A Market Approach to Regulating the Energy Revolution: Assurance Bonds, Insurance, and the Certain and Uncertain Risks of Hydraulic Fracturing

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ABSTRACT: The United States faces a critical moment in environmental regulation. As tens of thousands of new unconventional, hydraulically fractured oil and gas wells spring up around the United States, we face a long-term threat of significant soil and water contamination. The current patchwork of state "command and control" regulations fails to prevent this contamination. Even in states with updated rules, sloppy operations have caused contamination events. Furthermore, thousands of abandoned wells, which can leak pollutants, already dot our landscape, and these numbers could rise over time as operators—the individuals and companies responsible for well development—drill and eventually abandon thousands of new wells each year.

Command and control regulations will be an important first step to prevent contamination but cannot address all risks, particularly those for which industry has more knowledge than agencies. These limitations call for a market-based approach of bonding requirements and mandatory environmental liability insurance. An insurance regime will incentivize the party with the most knowledge of the risks—industry—to produce risk information, and it will spur third-party monitoring of risks by companies with a powerful monetary incentive to reduce claim events. Assurance bonds and insurance will also provide a pool of money to support later clean-up, which will be particularly important for disadvantaged areas that lack financial resources and political clout.

This Article proposes a market-based approach and responds to objections, and then explores the bottom-up, localities-as-leaders political economy by which bonding and insurance mandates are most likely to emerge and

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ultimately become established as a matter of state law. Without adequate bonding and insurance requirements, we risk creating a new wave of widespread, unaddressed pollution from the current energy revolution. At this critical decision point, this Article proposes a better path forward.

INTRODUCTION

In the Industrial Revolution of the nineteenth century, the United States was transformed from a largely agrarian nation of farmers to a major center of manufacturing. With industrialization came new risks to public welfare and, ultimately, changes in law to address those. The United States is now undergoing another revolution, an energy revolution that has the potential to transform the United States from a net energy importer into the next Saudi Arabia.[1] And like the Industrial Revolution, this energy revolution entails new risks and, by necessity, will produce new legal responses to those risks. It has fomented one of the greatest environmental regulatory challenges of our time, and it calls for an effective solution that must be rapidly implemented. This Article addresses a set of important legal responses that so far have received scant attention from academic commentators and lawmakers—market-based requirements for enhanced bonding and, more importantly, environmental liability insurance for wells.

The key to the current energy revolution is innovation in the techniques that allow extraction of natural gas from underground rock formations. Advances in horizontal drilling and hydraulic fracturing—fracing, or, more commonly, fracking—have opened up massive natural gas deposits in several regions of the United States.[2] These technologies have driven this revolution by enabling unconventional well development—the production of oil and gas from formations once deemed inaccessible—which we describe as "unconventional development" or "unconventional oil and gas."[3] Unconventional development has begun, and will continue, to

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1. *See* INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK 2012: EXECUTIVE SUMMARY 1 (2012), *available at* http://www.worldenergyoutlook.org/publications/weo-2012/.

2. *See Shale Gas Production*, U.S. ENERGY INFO. ADMIN. (Aug. 1, 2013), http://www.eia.gov/dnav/ng/ng_prod_shalegas_s1_a.htm (showing major increases in production in states like Arkansas, Louisiana, Oklahoma, Pennsylvania, and Texas).

3. This Article focuses on unconventional wells and proposes assurance bonds and mandatory environmental liability insurance for these wells for several reasons. First, although all conventional oil and gas wells pose many of the same risks we describe here, such as spills of drilling chemicals at the surface and leaking methane from improperly plugged wells, unconventional wells pose more risks by adding more stages to the well-development process, including the use of fracturing chemicals and increased pressure on wells caused by hydraulic fracturing. Although horizontal drilling of unconventional wells might cause some risks to decline by lowering the surface footprint, on net the risks might be higher. *See generally* Hannah J. Wiseman, *Risk and Response in Fracturing Policy*, 84 U. COLO. L. REV. 729 (2013). Second, unconventional well development will be the most common form of well development in the United States moving forward. Shale gas and tight sandstone wells, which will dominate production, are the most prevalent forms of unconventional development; they are unconventional because they require advanced technologies and are expensive to develop compared to conventional wells. *See* U.S. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ANNUAL ENERGY OUTLOOK 2013 WITH PROJECTIONS TO 2040 76–79 (2013), *available at* http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf (showing that shale gas and "tight gas"—from tight sandstones—will make up the majority of production). Third, oil and gas regulations, primarily written and administered by states, tend to cover both conventional and unconventional well

change the landscape of this country. Wells already dot the surface of many counties[4] and this is only the beginning. This development will continue, with tremendous intensity, very likely for several decades at a minimum.[5]

Just as the Industrial Revolution gave rise to new risks, such as risks from industrial air pollution and factory fires, unconventional development has generated new risks to public welfare and will continue to do so.[6] These risks are not, individually, as massive as those seen in the Industrial Revolution; public perceptions and environmental protections have changed. But cumulatively, they are likely to be substantial. Some of these risks are relatively certain: We know from past experiences with drilling and mining that there is a large risk that certain well operators—the individuals and companies responsible for well development—will simply abandon wells when they are no longer productive, and that they sometimes will not make the investments necessary to ensure that the wells are safely closed and sites adequately restored and will not become a source of pollution.[7] While the rates of abandonment will likely be lower than in the past due to improved state well-plugging regulations, constraints on state enforcement of regulations[8] and the sheer number of new wells being developed suggest

development—there are not separate regimes for these two fields. States are, however, beginning to write regulations that address certain aspects of unconventional development specifically. For example, some states require that operators test wells prior to fracturing to ensure that wells can withstand the pressure. *See, e.g.*, ARK. OIL & GAS COMM'N R. B-19 (2014), *available at* http://www.aogc.state.ar.us/onlinedata/forms/rules%20and%20regulations.pdf. Finally, although our goal of ensuring that funds will be available for site clean-up would best be met by requiring assurance bonds and insurance coverage for all wells, not just unconventional ones, this would be more difficult from a political economy perspective.

4. For example, in Fort Worth Texas alone there are 1878 producing wells with 56 permitted. *See Applications and Permits*, CITY OF FORT WORTH, http://fortworthtexas.gov/gaswells/default.aspx?id=50608 (last visited Mar. 14, 2014). Well numbers have also rapidly expanded in Pennsylvania, Colorado, North Dakota (shale oil), and other states. *See* Wiseman, *supra* note 3, at 735–36 (providing numbers and sources).

5. *See infra* notes 68–73 and accompanying text.

6. *See, e.g.*, Daniel J. Rozell & Sheldon J. Reaven, *Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale*, 32 RISK ANALYSIS 1382 (2012) (describing five pathways of water contamination from drilling and fracturing); Wiseman, *supra* note 3 (documenting the risks based on violations of state laws).

7. *See, e.g.*, R.R. COMM'N OF TEX., OIL FIELD CLEANUP: STATE WELL PLUGGINGS REMAINING BY DISTRICT (PUBLIC) (Mar. 31, 2013), *available at* http://www.rrc.state.tx.us/environmental/plugging/Wells_Remaining_0313.pdf (showing approximately 850 abandoned, unplugged wells); BUREAU OF OIL & GAS MGMT., PA. DEP'T OF ENVTL. PROT., PENNSYLVANIA'S PLAN FOR ADDRESSING PROBLEM ABANDONED WELLS AND ORPHANED WELLS 4 (2000), *available at* http://www.elibrary.dep.state.pa.us/dsweb/Get/Version-48262/ (noting that the state's oil and gas agency has "approximately 8,000 orphaned and abandoned wells" on its records and that "[t]he status of the remaining 184,000 wells [drilled in the state since the 1800s and not currently operating or plugged] is unknown").

8. *See* Hannah Wiseman, *State Regulation: Regulatory Risks in Tight Oil and Gas Development*, NAT. GAS & ELECTRICITY, Dec. 2012, at 6 (comparing well numbers and numbers of state inspectors).

that abandonment still will occur, as will, perhaps more commonly, inadequate site restoration and clean-up. There is also the relatively near-term risk that while the wells and their associated disposal facilities are operating, there will be major accidents and associated pollutant releases.[9] And then there is the long-term risk, a highly uncertain risk—often referred to as "the long-tail risk"—that once all the unconventional development is done, we will discover that this activity degraded the environment and endangered public health in ways that cannot be linked to specific, identified accidents at active well operations.

To date, the debate over how to address these various near-term and long-term risks has focused on *who* should govern, or more specifically, whether state legislators and regulators should be responsible for addressing unconventional oil and gas risks rather than federal legislators and regulators. Various commentators have offered different perspectives and answers to this state or federal question.[10]

While commentators have addressed the question of who should regulate fracking and other unconventional well development risks, they have paid less attention to how these risks should be addressed. By and large, scholars have assumed that the way to address these risks is prescriptive, "command and control" public regulations that establish specific requirements that drilling operators must follow or technologies they must implement.[11] More recently, it has been suggested that state tort law can fill any holes left by command and control regulations by

9. *See, e.g.*, *infra* text accompanying note 44 (describing a well blowout); *infra* text accompanying notes 83–84 (describing aquifer pollution from a disposal well).

10. *See* Michael Burger, *Fracking and Federalism Choice*, 161 U. PA. L. REV. PENNUMBRA 150, 163 (2013) (concluding that "pure federalism might not be the best tack" for regulating fracking); Elizabeth Burleson, *Climate Change and Natural Gas Dynamic Governance*, 63 CASE W. RES. L. REV. 1217, 1277 (2013) (proposing a dynamic system rather than "'either/or' federalism"); Robin Kundis Craig, *Hydraulic Fracturing (Fracking), Federalism, and the Water-Energy Nexus*, 49 IDAHO L. REV. 241, 264 (2013) (encouraging states and the federal government "to begin creating new governance structures for the water-dependent production of energy"); Cameron Jefferies, *Unconventional Bridges over Troubled Water—Lessons to Be Learned from the Canadian Oil Sands as the United States Moves to Develop the Natural Gas of the Marcellus Shale Play*, 33 ENERGY L.J. 75, 111–16 (2012) (proposing a federal or regional regulatory role); John R. Nolon & Steven E. Gavin, *Hydrofracking: State Preemption, Local Power, and Cooperative Governance*, 63 CASE W. RES. L. REV. 995, 1038 (2013) (arguing that states should pursue an "intentional policy of including and working with local governments in the regulation of hydrofracking"); David B. Spence, *Federalism, Regulatory Lags, and the Political Economy of Energy Production*, 161 U. PA. L. REV. 431, 506–08 (2013) (arguing for largely local and state control, with federal control over interstate risks); Jody Freeman, *The Wise Way to Regulate Gas Drilling*, N.Y. TIMES (July 5, 2012), http://www.nytimes.com/2012/07/06/opinion/the-wise-way-to-regulate-hydraulic-fracturing.html (arguing for regulation through cooperative federalism).

