then equates to 0.46 units leading to 2.46 units of emission in 1990. For 2010, coal is 2.07 units while NG has risen to 1.4 units for a total emission of 3.47 units or a 41% increase in GHG emissions associated with increasing electricity generation over the last 20 years. Therefore our GHG emission budget is not getting smaller as the result of building our NG infrastructure.

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[1] Unless otherwise indicated, all data values were obtained from data tables contained at the EIA webdite

[2] Throughout, electrical power may be expressed as Terawatts (TW), Gigawatts (GW), or Megawatts (MW)

b) **200 GWof new facilities by 2020: Wind vs. Shale Gas**

By the end of 2012 the US will have an installed wind nameplate capacity of 53 GW. In 2011 and 2012 approximately 13 GW has been installed using mostly 1.5 MW turbines yielding a deployment rate of 4300 turbines per year. In the near future, wind farms will install 2.5 MW turbines with 3 MW considered the limit (due to transporting the blades) for any land based wind farm. Our physical model for turbine build out that annual growth of installed turbines, with continued investment, will be 15% over the 2013-2020 period (this is lower than the current data suggest as its unclear if the production tax credit for wind installation will continue throughout this period) and that 2.5 MW turbines will be installed from 2013-2016 and then 3 MW turbines installed from 2017-2020. As shown below 200 GW is reached by end 2020 as powered by 68000 new turbines.

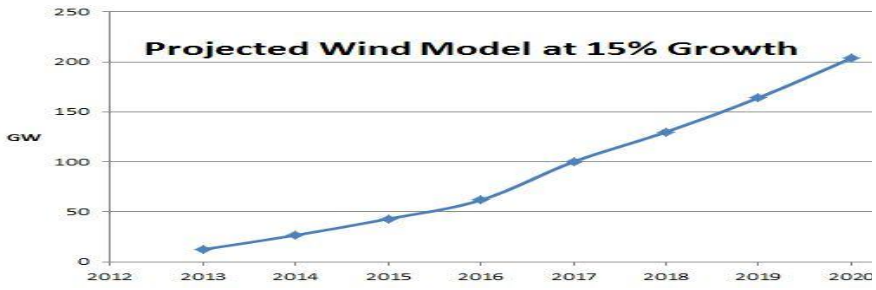

Figure 1: Model Cumulative build out of wind nameplate capacity from to 2020

We now estimate the wellhead infrastructure needed to produce 200 GW of nameplate capacity in the Marcellus shale basin. In 2011 total US Natural Gas Consumption was 24.3 TCF[3]. Of this 14.2 TCF is used for space heating; 7.6 TCF is used to generate electrical power at the 467 GW current nameplate capacity of NG. This scaling yields 3.3 TCF (per year) necessary to produce 200 GW of NG fired electricity. As 75% of the Marcellus resource is contained in Pennsylvania (PA) we will use that data[4] as the basis for our model. The table below summarizes recent well head construction in PA that involves the Marcellus Shale basin:

Year	**Well Heads Constructed**
2008	**185**
2009	**770**
2010	**1385**
2011	**1850**
Through 9/2012	**1065**
Total:	**5315**

The 2012 data suggest that wellhead build-out is no longer increasing at the rate that was previously established as its on pace to be less than 2011. Indeed, in 2011 on average 5 wellheads per day were constructed – data for July 2012 show that this has declined to 2.5 per

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[3] TCF = trillion cubic feet; MCF = million cubic feet

[4] All data come from the State of Pennsylvania Dept. of Environmental Protection Website (PADEP)

day. This decline in well head construction is consistent with the 2012 NG production data for PA (Figure 2) which shows asymptotic behavior suggesting PA is at peak production of 5.8 BCF per day from its combined 5000-5500 well heads operational since 2008.