11. *See* Wiseman, *supra* note 3, at 809–12 (proposing regulatory modifications and some new regulations).

incentivizing operators to follow certain practices or risk penalties in court.[12] What has been missing from the academic literature, and largely the political debate, is a discussion of a market approach to addressing the known and unknown risks from unconventional development.

In market approaches to addressing risk, the sources of risk face financial incentives to mitigate the risks that are subject to their control. Assurance bonds are one kind of market mechanism whereby the operator of a facility is required to post upfront funds or other proof of committed financial resources, which the bondholder can return to the operator once it provides assurance that it closed the facility in a safe way. The incentive to recover the bond motivates, at least in part, responsible conduct. Mandatory insurance is another market mechanism, and generally a more effective one, especially for longer-term risks. Insurance provides a mechanism for reducing risk to the extent insurance premiums are set to reward behavior that creates less risk and penalize behavior that creates more risk.

These two market approaches, assurance bonds and mandatory insurance, have important advantages over other responses to risk. First, precisely because the risks from emerging or new industries are not well understood,[13] policymakers cannot easily formulate command and control regulations that assure a reasonable level of safety. Market approaches tap into industry's own understandings of the risks associated with its behaviors, and incentivize another actor, insurers, to generate more information about which behaviors are more or less risky. Market approaches are thus information-generating—and in a much more meaningful and comprehensive way than, for example, information-forcing regulations.[14] And information generation is key in an industry where, as with unconventional well development, several of the risks associated with the industry are not completely understood, but barring the industry until the risks are known seems to be too economically costly. Market mechanisms offer an appealing, pragmatic alternative that sits between the precautionary approach, in which no practice should be undertaken until it is known to be

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12. *See generally* Thomas W. Merrill & David M. Schizer, *The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy*, 98 MINN. L. REV. 145 (2013).

13. As Merrill & Schizer and others have discussed, some of the risks of gas and oil development enabled by fracturing—and of fracturing—itself are well understood, but others are not. *Id.* at 217–22; *see also* U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-12-732, OIL AND GAS: INFORMATION ON SHALE RESOURCES, DEVELOPMENT, AND ENVIRONMENTAL AND PUBLIC HEALTH RISKS 4 (2012), *available at* http://www.gao.gov/assets/650/647791.pdf (concluding that risks cannot be quantified).

14. For discussion of the limited information-forcing requirements in the hydraulic fracturing context, see, for example, Keith B. Hall, *Hydraulic Fracturing: Trade Secrets and the Mandatory Disclosure of Fracturing Water Composition*, 49 IDAHO L. REV. 399, 405–09 (2013) (describing chemical disclosure requirements); Hannah J. Wiseman, *Hydraulic Fracturing and Information Forcing*, 74 OHIO ST. L.J. FURTHERMORE 86, 92–93 (2012) (describing limited requirements for testing for pollution).

safe,[15] and the laissez faire approach, which allows economic activity to continue until it is shown to be unsafe.

Second, assurance bonds and mandatory insurance, even when they do nothing to alter the conduct of industry actors, generate a pool of money that can be used for the remediation of the environmental harms that the actors knowingly or (more often) unknowingly created. Reserving this pool of money[16] is critical because, absent such funds, there is a high likelihood that operators or public actors will never undertake environmental remediation. Abandoned wells and mines are commonplace, and "orphan" contaminated industrial waste can be found in virtually every city.[17] Even where such sites pose environmental and health risks, no action is what we often observe. In theory, after well development is done and the damage is apparent, policymakers could reallocate public funds from other uses to address that damage. But history (as well as theories of political economy) tells us that the political process usually does not work that way, and hence if there is not a source of remediation funds other than tax revenue, remediation will not occur, especially in the poorer and less politically powerful localities.[18]

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15. For definitions of the precautionary approach, see Jonathan B. Wiener, *Whose Precaution After All? A Comment on the Comparison and Evolution of Risk Regulatory Systems*, 13 DUKE J. COMP. & INT'L L. 207, 210 n.11 (2003).

16. Insurance and assurance bonds require parties to produce different types of information in order to tap money from the pool. For bonds, the pool is more accessible. State agencies typically presume that the bond money will be available for clean-up unless oil and gas operators demonstrate that they have adequately restored sites and plugged wells. For insurance, in the scheme we envision, money would not go to a general clean-up fund. Rather, parties demanding insurance funds would have to show that the insured caused contamination, but, unlike in tort cases, plaintiffs and plaintiffs' attorneys will see more payoff in lawsuits because insurance funds will be available, and the causation standard is different. *See, e.g.*, Tom Baker, *Liability Insurance as Tort Regulation: Six Ways That Liability Insurance Shapes Tort Law in Action*, 12 CONN. INS. L.J. 1, 4 (2005) ("Insurance has a fundamental effect on what [a typical tort] lawyer called collectibility—the defendant's ability to pay and the facility with which the defendant can be made to pay."); Kent D. Syverud, *On the Demand for Liability Insurance*, 72 TEX. L. REV. 1629, 1634 (1994) (noting that "liability insurance creates a significant asset against which to secure a judgment, one that an uninsured defendant is less likely to possess" and that "the more widely a particular activity is insured, the more likely it is to give rise to a lawsuit").

17. *See infra* text accompanying note 156.

18. *See* David A. Dana, *State Brownfields Programs as Laboratories of Democracy?*, 14 N.Y.U. ENVTL. L.J. 86, 103 (2005) (noting that "affected individuals (and communities) right now are almost certainly exposed to very different levels of health risk at different redeveloped brownfields sites"); Kirsten H. Engel, *Brownfield Initiatives and Environmental Justice: Second-Class Cleanups or Market-Based Equity?*, 13 J. NAT. RESOURCES & ENVTL. L. 317, 319 (1997–1998) (noting that some believe that "brownfield cleanups . . . provide 'second-class' cleanup remedies for persons who have long been treated as 'second-class' citizens for purposes of the distribution of environmental hazards"); *cf.* OFFICE OF TECH. ASSESSMENT, STATE OF THE STATES ON BROWNFIELDS: PROGRAMS FOR CLEANUP AND REUSE OF CONTAMINATED SITES 4 (1995), *available at* http://ota-cdn.fas.org/reports/9540.pdf (noting that brownfields sites in 1995 were "frequently identified with distressed urban areas").

Assurance bonds and mandatory insurance thus should be a central part of the response to the risks posed by unconventional wells on a massive scale. But neither mainstream commentators nor lawmakers have recognized these approaches. Certain states and localities require bonds,[19] although not bonds especially for fracking (as opposed to drilling generally); the bonds that are required vary substantially and are not nearly high enough.[20] Mandatory insurance for modest coverage is required in a few localities[21] but in only two states that we are aware of,[22] and no state has

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19. *See, e.g.*, CAL. PUB. RES. CODE § 3205.2 (West 2001) (requiring an indemnity bond of $100,000 per oil and gas waste disposal well); IND. CODE ANN. 14-37-6-1 (LexisNexis 2003) (requiring a bond of $2500 per oil and gas well in addition to an annual fee); OHIO ADMIN. CODE 1501: 9-1-03 (2004) (requiring a bond of $5000 for a single well); TENN. CODE ANN. § 60-1-202(a)(4)(R) (West 2001 & Supp. 2013) (giving the state regulatory board the power to require a bond of up to $15,000 per well site); N.M. CODE R. § 19.2.100.23 (LexisNexis 2002) (requiring a bond of not less than $10,000 "for each lease"); ARLINGTON, TEX. CODE OF ORDINANCES No. 11-068, art. VI, § 6.01(B)(1)(c) (2011), *available at* http://www.arlingtontx.gov/citysecretary/pdf/codeofordinances/GasDrilling-Chapter.pdf (requiring a $100,000 "cash, bond, or letter of credit" for operators with one well per site); FORT WORTH, TEX., ORDINANCES ch. 15, art. II, § 15-41(B)(1) (2009), *available at* http://www.fortworthgov.org/uploadedFiles/Gas_wells/090120_gas_drilling_final.pdf (requiring, during well drilling, a blanket bond of $150,000 for companies drilling 1–5 wells within the city, and, during well production, a $100,000 bond for operators with up to 75 wells producing). Many of the jurisdictions listed above have lower per-well bonding requirements—"blanket bond" provisions—if operators have more than a minimum number of wells within the jurisdiction.

20. *See supra* note 19.

21. *See, e.g.*, ARLINGTON, TEX. CODE OF ORDINANCES No. 11-068, art. VI, § 6.01(C)(4)(a) (2011), *available at* http://www.arlingtontx.gov/citysecretary/pdf/codeofordinances/Gas Drilling-Chapter.pdf (requiring energy companies to carry environmental pollution liability insurance that will cover at least $5 million per loss); FARMINGTON, N.M., CODE OF ORDINANCES § 19-2-102(a) (2006), *available at* http://library.municode.com/index.aspx?clientId=10760 (same); FORT WORTH, TEX., ORDINANCES ch. 15, art. II, § 15-41(C)(4)(a) (2009), *available at* http://www.fortworthgov.org/uploadedFiles/Gas_Wells/090120_gas_drilling_final.pdf (same).