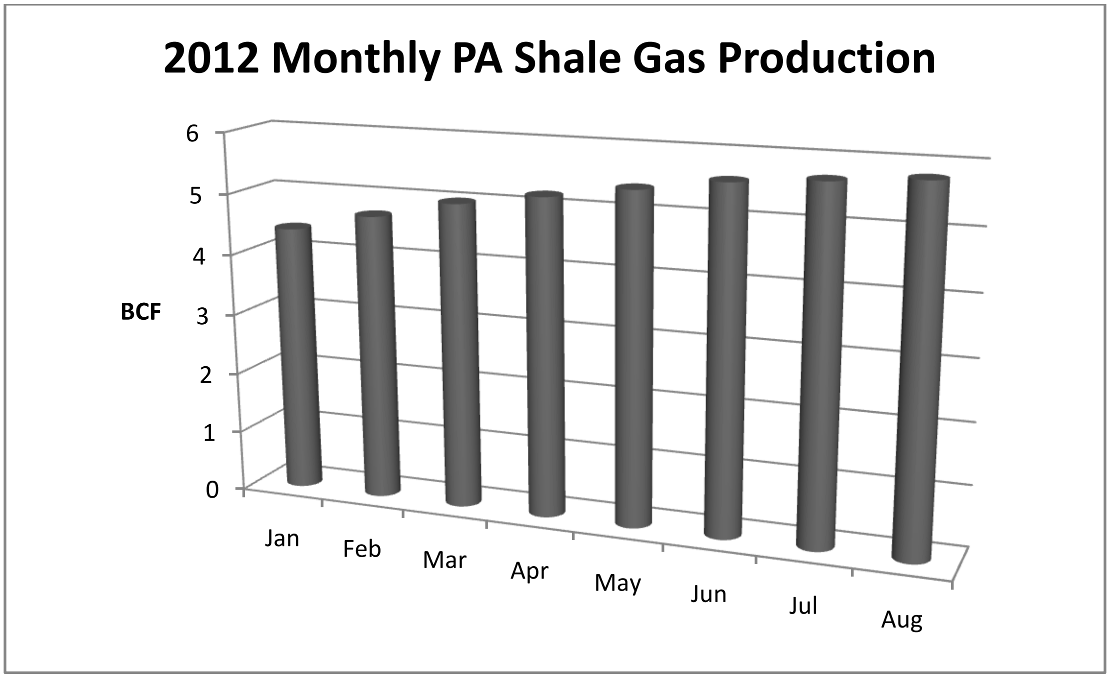

Figure 2: Monthly averages of shall gas production in PA in units of BDF per day. Data Source: Bertek Energy (EIA)

The above production data shows an increase of about 1.3 BCF per day based on the addition of about 1000 new wells over the 2012 period. Thusa new well-head yields approximately 1.3BCF/1000 = 1.3 MCF per day of production but then declines (significantly) with time as the pressure inside the well head drops.The estimated ultimate recovery (EUR) from a given wellhead is currently a contentious issue between the industry and independent studies, due tostrong differences in formal mathematical models of individual well head decline[5]. While complex hyperbolic functions are often used (Mason 2011; England etal 2000) to formally compute daily well-head declines, we take a simpler approach by using a simple exponential decline to describe decline over the period of many years. A qualitative figure of merit from analysis of raw data[6] is that after 24 months, a typical well head is down to 10% of its peak production. Our modeluses a somewhat high initial production rate of 2 MCF per day for a PA Marcellus new well-head and a formal exponential decline rate of 0.3% per day. Under this model, production declines to 1% after 4 years; any annual yield comes from wellheads constructed over the most recent 3 year period. Hence, if 2000 new wells were (hypothetically) built in 2012 and turned on for one year starting Jan 1 2013 they would produce 1.1 TCF of NG for 2013, 0.4 TCF in 2014 and 0.1 TCF in 2015.The combined 3 year sum is 1.6 TCF or about ½ of the 3 TCF target value. Therefore to reach 3 TCF would require the building of 4000 new wells every year for each 3 year period. If the initial yield was 1 MCF per day then 8000 new wells per year would need to be built.

From the mathematical/physical point of view, it is quite clear that significant well head loss makes this entire enterprise completely unsustainable. Even at a capacity factor of 1/3, it seems much wiser to build out 70,000 new wind turbines (with no GHG emissions) spread out over the windy Midwest (which likely increases the overall capacity factor) and leave them standing there for 20-30 years of operational lifetime compared to building 4000-8000 new wells a year and then abandoning them every 3 years! On average, this would be 16 wellheads a day being built, 7 times larger than the current rate of deployment. Furthermore, the impact on the land would be severe. At a current well head surface density of 8 per square mile this would mean that, on

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[5] See the extensive discussion in http://www.theoildrum.com/node/8212

[6] Raw production data on individual wells is available at www.hdpi.com

average**, PA would acquire about 750 square miles of abandoned well head wasteland per year!**

Moreover, on a 25 year timescale our model wind energy build out would yield 200 GW*0.4 (capacity factor) *25 = 17250 TW-hrs of total energy with 0 GHG emissions. At a constant value of 2000 well-heads per year, assuming 2 MCF initial yield, we reach a nameplate capacity of ~100 GW at ~90% capacity factor. Over a 25 year period this produces slightly more aenergy at 19710 TW-hrs but would require installing50,000 well-heads occupying 6200 sq. miles or 14% the size of PA. In addition, 7.5 Gigatons of CO_2 emissions would result**. At this level, the entire enterprise can be avoided if area consumers simply used 10% less electricity.**

c) Estimated yields of the Marcellus Basin

Calculating the exhaustion timescale of any resource that is consumed is given by expression below (see Bartlett 1978)

$$\mathbf{T_e = 1/k * \ln (Rk/r_o +1)}$$

Where k represents exponential consumption increase, R represents the total estimated recoverable reserve, and r_o is the initial use. The peak time ($\mathbf{T_p}$) in the above formulation occurs at ½ $\mathbf{T_e}$. In the table below we assume that all the estimated TCF in the Marcellus shale formation will be used for electricity generation and that the resource can be (theoretically mined) to scale with an annual 2% increase in demand (driven by current low prices). We use an initial value of r_o = 1.5 TCF harvested per year, consistent with the optimistic value previously derived. There are extremely large variations in the overall estimated yields with the trend that more recent estimates are much less than the earlier optimism.

Year of Estimate	Yield Estimate (TCF)	Agency	T_p(years)
2002	**31**	**USGS**[7]	**8**
2008	**392**	**Engelder and Lash (2008)**	**45**
2009	**500**	**Engelder (2009)**	**50**
2009	**1500**	**Dept. of Energy**	**76**
2011	**84**	**USGS**	**19**
2011	**410**	**EIA**	**46**
2012	**141**	**EIA**	**26**

The relatively small values for $\mathbf{T_p}$(particularly for the most recent 2012 estimate)provide a clear indication that harvesting the available shale resource is only a short term solution to increasing electricity demand; the reserves are simply not big enough to scale to demand to make harvesting, in the wake of a huge infrastructure impact, very sensible.

III. **Regulatory and Legal Issues**

The first section of this article addressed the doubtful utility of hydraulic fracturing of shale gas for greenhouse gas mitigation. This section will focus on legal and regulatory aspects of fracking in the Marcellus Shale formation. A primary goal of legal and regulatory frameworks is to limit the harmful impact from resource extraction under a variety of extraction scenarios.

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[7] United States Geological Survey

a) Shale Rock Characteristics:

The potential damage to humans, animals, and water resources caused by fracking depends on the physical characteristics of the particular shale gas deposit. Soeder(1988) demonstrates that significant variations exist in the porosity and permeability of the shale gas deposits throughout the northeastern US. Due to the potential extraction of shale gas (see Soeder 2010), there have been a flood of more recent studies (e.g. Eseme etal 2007; Passey etal 2010; Sondergeld etal 2010; Curtis etal 2011;). Porosity and permeability characteristics within shale oil determine the amount of "gas flow" that can occur and the overall efficiency of extraction. Explosive release (e.g. hydraulic fracking) of trapped gas can have a wide range of outcomes depending upon these physical characteristics. Simply put, shale gas that is entrained in rock with high porosity/permeability will more readily "leak" to places other than the intended well head pipeline. Mining operations in these kinds of formations enhance the probability of methane release. Pipeline leaks can also vent methane into the atmosphere. In August of 2011, the US Department of Transportation issued a safety order[8] on the newly constructed Millennium pipeline in New York for apparently faulty welds. Santoro etal (2011) and Howarth etal (2011,2012) have both argued that the combined effects of these processes may be leading to more methane release to the atmosphere than is actually captured by the well-head/pipeline infrastructure. While the magnitude of well head or pipeline leakage remains controversial (and under studied) it nevertheless raises the issue that porosity and permeability characteristics of each individual shale deposit should become part of the scientific basis for regulation and permitting

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[8] http://primis.phmsa.dot.gov/comm/reports/enforce/documents/120111013S/120111013S_NOPSO_07062011_text.pdf

b) Water Usage Details

Since large volumes of water are required to drill the wellhead, large volumes of waste water are generated by this drilling process. This wastewater is considered by the Susquehanna and Delaware River Basin commissions to be industrial wastewater and the permitting process must identify where drillers plan to obtain and store their water and to specify their rate of water withdrawal. Drillers must also specify where the produced wastewater will be stored and properly treated. According to a 2012 study by Chesapeake Energy 5.6 million gallons[9] of water per well are needed. For 6000 wells per year this is a daily water usage of 90million gallons all of which needs to be regulated and monitored to be in compliance with existing codes.