22. Maryland, which does not yet allow hydraulic fracturing, appears to require environmental pollution liability coverage. *See* MD. CODE ANN., ENVIR. § 14-111 (West 2013) (requiring coverage of "not less than $1,000,000 per loss" to cover natural resource damage in addition to bodily injury). In addition, Illinois requires "proof of insurance to cover injuries, damages, or loss related to pollution or diminution in the amount of at least $5,000,000." 225 ILL. COMP. STAT. 732/1-35(a)(3) (2013). Only five other states appear to require any insurance for oil and gas operators, and the requirements do not directly include environmental liability insurance. *See* 2 COLO. CODE REGS. § 404-1:708 (LexisNexis 2009) ("All operators shall maintain general liability insurance coverage for property damage and bodily injury to third parties in the minimum amount of one million dollars ($1,000,000) per occurrence."); N.J. STAT. ANN. § 13:1M-2(p) (West 2003) (requiring oil and gas well operators to have "liability insurance coverage in an amount not less than $10,000,000.00 for bodily injury and $10,000,000.00 for property damage"); OHIO REV. CODE ANN. § 1509.07(A)(1) (West 2013) (requiring operators to have "one million dollars bodily injury coverage and property damage coverage," and three million in coverage in urbanized areas). Idaho requires "public liability, property damage, and products liability insurance in the sum of four hundred thousand dollars ($400,000) for injury or death for each occurrence" and, more generally, "insur[ance] against explosion, blow out, collapse, fire, oil spill and underground hazards" for oil and gas operators leasing state lands. IDAHO ADMIN. CODE r. 20.03.16.095.01 (2009). Oregon similarly requires

attempted to establish insurance pooling for areas with unconventional well development, which, as we explain, will need to be a key component of effective mandatory insurance. This Article aspires to shift attention to the pressing need for federal, state, and local governments to move forward with market mechanisms as part of their overall response to unconventional development.

We begin, in Part I, by explaining what unconventional well development is and the health and environmental risks it poses. As we detail, those risks include both relatively certain risks and highly uncertain ones,[23] and relatively near-term and long-term ones. In emphasizing the massive scale of unconventional development that we will certainly observe in the next decades, we seek to highlight the enormity of the aggregate risks posed by this development and the need for a truly effective legal response.

In Part II, we then explain why command and control regulations and state tort remedies will be insufficient to address the risks posed by unconventional wells. Command and control regulations are constrained by regulators' lack of understanding of the relevant risks—some of which no one may yet fully appreciate—and regulators' enormous resource constraints. The political economy of rulemaking and enforcement is also such that it is predictable that, in many jurisdictions, industry will, de facto, be able to dilute regulatory controls. Tort remedies are not especially helpful because most entities that undertake unconventional well development are organized as limited liability companies, and many of these corporations will be defunct or dissolved by the time the tort process is able to identify liability and produce judgments. Moreover, in areas with multiple fracking and drilling operations, the common law requirement of proving specific causation will impede suits against even solvent corporations.[24]

Part III takes up the principal objections to mandatory environmental insurance generally—objections that no doubt others will raise if the proposals we make receive attention. These objections are: that the private insurance market will not generate the capacity to meet the product

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coverage of a minimum of one million dollars per occurrence for "personal injury [or] property damage to third persons" for oil and gas operations on state lands. OR. ADMIN. R. 141-070-0110(3) (2013).

23. *See* U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 13.

24. On causation in insurance, see, for example, Erik S. Knutsen, *Confusion About Causation in Insurance: Solutions for Catastrophic Losses*, 61 ALA. L. REV. 957, 969 (2010) ("Even if a cause of an insured loss is human behavior—a breach of the applicable standard of care via the tort system—in the insurance law context, the causation question is not asked to determine fault of the tortfeasor but instead is merely asked to determine whether or not the mere happening of the behavior triggers insurance coverage within the language of the policy."). Although parties must demonstrate underlying tort liability to trigger liability insurance, our proposal will not fully address causation difficulties in tort, but parties will be more likely to file tort claims knowing that a pool of money is available. *See supra* note 16. Further, a finding of tort liability is not necessary to use assurance bonds for contamination clean-up.

demand that would be required with mandatory insurance; that insurers will not know how to price premiums based on risk and will not be effective agents for risk reduction; and that mandatory insurance will favor large business over small operators. We explain that none of these objections is persuasive. The insurance market has proven over time that it will innovate and expand to meet new market demands; insurance pools can make premium setting easier even given informational limitations and can also help temper the burden on smaller operators. Further, insurers of all kinds have repeatedly demonstrated an ability and willingness to require insureds to follow practices that mitigate risks.

In Part IV, we turn to the question of who—what level of government—should be responsible for bonding and insurance requirements. The federal government would have certain advantages in structuring these requirements, but given the history of state law jurisdiction over bonding and insurance, we advocate for action at the state level. Locality-by-locality approaches would not allow some of the actions necessary to make an insurance regime work fully, but we argue that it is important that localities have the legal authority to enact insurance requirements in addition to or on top of any adopted by the state. Indeed, the most likely way that an insurance regime may emerge is from the bottom up—from insurance requirements made by localities concerned about footing the bill from unconventional development over the longer term.

Unconventional development is, in many ways, an exceedingly good thing. It certainly will generate an enormous amount of economic wealth.[25] And of course, the Industrial Revolution also was a good thing, generating huge wealth. However, the unconventional oil and gas revolution enabled by horizontal drilling and fracking, just like the Industrial Revolution, could leave large parts of the country, from an environmental and public health standpoint, a mess. Much of modern environmental law has been about cleaning the waters and soils contaminated by the Industrial Revolution and decades of coal mining and other resource extraction that proceeded without regard to environmental consequences. With this new revolution, the unconventional revolution in energy production, we can be more forward-looking, mitigating harm and setting aside specific funds for the remediation of the harms that were not prevented. Command and control

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25. *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, PRELIMINARY REVISED DRAFT: SUPPLEMENTAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON THE OIL, GAS AND SOLUTION MINING REGULATORY PROGRAM, at 2-6 (2009), *available at* http://www.dec.ny.gov/data/dmn/ogprdsgeisfull.pdf (estimating that individuals leasing oil and gas rights in New York could make "over $1 million over a five-year period"). *But see generally* Susan Christopherson & Ned Rightor, *How Should We Think About the Economic Consequences of Shale Gas Drilling?* (City & Reg'l Planning, Cornell Univ., Working Paper, 2011), *available at* http://www.greenchoices.cornell.edu/downloads/development/shale/marcellus/Thinking_about_Economic_Consequences.pdf (critiquing economic studies with highly optimistic estimates of wealth).

regulation is undoubtedly a large part of how we can mitigate risk from unconventional well development, but that regulation, alone, will not be enough. A market approach, focused on assurance bonding and mandatory insurance, is necessary.

I. WELL CONTAMINATION OVER TIME

The thousands of new oil and gas wells that are drilled and fractured in the United States each year will cause substantial environmental contamination over time.[26] One can estimate the extent of this contamination by looking to the time periods over which wells are drilled, remain active, and are abandoned, and the pollutional events that occur during these time frames. Combining these data with estimates of the number of new wells, as well as active and abandoned ones, provides a rough picture of the widespread pollution that could occur from expanding unconventional oil and gas development. The rate of incidents at wells might decline over time in light of growing public scrutiny, more stringent regulation, and the fear within industry that a catastrophic incident could have severe repercussions. But the sheer number of wells drilled and abandoned over time will contribute to a substantial number of pollution events, which, although individually small, could have cumulative and interactive effects.

A. THE LIFE OF OIL AND GAS WELLS AND ASSOCIATED CONTAMINATION

The intense industrial activity associated with drilling and fracturing unconventional wells lasts for approximately three months,[27] followed by up to one year of moderately intense activity involving the handling and disposal of wastes and site-clean-up. Low levels of activity associated with gathering and treating produced oil or gas then remain at the site for decades—as long as the well is active. After up to 30 or more years of production,[28] gas and oil wells are then plugged (or left unplugged) and permanently abandoned.

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26. Conventional wells, which will continue to be developed but not at as high of a rate, will also contribute to environmental contamination. Indeed, many of the risks of conventional and unconventional development are the same. *See* Wiseman, *supra* note 3. As we describe above, however, we focus on unconventional development here because it will be more common, it likely poses higher risks, and, from a political economy perspective, is more feasible to address. *See supra* note 3.

27. *See, e.g.*, ENCANA NATURAL GAS, WELL COMPLETION & HYDRAULIC FRACTURING 2 (2011), *available at* http://www.encana.com/pdf/communities/usa/wellcompletionandhydraulicfracturing(DJ).pdf (estimating fifty-five days for fracturing and wellhead installation after the drilling process); *infra* notes 34, 37 and accompanying text (estimating more than a month of drilling activity, and approximately two weeks of construction activity).

28. *See infra* note 63 and accompanying text.

The pre-well development process begins with several days of testing.[29] Energy companies drive trucks into an area in an effort to determine the volume of oil or gas underground. They use large metal equipment attached to trucks to strike the ground, or they blast shot holes, to produce vibrations and associated data.[30] Once companies have completed this seismic testing, most states require them to fill in any shot holes they have created,[31] and some require restoration of the surface around the areas of blasting or other seismic work.[32] At this stage of well development, soil and other sediment can run off and pollute surface waters, and diesel, antifreeze, and other substances can spill from equipment and pollute soil and surface or underground waters.[33]

Following seismic testing, an oil or gas operator selects a site based on the testing data and available property rights. The operator also begins the process of obtaining the necessary drilling and environmental permits. She then constructs the well pad that will host oil and gas production activity and a road to it. Building the road using excavators, bulldozers, and other equipment typically requires between three and seven days of construction

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29. *See* Owen L. Anderson & Dr. John D. Piggot, *3D Seismic Technology: Its Uses, Limits & Legal Ramifications*, 42 ROCKY MTN. MIN. L. INST. 16-1, at 16-4 (1996) (describing seismic testing techniques); Joseph H. Frantz, Jr., *Natural Gas, Range Resources, and the Marcellus Shale*, 2010 No. 5 ROCKY MTN. MIN. LAW FOUND.-INST. Paper No. 2, at 3 (2010) (describing the seismic testing that occurs in order to "determine drilling locations").

30. *Cf.* MARK LANDEFELD & CHRISTOPHER HOGAN, OHIO STATE UNIV. EXTENSION, SEISMIC TESTING AND OIL & GAS PRODUCTION (2012), *available at* http://serc.osu.edu/sites/drupal-serc.web/files/2012%20seismic%20testing%20Fact%20Sheet%281%29.pdf (using the term "vibrator truck" to describe the equipment used for seismic testing).