Drilling down a few thousand feet should protect groundwater resources from contamination, but flaws in well casings may result in leakage. Between 15 to 80 percent of the fracking fluid is recovered as “flowback”[10]. The flowback fluid is contaminated with the fracking chemicals as well as salts, metals, and radioactive chemicals that come out of the rock itself. Fracking wastewater is a combination of flowback liquid and waste water. The wastewater is typically stored in surface containment ponds until it can be treated and either pumped into permanent storage wells or discharged into surface water. In some cases, the wastewater is reused as fracking fluid. Contaminants may find their way to groundwater or the surface by way of abandoned gas wells or natural fractures. In addition, methane from fracking operations may migrate to drinking water wells. While methane does not affect the potability of the water, it does pose an asphyxiation and explosion hazard when it moves from the water into the air, for example, when an indoor tap is turned on. (Jackson et al., 2011)

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[9] http://www.chk.com/media/educational-library/fact-sheets/marcellus/marcellus_water_use_fact_sheet.pdf

[10] Tiemann, et al., 2012 Marcellus Shale Gas, CRS p. 11

C) Potential Harmful Impacts

Reports detail many instances of animal and human injury attributed to fracking. (Bamberger & Oswald 2012). Inadvertent release of fracking fluids into a cow pasture killed 17 cows in one hour. Out of sixty cows that were exposed to where fracking wastewater was dumped, 21 died, and 16 failed to produce calves the next spring. Reproductive and neurological problems were most commonly reported among the animals studied. Some of the exposed animals continued to produce milk and meat products that were sold for human consumption without testing of the animals or products. The animals' owners most frequently suffered from respiratory symptoms, headaches, and gastrointestinal problems. In addition, numerous fish kills in Pennsylvania have been attributed to fracking operations. (Dutzik, Ridlington, &Rumpler, 2012).

D) Applicable/Inapplicable Federal Law

Fracking is exempt from most federal environmental laws. The Clean Water Act (CWA) specifically exempts oil and gas operations from federal storm water regulations. (33 U.S.C. § 1362(6)). Fracking operations are subject to the CWA requirements for discharge into surface waters, although the CWA's regulatory program is not comprehensive and does not include pretreatment requirements for fracking wastewater. (33 U.S.C. § 1251 et seq.) The Resource Conservation and Recovery Act (RCRA) exempts natural gas exploration wastes from federal regulation. 42 U.S.C. § 6901 (Ch 82). The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) excludes natural gas and natural gas liquids from its definition of hazardous substance, although fracking fluids are not specifically exempted. 42 U.S.C. (CERCLA) § 101(14). The oil and gas industry is exempt from reporting releases of toxic materials under the Emergency Planning and Right to Know Act (EPCRA). 42 U.S.C. § 11047 (Ch 116). The Safe Drinking Water Act (SDWA) does not apply to injections of fracking fluid for gas recovery purposes (unless diesel fuel is used). 42 U.S.C. § 300h(d). The SDWA does apply to disposal of fracking wastewater by injection, but fracking wastewater is not considered hazardous and can be disposed of in Class II wells, subject to less stringent requirements than Class I wells for hazardous waste. The EPA directly implements the Underground Injection Control (UIC) program in New York and Pennsylvania. Ohio and West Virginia have assumed primacy as allowed under the SDWA and implement their own UIC programs. 42 U.S.C. § 300h-4.

The fracking exemption under SDWA was added by the Energy Policy Act of 2005 (P.L. 109-58, § 322), which also limited the applicability of the National Environmental Policy Act (NEPA, 42 U.S.C. ch 55) review procedures to oil and gas well expansions. The provision in the Energy Policy Act may have originated with a recommendation by the National Energy Task Force that technologically advanced resource extraction techniques, such as fracking, should be exempted[11] In 2004, the EPA published a study of fracking’s impact on public water supplies, concluding that fracking posed little risk to water supplies[12]. A 2007 Washington Post article noted that the Energy Task Force was dominated by industry groups and excluded the views of environmental groups. Congress has since requested the EPA to revisit the issue, and the final report is expected in 2014. (P.L. 111-88, H. Rept. 316).