31. *See, e.g.*, LA. ADMIN. CODE tit. 76 § 301(C)(6)(Q) (2013) (requiring backfilling of shot holes); MONT. ADMIN. R. 36.22.502 (2013) (requiring all shot holes to be "plugged and abandoned" unless the company conducting the seismic testing reaches another agreement with the surface owner).

32. *See, e.g.*, MONT. ADMIN. R. 36.22.502(4) (2013) ("The surface area around each seismic shot hole shall be restored to its original condition insofar as such restoration is practicable."); UTAH ADMIN. CODE r. 649-3-34(1) (2013) (requiring restoration of the well site); WASH. ADMIN. CODE § 344-012-145 (Westlaw 2013) (requiring a "minimum reclamation program for seismic surveys" including, for example, removing refuse, "[s]uccessful revegetation of disturbed ground to prevent substantial erosion," "[p]lugging of all shot holes that encountered water," and "[r]egrading, when appropriate"); W. VA. CODE ANN. § 22-6A-10(j)(1), (3) (West Supp. 2013) (requiring a reclamation plan).

33. *See* Wiseman, *supra* note 3, at 794–96, 799–801 (discussing erosion and spills); *see also* PA. DEP'T OF ENVTL. PROT., OIL & GAS COMPLIANCE REPORT, *available at* http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/OG_Compliance (select "Yes" from "Unconventional Only," "Yes" from "Resolved Violations Only," enter 01/01/2008 as "Date Inspected From," and 12/31/2013 as "Date Inspected To," then select "View Report") (showing numerous spill incidents in Pennsylvania); *infra* note 76 and accompanying text (showing the likely total volume of spills in the Marcellus Region as a result of fracturing).

activity, followed by up to two additional weeks for well site construction.[34] Similar contamination to the pollution associated with seismic testing occurs at this stage. Diesel spills from storage tanks and construction equipment, and soil—including soil contaminated with diesel—can run off site and pollute surface waters.[35] This erosion can also occur after construction, during site operation.[36]

The operator then brings a rig and other equipment to the site, and drilling begins. For many fractured wells, the operator drills down vertically for thousands of feet, and then laterally through a shale or tight sandstone (or other unconventional) formation underground. This complex process of horizontal drilling often requires more than a month of twenty-four-hour rig activity.[37] Once an operator or contractor has drilled and cased the well, a fracturing service company then hydraulically fractures it, which takes two to five days per fracturing job,[38] with multiple fracturing jobs often performed at one site.[39] At sites with multiple horizontal wellbores, this can amount to approximately two months of fracturing at a site.[40] Equipment at the site during the drilling and fracturing stages includes air compressor units, rigs, trucks, and other machines that typically run on diesel.

As with the previous stages of development, drilling and fracturing equipment can leak,[41] but several additional contamination-causing

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34. N.Y. STATE DEP'T OF ENVTL. CONSERVATION, REVISED DRAFT: SUPPLEMENTAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON THE OIL, GAS AND SOLUTION MINING REGULATORY PROGRAM, at 6-298 (2011), *available at* http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf.

35. *See* Wiseman, *supra* note 3, at 794–96, 799–800 (discussing erosion and spills).

36. *See, e.g.*, PA. DEP'T OF ENVTL. PROT., ROUTINE/PARTIAL INSPECTION OF CHIEF OIL & GAS LLC API PERMIT NO. 113-20024 (May 9, 2011) (enforcement records on file with authors) (noting that "[e]roded fill slope caused sediment discharge outside" of the leased area); PA. DEP'T OF ENVTL. PROT., ROUTINE/PARTIAL INSPECTION OF CHIEF OIL & GAS LLC API PERMIT NO. 113-20005 (May 9, 2011) (enforcement records on file with authors) (noting "[e]roded sediment trap with sediment discharge outside" the leased area).

37. N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 34, at 6-289 ("A horizontal well takes four to five weeks of drilling at 24 hours per day to complete.").

38. *Id.* at 6-298.

39. *See* ENCANA NATURAL GAS, *supra* note 27.

40. *Id.* (estimating "approximately 55 days" of fracturing at one site).

41. *See, e.g.*, N.M. OIL CONSERVATION DIV., OIL RELEASE OF ENERVEST OPERATING L.L.C. API PERMIT NO. 30-039-30557 (July 29, 2010) (enforcement records on file with authors) (noting that a fuel pump failed and caused 1,000 gallons of diesel to spill); PA. DEP'T OF ENVTL. PROT., ROUTINE/COMPLETE OF CHESAPEAKE APPALACHIA LLC API PERMIT NO. 115-20298 (Dec. 22, 2010) (enforcement records on file with authors) (noting a 20-gallon diesel spill from a fuel delivery truck); PA. DEP'T OF ENVTL. PROT., ROUTINE/COMPLETE INSPECTION OF CHESAPEAKE APPALACHIA LLC API PERMIT NO. 115-20293 (Dec. 22, 2010) (enforcement records on file with authors) (describing two fuel trucks that collided and leaked approximately 15 gallons of diesel); PA. DEP'T OF ENVTL. PROT., DRILLING/ALTERATION OF CITRUS ENERGY CORP API PERMIT NO. 131-20015 (Oct. 30, 2009) (enforcement records on file with authors) (noting some spills at the site included "[d]iesel and [a]ntifreeze on ground near air compressor units" and diesel fuel in other areas); PA. DEP'T OF ENVTL. PROT., COMPLIANCE EVALUATION OF EAST RESOURCES, INC. API PERMIT NO. 117-20673 (June 2, 2010) (enforcement records on file with authors)

incidents also occur. Chemicals used in hydraulic fracturing fluids, which are transported to sites in trucks, can spill during accidents, or if tanks on trucks are improperly constructed or operated.[42] Drilling materials—some of which are petroleum-based—can spill when stored on site in pits or transferred to the well, as can hydraulic fracturing fluids that contain about a dozen types of chemicals.[43] During drilling or fracturing, operators may encounter unanticipated pressure zones underground, or fluids may build up in the well, causing an explosion called a well blowout. Blowouts can cause the well to release drilling or fracturing substances above ground uncontrollably[44]—sometimes sending these substances into nearby surface waters.[45] More rarely, underground blowouts can pollute aquifers.[46] Finally,

("Diesel spill of unknown quantity migraged [sic] off pad with potential to impact down gradient pond and stream."); PA. DEP'T OF ENVTL. PROT., ROUTINE/COMPLETE INSPECTION OF ATLAS RESOURCES LLC API PERMIT NO. 129-28012 (Nov. 2, 2009) (enforcement records on file with authors) (noting a "790+/- gallon diesel fuel spill," which "reportedly was the result of an improperly connected fuel line" on the drilling rig and "approximately 200–250 gallons were recovered"); PA. DEP'T OF ENVTL. PROT., ROUTINE/COMPLETE INSPECTION OF EXCO RESOURCES PA INC API PERMIT NO. 027-21602 (Sept. 8, 2010) (enforcement records on file with authors) (noting two 20 to 30 gallon diesel spills that were unreported by the operator); PA. DEP'T OF ENVTL. PROT., ROUTINE/COMPLETE INSPECTION OF NOVUS OPERATING LLC API PERMIT NO. 117-20605 (Sept. 22, 2010) (enforcement records on file with authors) (noting that a "pump transferring water . . . leaked diesel fuel . . . which mixed with water" and overflowed the containment under the pump, entering "a rock-lined ditch near the access road"); PA. DEP'T OF ENVTL. PROT., ROUTINE/COMPLETE INSPECTION OF EQT PRODUCTION CO. API PERMIT NO. 117-20969 (Jan. 4, 2011) (enforcement records on file with authors) (noting "[m]ultiple areas of diesel fuel staining observed near the fueling area and equipment staging area").

42. *See* Wiseman, *supra* note 3 (describing chemical spills).

43. *See, e.g.*, PA. DEP'T OF ENVTL. PROT., FOLLOW-UP INSPECTION OF CABOT OIL & GAS CORP. API PERMIT NO. 115-20150 (Feb. 4, 2010) (enforcement records on file with authors) (noting "drilling mud seeping out of ground downslope of the wellpad"); PA. DEP'T OF ENVTL. PROT., ROUTINE/COMPLETE INSPECTION OF CARRIZO (MARCELLUS) LLC API PERMIT NO. 131-20047 (Feb. 14, 2011) (enforcement records on file with authors) (noting "a 1,500 gallon spill of drilling mud . . . observed on the surface of the ground outside of the containment area").

44. *See, e.g.*, Press Release, Pa. Dep't of Envtl. Prot., Independent Report Faults Clearfield County Gas Well Operators for June 3 Blowout (July 13, 2010), http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=12818&typeid=1 (describing a blowout that "allowed natural gas and wastewater to escape from the well uncontrollably for 16 hours").

45. *See, e.g.*, Press Release, Md. Attorney Gen., AG Gansler Secures Funding to Safeguard Susquehanna Water Quality (June 14, 2012), http://www.oag.state.md.us/Press/2012/061412.html (noting $500,000 paid by Chesapeake Energy Corporation to the Susquehanna River Basin Commission after a "blowout of a natural gas drilling site resulted in the release of 'fracking fluids' into Pennsylvania's Towanda Creek, a tributary of the Susquehanna River").

46. *See* WYO. DEP'T OF ENVTL. QUALITY, GROUNDWATER POLLUTION CONTROL PROGRAM REVIEW COMMENTS: PLANS/ SPECIFICATIONS/ PROPOSALS/ REPORTS 2–3 (Nov. 17, 2006), *available at* http://deq.state.wy.us/volremedi/downloads/Web%20Notices/Windsor%20Well_Clark/nov%2006%20roi%20rpt%20rev.pdf (describing an underground blowout at what appears to have been a conventional gas well, and associated surface and underground water pollution, although noting that some of the underground water pollution was likely caused by "prior/historical oil and gas exploration activities"); Brian A. Torr & L. Flak, *Part 6—Underground Blowouts*, JOHN WRIGHT CO., http://www.jwco.com/technical-litterature/p06.htm (last visited Mar. 15, 2014) (noting that

wastes from the well—including drill cuttings (soil and rock from the well, sometimes with low levels of radioactivity),[47] and produced water that naturally flows out of the well during production of oil and gas, and used fracturing fluids[48]—can also spill when being transferred out of the well into storage. One of the most substantial threats of contamination at well sites may be from the fracturing fluid that flows out of the well, which can pick up naturally occurring radiation from the formation and can contain benzene and other toxic substances.[49]

The end of the hydraulic fracturing process is also the end of intense industrial activity at the site. Operators collect the wastes produced during drilling and store them in pits and tanks on the surface. These pits are typically dug into the site's surface and lined with plastic. Properly constructed and operated pits and tanks sometimes leak, due to vandalism[50] or human error. Even more spills occur when pits are improperly constructed or tanks have faulty equipment. For example, when a gauge on a tank breaks, a hose that transfers liquid waste to the well may continue filling the tank even after it is full.[51] And pits with tears in their liners, or that are over-filled and then encounter precipitation, can leak large amounts of waste.[52]

"fresh water aquifer contamination" can occur from underground blowouts); *Blowouts and Well Control Problems,* R.R. COMM'N OF TEX. (May 18, 2011), http://www.rrc.state.tx.us/data/drilling/blowouts/district3.php (describing blowout incidents for all types of wells (including conventional)).

47. *See, e.g.*, PA. DEP'T OF ENVTL. PROT., ROUTINE/PARTIAL INSPECTION OF EAST RESOURCES, INC. API PERMIT NO. 081-20288 (June 3, 2010) (enforcement records on file with authors) (noting drill cuttings on the ground, which were "cleaned up within hours").

48. *See, e.g.*, PA. DEP'T OF ENVTL. PROT., INCIDENT-RESPONSE TO ACCIDENT OR EVENT OF EXCO RESOURCES PA LLC API PERMIT NO. 081-20244 (Nov. 15, 2012) (enforcement records on file with authors) (noting a spill of fracturing flowback to a ditch).

49. *See* Lara O. Haluszczak et al., *Geochemical Evaluation of Flowback Brine from Marcellus Gas Wells in Pennsylvania, USA*, 28 APPLIED GEOCHEMISTRY 55, 60 (2013) (noting levels of radium in flowback water "13–1300 times the maximum contaminant level for drinking water standards"). While in most cases this flowback will be diluted if it pollutes soil or aquifers, it still poses concerns.

50. *See, e.g.*, N.M. OIL CONSERVATION DIV., INCIDENT REPORT NO. nRMD0929433632 (Mar. 2009), *available at* https://wwwapps.emnrd.state.nm.us/ocd/ocdpermitting//Data/Incidents/Spills.aspx (search "nRMD0929433632" in "Incident Number" field) (showing an 800-gallon unrecovered spill of "frac water" due to vandalism).

51. *See, e.g.*, LA. DEP'T OF ENVTL. QUALITY, INCIDENT REPORT ON WELL PERMIT NO. 238585 (Mar. 18, 2009) (source on file with author) (noting that "[f]rac tanks were being used as temporary storage for produced saltwater," and "[w]ater overflowed into ditch and swampy area"); *see also* N.M. OIL CONSERVATION DIV., INCIDENT REPORT NO. nBP0918933399 (Feb. 2009), *available at* https://wwwapps.emnrd.state.nm.us/ocd/ocdpermitting//Data/Incidents/Spills.aspx (search "nBP0918933399" in "Incident Number" field) (noting a frozen valve on a tank that caused a spill). The authors would like to thank Molly Wurzer of the University of Texas School of Law for her help gathering this data.

52. *See, e.g.*, Wiseman, *supra* note 3, at 789–90 (citing to other incidents involving leaking pits and tanks); PA. DEP'T OF ENVTL. PROT., COMPLAINT INSPECTION OF CABOT OIL & GAS CORP.

Following the drilling and fracturing operation and waste storage, operators must remove wastes from pits and dispose of these wastes. This stage typically lasts somewhere between one month and one year, as most states require operators to remove wastes from pits and fill and close the pits within this time period.[53] To get rid of the wastes, operators haul drilling and fracturing wastes off site, or spread or bury some of the wastes on the site itself.[54] On-site disposal of wastes can contaminate surface waters and soil and groundwater.[55] Further problems can occur off site. Operators typically dispose of produced water (which sometimes contains high levels of salts) and flowback water in an underground injection control ("UIC") well designed to permanently hold wastes. Improperly constructed UIC wells have in rare circumstances leaked into aquifers, polluting billions of gallons of water that is difficult to access and treat.[56] A number of UIC wells have also caused earthquakes.[57] Alternatively, produced water and flowback are sent through a wastewater treatment plant; if the plant lacks the necessary technology to treat millions of gallons of new wastes that it receives, it could send polluted wastewater into rivers.[58]

Following the handling and disposal of wastes and site restoration, the well site hosts a relatively low level of industrial activity. The operator places a metal wellhead on top of the well after drilling and fracturing. This wellhead controls the flow of oil, gas, and other produced liquids out of the

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API PERMIT NO. 115-20149 (Mar. 22, 2010) (enforcement records on file with authors) (noting a tear in the liner and black fluid discharge).

53. *See, e.g.*, ALA. ADMIN. CODE r. 400-1-4.11 (2009) (requiring pits to be "properly filled and compacted" within ninety days after the end of well operations); LA. ADMIN. CODE tit. 43-XIX-3, § 307(D)(6) (2010) (requiring pits to be closed within six months of abandonment); 25 PA. CODE § 78.56(d) (2013) (requiring removal of wastes from pits or filling within nine months of the completion of drilling); 055-000-004 WYO. CODE R. § 1(q) (LexisNexis 2013) (providing that "pits shall be open only for the duration of operations and must be closed within thirty (30) days after the operation is complete").

54. *See, e.g.*, 25 PA. CODE § 78.61 (2013) (allowing disposal of certain drill cuttings (rocks and soil, which sometimes contain low levels of naturally-occurring radioactive substances) in pits, with certain protections).

55. Wiseman, *supra* note 3, at 790–91.

56. *See* City of Midland's Motion for Estimation of Claims for Purpose of Allowance, Voting, and Determining Plan Feasibility and Request for Determination that Remediation Claim Is Entitled to Administrative Expense Priority, *In re* Heritage Consol., LLC et al. (No. 10-36484-hdh-11) (Bankr. N.D. Tex. Nov. 15, 2010) [hereinafter City of Midland's Motion] (on file with authors) (describing contamination from a leaking UIC well).

57. *See generally* Cliff Frohlich et al., *The Dallas–Fort Worth Earthquake Sequence: October 2008 Through May 2009*, 101 BULL. SEISMOLOGICAL SOC'Y AM. 327 (2011) (noting Dallas and Fort Worth earthquakes caused by UIC wells); Katie M. Keranen et al., *Potentially Induced Earthquakes in Oklahoma, USA: Links Between Wastewater Injection and the 2011 M_w 5.7 Earthquake Sequence*, 41 GEOLOGY 699 (2013) (noting Oklahoma earthquakes potentially caused by UIC wells).

58. *See, e.g.*, Letter from Shawn M. Garvin, Reg'l Adm'r, Envtl. Prot. Agency, to the Honorable Michael Krancer, Acting Sec'y, Pa. Dep't of Envtl. Prot. (Mar. 7, 2011), *available at* http://www.epa.gov/region3/marcellus_shale/PADEP_Marcellus_Shale_030711.pdf (alleging that wastewater treatment plants were sending fracturing wastes into rivers).

well over time. At some sites, the only equipment that remains is the wellhead and gathering lines, which collect oil and gas from the well and send it to pipelines. At sites with oil or gas condensate or oil and gas that must be processed, certain industrial equipment remains on site over the long term to process the liquids and separate oil and gas from water and other substances.[59] This equipment sometimes leaks or spills oil and other liquid substances.[60] Finally, numerous[61] natural gas compressor stations, (which pressurize gas for long-distance transport) also emit pollutants—primarily to the air.[62]

Wells may remain in this production stage for 25, 50, or even 100 years, depending on the abundance of oil and gas. Estimates vary and will likely change as more production numbers are available, but some suggest that the average shale gas well produces for 30 years or more.[63] When production tails off during this period, operators refracture the well, use other enhanced recovery techniques, or abandon it. Abandonment of a well triggers another stage of potential pollution. Nearly all states require operators to plug wells—to remove some of the casing and pour cement into the well and seal it off.[64] This is supposed to prevent any lingering oil or gas

59. *See, e.g.*, AIR POLLUTION CONTROL DIV., COLO. DEP'T OF PUBLIC HEALTH AND ENV'T, HEATER-TREATER SOURCE CATEGORY: NOX EMISSION 4-FACTOR ANALYSIS FOR REASONABLE PROGRESS (RP), *available at* http://www.fossil.energy.gov/programs/gasregulation/authorizations/Orders_Issued_2012/17._Colorado_Haze_Plan.pdf (describing treatment technologies at sites).

60. *See, e.g.*, OHIO DEP'T OF NATURAL RES. CONSERVATION, CORTLAND ENERGY WELL NO. 34117228910000, MAY 5, 2008 VIOLATION (enforcement records on file with authors) ("The heater treater has run over and created a small spill around it."). The authors would like to thank Jeremy Schepers at the University of Texas School of Law for his able research assistance regarding this data. *See also* PA. DEP'T OF ENVTL. PROTECTION, ROUTINE/COMPLETE INSPECTION OF CHESAPEAKE APPALACHIA LLC API PERMIT NO. 015-20425 (Dec. 2, 2010) (enforcement records on file with authors) (noting "[o]range liquid seaping [sic] out from underneath separator and heater treater" and "dripping onto ground and not contained or lined").

61. The City of Fort Worth alone has 41 compressor stations. Sarah Fullenwider, City Attorney, Fort Worth, Tex., Remarks at the Workshop on Governance of Risks of Unconventional Shale Gas Development 10 (Aug. 15, 2013), *available at* http://www4.nationalacademies.org/xpedio/groups/dbassesite/documents/webpage/dbasse_084384.pdf.