E. State Law

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[11] National Energy Policy 2001, p. x & 5-6.

[12] EPA National Study Final Report 2004.

Although fracking largely escapes federal regulations, it is subject to a number of state and local laws and regulations. State laws govern the permitting process, the drilling and fracturing process, production operations, management and disposal of wastes, and abandonment and plugging of the well. In some states, local authorities may also regulate well placement and operations. Fracking may provide significant financial benefits to state and local governments in the form of tax revenue, impact fees, and employment. Thus, the governmental authorities may have conflicting interests: protecting citizens' rights to clean water and encouraging economic growth. On the other hand, polluting streams and water sources can have a negative impact on economic growth, as damage to aquatic systems can have impacts on local businesses. In Pennsylvania, fishing had an economic impact of $1.6 billion in 2001. (Dutzik&Ridlington 2012).

A. New York

New York's fracking industry is regulated by the Department of Environmental Conservation (DEC). New York has particular cause to be concerned about water pollution. New York City's water supply comes from pristine upstate New York watersheds that need no water filtration. (Dutzik&Ridlington 2012). These upstate watersheds sit atop the Marcellus Shale formation. If the watershed were to become polluted, the cost of building a filtration plant would be significant. In 2009, Governor Patterson issued an executive order[13] putting a moratorium on new fracking permits until an environmental impact statement could be updated. (The supplemental generic environmental statement (SGEIS) is required by the State Environmental Quality Review Act (SEQRA). The SGEIS notes that DEC's existing oil and gas well regulations will need to be revised to face the new challenges of fracking. On September

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[13] Ex. Ord. 41 (2009).

20, 2012, Governor Cuomo announced that the moratorium will continue until the health commissioner analyzes the health effects of fracking. The oil and gas extraction industry is a very small portion of total employment in New York, less than 0.01 percent of the state's total employment[14]. The Park Slope Food Cooperative, which buys more than $3 million worth of products from upstate farms, has told farmers its members will not buy products from any area that allows fracking, due to fear of contamination[15]

B. Pennsylvania

The Pennsylvania Department of Environmental Protection, Office of Oil and Gas Management, administers the state laws and regulations relating to fracking. In the Marcellus Shale formation, over 12,000 drilling permits have been issued since the first fracking operations began in 2005. The PADEP increased the size of its enforcement staff to 130 employees, 65 of which are inspectors. In 2010, each Pennsylvania oil and gas inspector was responsible for, on average, 1,092 active wells. Pennsylvania has seen some of the most spectacular environmental problems from fracking, including methane gas incursions into drinking water wells, resulting in flaming water coming out of household taps. In response, in 2011, the legislature amended 25 Pa. Code Ch 78 to update regulations for the drilling, casing, cementing, testing, and monitoring of oil and gas wells. The PADEP issued 1,192 violations to drilling companies in 2011, but only six percent of those violations resulted in fines, which totaled $2.4 million[16]. In February 2012, the Pennsylvania legislature enacted Act 13, which removes local municipalities' power to ban

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[14] (NYSDEC, Economic Assessment Report 2011)

[15] Mary Esch, Fracking in New York: For Farmers, Gas Drilling Could Mean Salvation—Or Ruin, Huffington Post, May 20, 2012

[16](Clean Water Action Report: Few Penalties for Violated Gas Drilling Rules (June 8, 2012).

drilling, requiring drilling to be allowed in all zoning districts. The legislation faces a legal challenge from municipalities[17].

In addition to the zoning override, Act 13 allows doctors to receive information about fracking chemicals, but if the doctors receive such information, they must agree not to disclose it to their patients. A Pennsylvania doctor has challenged this provision under 1st Amendment grounds. *Rodriguez v. Krancer,*[18]. Act 13 also imposes an impact fee on drillers of $50,000 per well for horizontal wells. Five percent of the impact fees, estimated to raise a total of $206 million in 2012, are earmarked for infrastructure improvements to attract drillers[19]. The most recent legislation, enacted Oct. 9, 2012, opens up state public university campuses to fracking operations[20].