62. *See* E. RESEARCH GRP., INC. & SAGE ENVTL. CONSULTING, LP, CITY OF FORT WORTH NATURAL GAS AIR QUALITY STUDY xii–xiii (2011), *available at* http://fortworthtexas.gov/uploadedFiles/Gas_Wells/AirQualityStudy_final.pdf (studying a limited number of sites and compressor stations and finding that "the total estimated emissions of organic compounds was 20,818 tons per year," although finding no air quality violations).

63. Kathy Shirley, *Tax Break Rekindled Interest: Shale Gas Exciting Again*, EXPLORER, Mar. 2001, *available at* http://archives.aapg.org/explorer/2001/03mar/gas_shales.cfm (estimating that the average well has "a productive life of 30 years"); NAT'L PARK SERV., U.S. DEP'T OF THE INTERIOR, DEVELOPMENT OF THE NATURAL GAS RESOURCES IN THE MARCELLUS SHALE 6 (2009), *available at* http://www.marcellus.psu.edu/resources/PDFs/marcellusshalereport09.pdf (estimating a lifespan of "30 years or more" for unconverted shale gas wells).

64. *See* NATHAN RICHARDSON ET AL., THE STATE OF STATE SHALE GAS REGULATION 67 (2013), *available at* http://www.rff.org/rff/documents/RFF-Rpt-StateofStateRegs_Report.pdf

from traveling into nearby groundwater and groundwater from entering the well. However, thousands of wells are improperly plugged or not plugged at all,[65] and even properly plugged wells can leak over time, causing methane and other substances to pollute underground or surface water sources.[66]

B. The Extent of Likely Contamination: Well Numbers

The threat of long-term, extensive surface and groundwater contamination from these many stages of fracturing and drilling arises in large part from the sheer scale of the activity.[67] Rates of incidents like blowouts, spills, and well abandonment will likely decline at both conventional and unconventional wells with the expansion of public scrutiny, regulatory improvements, and industry concern that highly-publicized incidents could lead to further regulation or even moratoria in light of public criticism. But the large numbers of wells developed might, in part, offset declining incident rates. There are more than one million active oil and gas wells in the United States.[68] Many of these wells are not unconventional wells (which will dominate U.S. gas production moving forward), but an increasing number are. The Environmental Protection Agency ("EPA") estimates that 11,400 new gas wells alone are fractured each year,[69] and this could be a low estimate.[70] Well numbers also may continue to

(noting that 28 of the 31 states studied had plugging requirements and limits on the time for which wells could sit idle before being plugged).

65. *See supra* note 7; *see also* Dan Frosch, *Wyoming May Act to Plug Abandoned Wells as Natural Gas Boom Ends*, N.Y. TIMES (Dec. 24, 2013), http://www.nytimes.com/2013/12/25/us/state-may-act-to-plug-abandoned-wyoming-wells-as-natural-gas-boom-ends.html?_r=0 (noting 1200 abandoned wells in Wyoming, 2300 wells "sitting idle" that may be abandoned, and concerns that "more will soon be deserted" without being properly plugged).

66. *See, e.g.*, BUREAU OF OIL & GAS MGMT., PA. DEP'T OF ENVTL. PROT., STRAY NATURAL GAS MIGRATION ASSOCIATED WITH OIL AND GAS WELLS 1 (2009), http://www.dep.state.pa.us/dep/subject/advcoun/oil_gas/2009/Stray%20Gas%20Migration%20Cases.pdf (noting "[l]egacy or abandoned well incidents . . . associated with natural gas and oil wells drilled from 1859" which occurred when the well was "abandoned by the operator and not properly plugged or plugged according to the standards or practices that were in place at the time" (emphasis omitted)).

67. *See* Hannah J. Wiseman, *Remedying Regulatory Diseconomies of Scale*, 94 B.U. L. REV. 235 (2014) (describing growing activities that can cause interactive, uneven, and cumulative effects and the lack of modified regulation to address changes in scale, and using the impacts of growing oil and gas development as an example of this type of problem).

68. ENVTL. PROT. AGENCY, OVERVIEW OF FINAL AMENDMENTS TO AIR REGULATIONS FOR THE OIL AND NATURAL GAS INDUSTRY: FACT SHEET 3 (2012), *available at* http://www.epa.gov/airquality/oilandgas/pdfs/20120417fs.pdf (indicating that there were more than 1.1 million oil and gas wells in 2009); *Number of Producing Gas Wells*, U.S. ENERGY INFO. ADMIN. (Jan. 7, 2014), http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm (showing 514,637 producing gas wells in 2011).

69. ENVTL. PROT. AGENCY, *supra* note 68, at 3.

70. *See, e.g.*, COLO. DIV. OF WATER RES. ET AL., WATER SOURCES AND DEMAND FOR THE HYDRAULIC FRACTURING OF OIL AND GAS WELLS IN COLORADO FROM 2010 THROUGH 2015, *available at* http://cogcc.state.co.us/Library/Oil_and_Gas_Water_Sources_Fact_Sheet.pdf (in Colorado alone, noting 2,975 new "well starts" in 2011); R.R. COMM'N OF TEX., NEWARK, EAST

rise. Texas, for example, currently has more than 17,000 gas wells in the Barnett Shale,[71] but estimates suggest that operators will have drilled approximately 28,000 wells in the Barnett by 2030, leaving at least 11,000 more wells to be drilled in this shale alone.[72] In New York, where high-volume hydraulic fracturing is currently on hold, the state estimates that up to 56,508 horizontal gas wells and 6,273 vertical gas wells could be drilled and fractured in 30 years.[73]

This volumetric expansion of wells causes certain impacts of oil and gas development to expand.[74] Although industry might become more cautious and experienced at preventing pollution as it drills more wells, certain events that have known, independent risks and can be difficult to prevent without careful oversight of operations, such as the likelihood of a spill entering surface or groundwater, will accumulate as the number of wells rises.[75] One study suggests, for example, that surface spills of fracturing chemicals and drilling and fracturing wastes will contaminate water volumes equal to the volume of several Olympic-sized swimming pools.[76] Further, events with interdependent risks—such as the risk that new wells will be drilled and fractured near sensitive environmental resources, and will disproportionately impact these resources—will likely also rise with rising well numbers.[77]

C. Short-, Medium-, and Long-Term Contamination Risks

All of the contamination incidents that occur during the life of a well can cause varying degrees of contamination, which result from routine activities or sloppy operations. In the short term—on the time scale of days

(BARNETT SHALE) FIELD DISCOVERY DATE – 10-15-1981, *available at* http://www.rrc.state.tx.us/data/fielddata/barnettshale.pdf (noting 2,010 new drilling permits issued for wells to be drilled and fractured in Texas's Barnett Shale in 2011, although not all drilling permits lead to actual production).

71. *See* R.R. COMM'N. OF TEX., NEWARK, EAST (BARNETT SHALE) WELL COUNT, *available at* http://www.rrc.state.tx.us/barnettshale/barnettshalewellcount_1993-2013.pdf (showing 17,494 gas wells as of December 13, 2013).

72. *New, Rigorous Assessment of Shale Gas Reserves Forecasts Reliable Supply from Barnett Shale Through 2030*, UNIV. OF TEX. AT AUSTIN (Feb. 28, 2013), http://www.utexas.edu/news/2013/02/28/new-rigorous-assessment-of-shale-gas-reserves-forecasts-reliable-supply-from-barnett-shale-through-2030/ (report in peer review and not yet released).

73. NEW YORK STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 34, at 6-208 (these numbers describe the high development scenario).

74. *See* Wiseman, *supra* note 67, at 243–44.

75. *Id.* at 253–54. In a cumulative effects context unrelated to contamination, but important from a general environmental perspective, Anthony Ingraffea has noted that "[w]ith hundreds of thousands of new wells expected," methane leakage from wells and pipelines creates a large climate problem. Anthony R. Ingraffea, Op-Ed., *Gangplank to a Warm Future*, N.Y. TIMES (July 28, 2013), http://www.nytimes.com/2013/07/29/opinion/gangplank-to-a-warm-future.html.

76. Rozell & Reaven, *supra* note 6, at 1388–91.

77. *See generally* Wiseman, *supra* note 67 (describing likely interdependent effects).

or weeks—spills can occur and be quickly cleaned up (or not),[78] pits and tanks can leak,[79] and soil can erode.[80] Even if quick clean-up occurs, workers and wildlife can be exposed to harmful chemicals.[81]

In the medium term—over the course of one or several years—substantial contamination of soil, surface water, and groundwater can occur. Spills or leaks to surface soil, if not fully recovered and cleaned up, can leach into ground water. The New Mexico Oil Conservation Division maintains a list of "Cases Where Pit Substances Contaminated New Mexico's Ground Water," which contains more than 450 cases.[82] These spills can, cumulatively, pollute large areas of soils and surface waters. Underground injection control wells containing oil and gas wastes also can, as introduced in Part A, leak into aquifers, causing damage that is difficult to clean up and which, in some cases, can expand geographically over time. For example, in Midland, Texas an improperly constructed injection well—maintained by a company now in bankruptcy—leaked into the city's drinking water aquifer, creating a "'plume' of chloride infested water that is (and has been for some time) migrating through the Aquifer" and progressively polluting more fresh water.[83] This event contaminated approximately 6.2 billion gallons by 2010.[84] These leaks can cause permanent damage, particularly when operators do not recover contamination quickly or fully remediate sites, or when the pollution enters a difficult-to-access area. The following table summarizes these many contamination risks and the activities that cause them.

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78. *See supra* note 33 and accompanying text.

79. *See supra* notes 50–52 and accompanying text.

80. *See supra* note 36 and accompanying text.

81. *See, e.g.*, United States v. Brigham Oil & Gas, L.P., 840 F. Supp. 2d 1202, 1204–06 (D.N.D. 2012) (describing birds found dead in pits at Bakken Shale sites); COLO. OIL & GAS CONSERVATION COMM'N, FIELD INSPECTION REPORT WELL NO. 05-103-08459, *available at* http://cogcc.state.co.us/cogis/FieldInspectionDetail.asp?doc_num=200312535 ("Accumulation of oil in produced water pit. . . . [B]oth excessive oil and both have been entered by deer . . . .").