C. Ohio

In 2004, H.B. 278 gave the Ohio Department of Natural Resources sole authority to regulate oil and gas wells, removing any authority by local governments. More recent legislation includes the doctors' "gag rule" similar to Pennsylvania's Act 13. In 2011, Ohio opened up its parks and other state-held lands for drilling. 140 permits for horizontal drilling into Marcellus Shale formation have been issued by the Ohio Department of Natural Resources. Ohio charges a resource severance fee of $0.025/1,000 cubic feet of natural gas. While drilling in Ohio is far behind Pennsylvania, Ohio's big contribution to fracking is in wastewater disposal. West Virginia and Pennsylvania ship most of their wastewater to Ohio for disposal. Ohio had 177

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[17] Inglar, Communities see Marcellus law as striking at the heart of autonomy, Post-Gazette July 26, 2012

[18] 12 CV-01458 (M.D. Pa. July 27, 2012)

[19] Morgan, Impact Fees Bring $10 Million for Infrastructure Improvements, shalereporter.com (Oct. 8, 2012)

[20] Brownstone, Pennsylvania Fracking Law Opens Up Drilling on College Campuses, Mother Jones Oct. 12, 2012

active Class II injection wells that absorbed almost 370 million gallons of wastewater in 2011. In 2012, Ohio increased its penalty for violation of storage regulations for natural gas fluids to a maximum of $20,000 per day in violation. (15 ORC ch 509 (2012)). Ohio collected only $17,500 in penalties in 2011.[21]

D. West Virginia

The Office of Oil and Gas of the West Virginia Department of Environmental Protection is responsible for regulating fracking in West Virginia. Between 2002 and 2008, the WVDEP issued over 2,800 permits for drilling in the Marcellus Shale formation[22]. West Virginia drilling permit costs are low ($600 per permit), but the state charges a 5 percent severance fee based on the value of the extracted fuel.

The WVDEP Office of Environmental Advocate publishes a guide for citizens outlining how to file complaints, although it has not been updated for the most recent legislation. In 2010, West Virginia imposed $87,710 in drilling violation penalties. In 2011, the West Virginia legislature enacted its Horizontal Drilling Act (H.B. 401), which emphasizes the positive employment aspect of fracking in its first section (§5B-2B-4a.) However, the legislation specifically preserves the common law rights of injured plaintiffs and creates a rebuttable presumption for litigation purposes that the drilling of a horizontal well is the proximate cause of any contamination of fresh water supply that occurred within 1,500 feet of the center of the well pad. (§22-6A-18). The WVDEP has also promulgated standards for centralized pits for wastewater disposal and casing and cementing standards for drilling. This legislation has restricted the rights of municipalities to regulate fracking. In Northeast Natural Energy LLC v.

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[21] Oil and Gas Drilling Enforcement data by state,http://www.eenews.ent/special_reports/ground_rules

[22] Paul J. Nyden, WVU Study Details Marcellus Shale permits, income, The Charleston Gazette (Jan. 25, 2011)

City of Morgantown, the court allowed a mining company to circumvent Morgantown's ban on hydraulic fracking, holding that the city ordinance was preempted by state law. Civil Action No. 11-C-411 (Cir. Ct. W. Va. Aug. 12, 2011).

F. River Basin Commissions

River basin commissions are regional governmental agencies created for the purpose of planning for conservation, use, development and management of the water and related natural resources of the basin. Three river basin commissions cover the Marcellus Shale formation: the Delaware River Basin Commission (DRBC), the Susquehanna River Basin Commission (SRBC) and the Ohio River Basin Commission (ORBC). The DRBC and SRBC are interstate compacts approved by Congress with the force of law. Each has one representative from each participating state and a representative from the federal government. The federal representative is a member of the Army Corps of Engineers. In 2010 DRBC drafted regulations[23] requiring all natural gas plans in the region to be approved by the commission. These include Natural Gas Development Plans (NGDP), water withdrawals, and water treatment and discharge plans.