82. N.M. OIL CONSERVATION DIV., CASES WHERE PIT SUBSTANCES CONTAMINATED NEW MEXICO'S GROUND WATER, *available at* http://www.emnrd.state.nm.us/ocd/documents/GWImpactPublicRecordsSixColumns20081119.pdf.

83. Motion for Estimation of Claims for Purpose of Allowance, Voting, and Determining Plan Feasibility, and Request for Determination that Remediation Claim is Entitled to Administrative Expense Priority at 2, *In re* Heritage Consol., LLC, Bankr. Nos. 10-36484 HDH-11, 10-36485 HDH-11 (Bankr. N.D. Tex. Aug. 26, 2013).

84. *See* City of Midland's Motion, *supra* note 56, at 2.

Table 1. Contamination Risks from Unconventional Gas and Oil Development

Activity ➡ / Type of Risk ⬇	Drilling and Fracturing	Waste Storage and Disposal	Well Termination	Post-Well Termination
Short-term	Seismic activity and related contamination and property damage	Improper localized storage with soil and water contamination	Abandonment or improper pit closure and site restoration; surface pollution and seepage of chemicals	Ongoing synergistic and cumulative surface water contamination
Medium-term	Surface and groundwater and soil contamination (transportation of materials to site, transfer and temporary storage of materials)	Surface and groundwater contamination even from localized disposal with proper techniques	Ongoing seepage; methane and other pollutant releases even from properly closed wells	Ongoing synergistic or aggregate groundwater contamination
Long-term	Ongoing synergistic and cumulative groundwater contamination from seepage	Ongoing synergistic and cumulative groundwater contamination from seepage or rupture of centralized disposal sites for multiple wells	Seepage-related surface and groundwater contamination; methane and other releases from properly or improperly plugged wells	Ecological, economic and human health impacts from ongoing synergistic and aggregate water contamination

These and other incidents create a challenging long-term contamination problem. And this contamination may expand over time. If we assume an average well life of 30 years, and that 11,400 new gas wells will be fractured in 2014[85] (ignoring the many oil wells that will also be fractured), in 2044 alone at least 11,000 gas wells will be plugged—if we assume solvent, responsible operators—and abandoned. And this estimate is likely quite low; in addition to the 2014 newly fractured wells that operators

85. *See supra* text accompanying note 69.

might abandon in 2044, a portion of this country's more than 500,000 existing gas wells[86] also will be abandoned that year, while others will still be active, causing their own types of pollution. Further, operators will drill new wells in 2044, contributing to a continuing cycle of potential contamination from newly drilled, active, and abandoned wells.

D. Certain and Uncertain Risks

Although some risks of drilling and fracturing remain unquantified, we can be certain of some risks: horizontal drilling, hydraulic fracturing, and associated waste disposal will contaminate soils, surface waters, and, in some cases, underground resources. As introduced above, thousands of gallons of fracturing chemicals and drilling and fracturing wastes have already spilled,[87] and many of these spills have not been recovered.[88] Further, numerous surface pits that store drilling and fracturing pits have leaked and have, in many cases, possibly contaminated groundwater.[89]

Other risks remain less certain—indeed, the Government Accountability Office, after reviewing the shale gas literature, concluded that environmental risks cannot yet be quantified.[90] There are still debates about whether fracturing fluids injected underground can contaminate groundwater. One EPA draft study suggested that very shallow fracturing jobs could cause this problem,[91] but most fracturing occurs in deeper formations.[92] And identifying the source of methane and sediment that contaminates groundwater after drilling and fracturing is exceedingly difficult; in some cases, the source is a combination of natural sources and improperly cased wells,[93] and in others, drilling may not contribute at all to

86. *See supra* note 68.

87. *See, e.g.*, *supra* notes 41–48 and accompanying text.

88. *See, e.g.*, Wiseman, *supra* note 3, at 766–800.

89. *See* N.M. OIL CONSERVATION DIV., *supra* note 82. *See also, cf.*, *Environmental Impacts Associated with Disposal of Saline Water Produced During Petroleum Production*, U.S. GEOLOGICAL SURVEY, http://toxics.usgs.gov/photo_gallery/osage.html (last modified Aug. 1, 2013) (providing photos of a well site that is not specified as conventional or unconventional, showing an unlined pit on the shore of a lake in Oklahoma and associated surface pollution).

90. *See supra* note 13.

91. DOMINIC C. DIGIULIO, ENVTL. PROT. AGENCY, DRAFT: INVESTIGATION OF GROUND WATER CONTAMINATION NEAR PAVILLION, WYOMING xi, xiii (2011), *available at* http://www2.epa.gov/sites/production/files/documents/EPA_ReportOnPavillion_Dec-8-2011.pdf (concluding that "the data indicates likely impact to ground water that can be explained by hydraulic fracturing").

92. *See* HALLIBURTON, U.S. SHALE GAS: AN UNCONVENTIONAL RESOURCE. UNCONVENTIONAL CHALLENGES. 2 (2008), *available at* http://www.halliburton.com/public/solutions/contents/shale/related_docs/H063771.pdf (discussing various shales and showing that fracturing generally occurs in deep formations).

93. *See, e.g.*, EAST RESOURCES, INC., DELCIOTTO NO. 2, SUBSURFACE NATURAL GAS RELEASE REPORT ROARING BRANCH, MCNETT TOWNSHIP, LYCOMING COUNTY, PENNSYLVANIA. 10–11 (2009) (concluding that naturally-occurring gas and gas leaking out of the casing contributed to groundwater and spring contamination).

the problem. Further, it is unclear how many UIC wells could fail and leak into underground aquifers and just how long modern well plugging jobs will last.

Overall, the fact that large numbers of newly drilled and fractured wells could contaminate large swaths of the United States—even if this contamination occurs at relatively low levels at each site, and even if incident rates decline—calls for a regime that will ensure that we can clean up these sites.

II. THE THEORETICAL CASE FOR MANDATORY INSURANCE: FRAMING UNCONVENTIONAL OIL AND GAS REGULATION AND INSURANCE REFORMS IN TERMS OF THREE DICHOTOMIES

In considering how unconventional well development should be regulated, it is helpful to review the menu of regulatory approaches that are available to address environmental risks. Horizontal drilling and fracking of unconventional wells (as now undertaken) are relatively new, but there is no reason to think that prior approaches and debates regarding environmental risks are irrelevant to the risks these technologies pose. The academic literature on institutional design and instrument choice is rich, and it helps frame and illuminate the role financial assurance bonds and mandatory insurance can and should play in regulating unconventional development-related risks.

One principal dichotomy in the academic literature is between "command and control" regulation and market-based or financial-incentive regulation. A second dichotomy is between regulatory enforcement via an exclusive regulator, versus overlapping and redundant enforcement by multiple sets of regulators operating in different political environments. Yet another major dichotomy is between *ex ante* regulation via legislative or agency action and *ex post* regulation via court-implemented tort liability for environmental harms.

As we explain, financial assurance bonds and mandatory insurance fit into these three dichotomies in important ways. First, bonds and mandatory insurance bring some of the comparative advantages of market-based approaches to regulatory risks into the current regime. This regime typically addresses both conventional and unconventional oil and gas development and is almost exclusively made up of command and control regulation, specifically, state command and control regulation. Bonds and mandatory assurance can improve allocative efficiency by forcing internalization of the social costs of oil and development, and these mechanisms can reduce these social costs by providing incentives for ongoing risk mitigation.

Second, in regimes (like the current oil and gas regime) characterized by non-redundant regulatory enforcement, where the sole regulators (for oil and gas, primarily state regulators) are constrained by possible "capture" and insufficient enforcement resources, insurance can help fill in the monitoring and enforcement gap by bringing to bear another regulatory force—private insurance companies. These entities cannot be captured in the way legislators or agencies can be, and they are not constrained by the pathologies of the budgetary appropriations processes. A number of important commentators have argued for adding redundancy and protection from capture and insufficient resources to the oil and gas regime by layering federal regulation on top of state regulation.[94] Given that this approach appears unlikely in the near term, those who are frustrated by the forces acting against the addition of a federal role, we argue, should look to insurers as an additional regulator that can check limitations and problems in state regulatory enforcement.

Third, bonds and insurance, if mandatory, will be essential to an effective liability regime for unconventional development, especially as to longer term risks, because bonds and insurance can mitigate what we call the "insolvent defendant" problem and the "clouded causation" problem. As we argue, an effective regime for unconventional development risk, especially long-term risk, will require both an adaptive insurance and an adaptive liability regime, and it is likely not possible to have one without the other.

We first explain these three dichotomies and how they are relevant to the current oil and gas regulatory regime. We then describe how assurance bonds and mandatory insurance generally, and in the specific context of unconventional development, fit in terms of these dichotomies.

A. *Command and Control Regulation Versus Market-Based Regulation*

In command and control regulation, the legislature, or an agency acting under legislative authority, develops rules or commands directed at regulated entities. The commands may be more or less specific, but "commands" uniquely characterize them: the regulated entity is required to comply and, as a formal matter, has no legitimate choice not to comply. In practice, however, enforcement depends on some inspection and regulatory implementation efforts by regulators. Regulators can fine regulated entities for noncompliance, order them to comply, and perhaps impose the most effective sanction—termination of the regulated entity's operation. Much of federal and state environmental law closely fits the command and control paradigm. Indeed, even our evolving regime for carbon emissions, one in which market mechanisms have figured centrally in all academic debates, appears to be taking the form of command and control regulation through Clean Air Act permitting requirements.[95]

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94. *See* Burger, *supra* note 10, at 152 (not directly arguing for federal regulation, but arguing that it has a role); Freeman, *supra* note 10 (proposing a cooperative federalist regime).