The State of New York and various non-governmental organizations (NGOs) sued the DRBC, seeking to require the DRBC to consider NEPA requirements in its final natural gas permitting regulations[24]. The Court dismissed the case without prejudice, finding that the plaintiffs lacked standing and deeming it premature as the final regulations had not been issued yet. In order to have standing a plaintiff must show 1) injury-in-fact; the injury is an actual or imminent, concrete and particularized, invasion of a legally protected interest; 2) causation; a fairly traceable causable connection to the injury; and 3) redressability; it is likely that a

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[23] Natural Gas Development Regulations, Delaware River Basin Commission, art. 7 part III Dec. 9, 2010

[24] (New York v. Army Corps of Engineers, 1L-CV-2S99, Sept. 24, 2012 (E.D.N.Y)

favorable decision will redress the plaintiff's injury. The Court stated that New York has a proprietary interest in the case in order to protect land, wildlife, and residents from pollution. The NGOs also have an interest through their members who use the area for hunting, hiking, skiing, boating, agriculture, and drinking water.

The SRBC was established after the DRBC and includes New York, Pennsylvania, and Maryland. Marcellus Shale lies under more than 72% of the river basin. Unlike the DRBC, the SRBC only regulates water withdrawals from surface and groundwater.[25] The SRBC only uses Approval by Rule, which is the equivalent of a permit from another agency. Companies may obtain approval from the SRBC by using other agency's regulations as their own as long as the regulations have already been pre-approved by the commission. The SRBC usually attaches "passby flows" conditions, low-flow regulations, to each approval. While the SRBC does monitor water quality, the commission left water quality regulation to the states and the federal government. The commission is in the process of erecting 30 monitoring stations between NY and PA to record real-time water quality data.

The ORBC is the least active of the three commissions. It was dissolved in 1981 by President Reagan because it "accomplished its goals." After being re-established, ORBC now acts to protect waters in Illinois, Indiana, Kentucky, Maryland, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia. It also works in conjunction with the Ohio River Valley Water Sanitation Commission (ORSANCO)[26], which represents IL, IN, OH, KY, WV, VA, PA, and NY.

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[25] (Susquehanna River Basin Commission, *The Susquehanna River Basin Commission's Role in Natural Gas Development*, Sept. 24, 2012 http://www.srbc.net/stateofsusq/documents/NaturalGasDevelopmentFeatureArticle.PDF)

[26] http://www.marcellus-shale.us/ORSANCO.htm

G. Common law

More than forty lawsuits have been filed in state and federal courts alleging injury or damage from fracking operations. (Hill et al., Shale Development and Fracking Litigation, Blank Rome Legal Intelligencer (July 31, 2012). Most of these claims are based on common law theories of liability, such as public nuisance, private nuisance, trespass, negligence, negligence per se, or strict liability for abnormally dangerous activities. In Fiorentino v. Cabot Oil & Gas Corporation, the plaintiffs (who were depicted in the movie Gasland) sought property and personal injury damage based on negligence, private nuisance, strict liability, and the Hazardous Sites Cleanup Act. *Fiorentino v. Cabot Oil & Gas Corp.*, 750 F. Supp. 2d 506 (M.D. Pa. Nov 15, 2010). The plaintiffs alleged that Cabot had negligently conducted fracking operations that allowed the release of methane, natural gas, and other toxins onto plaintiff's land and into their groundwater. This case was settled in August 2012. No. 09-CV-2284

IV. Conclusion:

In this paper we have made a set of physical and legal arguments that call into question the wisdom of harvesting shale gas. From the legal and regulatory views it is clear that extant law largely has little applicability to shale gas mining operations despite the significant potential of harmful effects to nearby land owners, water quality in the relevant water sheds, and to the consumer. The lack of strong regulatory statutes allows for drilling to occur at almost any location, independent of the physical nature of the material which is being drilled (similar problems exist for Gulf Oil Wells drilling through thousands of feet of marine sediment). Little if any science is being applied to well head locations and the permitting process. In addition, there is strong evidence of pipeline leakage associated with faulty well heads as well as direct leakage of methane, a potent GHG, into the atmosphere at individual fracking locations. From the physical point we have argued a) the estimated size of the harvestable resource is not large compared to current NG use and b) that the rapid rate of a typical well head decline requires a very large commitment to building new wells to make up for these losses. Under our models we show that sustainability of shale gas yield (in PA), at the level of 3 TCF per year needed to produce 20% more national electricity generation, requires building approximately 6000 new well heads a year at the expense of producing 750 square miles of abandoned well-head wasteland each year. In addition, this scheme would also produce 14gigatons of CO_2 emission over a 25 year period. In terms of reducing our GHG emission and not producing vast amounts of wasteland, it seems to us much wiser for the US to continue investing in non-GHG producing technologies such as wind turbine power.

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