95. *See* Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31514 (June 3, 2010) (codified at 40 C.F.R. pts. 51, 52, 70, & 71);

Beginning in the late 1970s and 1980s, academics and others began to identify certain general disadvantages in a command and control approach to regulation. Among these disadvantages is that command and control regulation requires a tremendous amount of information on the part of regulators to figure out what commands to make and how to make them, as well as constant updating of information. While regulators in theory can obtain the information needed from regulated entities, regulated entities lack an incentive to share or uncover relevant information, since almost any new information can result in new regulatory restrictions.[96] In the standard critique, command and control regulation tends to be inert or sticky—rarely keeping up with developments in the underlying technology or economy—not only because regulators lack information, but also because of general phenomena of legislative and bureaucratic inertia, as well as regulated entities' lobbying against any new requirements.[97] Permits tend not to be updated, pollutant standards tend not to be revisited, and programs tend to stagnate. There are numerous examples of this stagnation in U.S. environmental law and regulation.[98]

Moreover, according to the critique, regulated entities have no incentive, no upside, to improve safety or mitigate compliance beyond what is required by command and control regulations and hence no incentive to research new methods of reducing risk. On the contrary, if entities come up with safer means to reduce risk beyond what is required by command and control regulation, they receive no immediate financial benefit and instead open themselves up to a new wave of regulatory requirements.[99] Implementation and enforcement of command and control regimes is often perceived as expensive and cumbersome, characterized by conflict, and bogged down by legal process.

Many of the critics of command and control regulation laud market-based regulation as an alternative. In market-based regulation, the government does not command a particular practice, but rather places a

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Regulations & Standards: Clean Air Act Permitting for Greenhouse Gases, ENVTL. PROT. AGENCY (Dec. 23, 2010), http://www.epa.gov/nsr/actions.html (describing subsequent rules).

96. *See* David A. Dana, *The Case for an Information-Forcing Regulatory Definition of "Nanomaterials,"* 30 PACE ENVTL. L. REV. 441, 462 (2013) (observing that industry knows that sharing information with agencies "can lead to costly new requirements or even product prohibitions"); Bradley C. Karkkainen, *Bottlenecks and Baselines: Tackling Information Deficits in Environmental Regulation*, 86 TEX. L. REV. 1409, 1412 (2008) (noting that industries often have the most knowledge about available pollution control technologies but "have a disincentive to share that information with regulatory agencies that might use it as a basis for regulation").

97. *See* Cass R. Sunstein, *Administrative Substance*, 1991 DUKE L.J. 607, 629 (describing how command-and-control technology-based regulation "promotes struggles among well-organized factions").

98. *See id.* at 628 (describing how technology-based controls on new sources under the Clean Air Act caused old, dirty plants to continue operating).

99. *See supra* note 96.

price on an activity associated with risk of harm, or on harm itself. Market methods include Pigouvian pollution taxes, and tradable pollution and renewable energy credits, among others.[100] The environmental regulatory regime has incorporated these market elements most significantly in the context of air pollution.[101] Market-based regulation places a lesser information burden on regulators in some respects, as agencies implementing this approach do not need to specify precisely what practices regulated entities should follow in many and diverse technical situations, but rather they only have to price the costs of risk of environmental harm. Proponents of market approaches also claim that these regulatory systems tap into market dynamism and are less stagnant and static than command and control regulations. Because regulated entities financially gain from reducing risk or risk of harm (in the form of less tax or more credits to sell), they have an ongoing incentive to develop information and practices that reduce risk.[102] In some accounts, enforcement of market regulation is also less costly and difficult[103] than for command and control regulation, because some regulated entities have a greater affirmative buy-in to the regulatory regime.

The reality of environmental regulation is that, while there is much talk of market-based or financial-oriented regulation, command and control regulation dominates and is often the exclusive content of the regime. The use of Pigouvian pollution taxes—where actors pay a tax per pollutant—is a widely discussed but largely unused market mechanism.[104] Tradeable

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100. *See* Eric W. Orts, *Reflexive Environmental Law*, 89 NW. U. L. REV. 1227, 1242–47 (1995) (identifying these and other approaches); Richard B. Stewart, *Models for Environmental Regulation: Central Planning Versus Market-Based Approaches*, 19 B.C. ENVTL. AFF. L. REV. 547, 552–55 (1992) (discussing market-based approaches and arguing that they cannot solve every environmental problem).

101. *See, e.g.*, A. DENNY ELLERMAN ET AL., EMISSIONS TRADING IN THE U.S.: EXPERIENCE, LESSONS, AND CONSIDERATIONS FOR GREENHOUSE GASES 8–31 (2003), *available at* http://web.mit.edu/globalchange/www/PewCtr_MIT_Rpt_Ellerman.pdf (describing major U.S. emissions trading programs, all of which relate to air quality).

102. *Cf.* Nicole Fradette et al., *New Strategies for a New Market: The Electric Industry's Response to the Environmental Protection Agency's Sulfur Dioxide Emission Allowance Trading Program*, 47 ADMIN. L. REV. 469, 481 (1995) (noting overcompliance responses to market-based sulfur dioxide regulation).

103. *See* Bruce R. Huber, *How Did RGGI Do It? Political Economy and Emissions Auctions*, 40 ECOLOGY L.Q. 59, 60 (2013) (noting that "emissions trading can in some cases reduce the cost of regulation while allowing regulated entities greater freedom in carrying out their business").

104. *See, e.g.*, Brian Galle, *The Tragedy of the Carrots: Economics and Politics in the Choice of Price Instruments*, 64 STAN. L. REV. 797, 800 (2012) (discussing how policymakers might best use the Pigouvian tax and similar instruments in the environmental context and other areas); Janet E. Milne, *Environmental Taxation in the United States: The Long View*, 15 LEWIS & CLARK L. REV. 417, 446–47 (2011) (noting that environmental taxation in the United States often has relied on solutions that are "second-best" as compared to an "idealized Pigouvian tax"); Jonathan Remy Nash, *Too Much Market? Conflict Between Tradable Pollution Allowances and the "Polluter Pays" Principle*, 24 HARV. ENVTL. L. REV. 465, 497–535 (2000) (arguing that pollution trading

pollution credits have been used, but only in very limited contexts, most notably with respect to certain air pollutants. Scholars have pondered why market-based regulation is so often absent.[105] Political economy plays a large role, no doubt: Taxes of any sort are often considered politically toxic, and financial rewards for better compliance, when tried, are readily criticized as government favoritism or just evidence of agency or legislative capture, as was the case with EPA's relatively brief Performance Track experiment.[106] In addition, precisely because command and control regulation tends to be stable and amenable to established industry actors, the regulated community may strongly prefer it, at least as compared to meaningful market-based regulation.[107]

Command and control regulations make up the entire oil and gas regulation regime: there are no pollution-based taxes or other market regulations in use. State oil and gas regulations have the highly specific nature of classic command and control regulation. Consider, for example, the numerous state mandates for specific types of blowout prevention technologies to prevent uncontrolled pressure build-ups during drilling and fracturing,[108] surface waste pits that must be lined with plastic of a certain

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schemes have been, at least facially, "inconsistent with the polluter pays principle" and suggesting how they could be better designed).

105. *See, e.g.*, Thomas W. Merrill, *Explaining Market Mechanisms*, 2000 U. ILL. L. REV. 275, 278 (arguing that distributive issues explain the under-utilization of market mechanisms and especially taxes and auctions); Jonathan Remy Nash, *Framing Effects and Regulatory Choice*, 82 NOTRE DAME L. REV. 313, 314 (2006) (noting that "[t]he academic popularity of market-based regulation has not translated into widespread implementation of market-based instruments" and exploring why this is so); Richard B. Stewart, *United States Environmental Regulation: A Failing Paradigm*, 15 J.L. & COM. 585, 591 (1996) (arguing that, among other instruments, "[d]omestic environmental problems should be addressed primarily through a combination of: (a) pollution fees and tradeable pollution permits to deal with widespread pollutants of regional or larger significance; [and] (b) deposit/refund systems to deal with hazardous wastes and post-consumer residues[,]" but noting that at the time of the article, environmental regulation had been primarily command and control).

106. *See, e.g.*, John Sullivan & John Shiffman, *Green Club an EPA Charade*, PHILA. INQUIRER (Dec. 8, 2008), http://articles.philly.com/2008-12-09/news/24992933_1_performance-track-environmental-performance-epa (critiquing EPA's Performance Track). Administrator Jackson terminated the Track at the beginning of the first Obama Administration, and there are no reported efforts to revive it. Robin Bravender, *EPA's Voluntary Programs Under Scrutiny as Regulatory Obligations Rise*, N.Y. TIMES (Feb. 5, 2010), http://www.nytimes.com/gwire/2010/02/05/05greenwire-epas-voluntary-programs-under-scrutiny-as-regu-28308.html.

107. *See, e.g.*, Sunstein, *supra* note 97, at 629 (describing how certain command and control regulations reduce competition and favor existing industries).

108. *See, e.g.*, 2 COLO. CODE REGS. § 404-1:603 (2013) (describing required blowout equipment and testing protocol); MICH. ADMIN. CODE r. 324.406 (2012) (discussing required blowout prevention equipment, including rams—which are devices that, if they work, shut down the well when high pressures are encountered—and blind rams, which do not move regardless of the pressure exerted on them).

thickness,[109] and cement that must reach a particular compressive strength within a certain number of hours of being pumped into the well.[110] And advocates for regulatory reform regarding unconventional development are, in effect, advocating more and better command and control regulations, rather than a different kind of regulation.[111]

Moreover, even if some better command and control regulations were adopted, unconventional oil and gas is exactly the kind of regime in which we would expect the regulations not to reflect all the relevant information and, for certain stages of development, to become obsolete quickly, to the extent they are effective. Regulators lack the information they need to craft and update command and control regulations[112] because certain horizontal drilling and fracking technology as deployed is new and evolving, the scale and proximity to population centers of unconventional development is unprecedented in some regions,[113] and this development is expanding into new areas where the underlying hydrology and geology is not fully understood.[114] Industry has an interest in securing stable state regulations

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109. *See, e.g.*, 178 ARK. CODE R. § B-17(g)(2)(A) (2013) (requiring a synthetic liner 40 mils thick for pits containing flowback from fractured wells); N.M. CODE R. § 19.15.17.11 (LexisNexis 2013) (requiring geomembrane 20-mil string reinforced LLDPE or equivalent for temporary pits).

110. *See, e.g.*, MD. CODE REGS. 26.19.01.10(P) (2012) (requiring surface casing cement to be American Petroleum Association Class A cement that is not greater than 3% calcium chloride); W. VA. CODE R. § 35-4-11 (2010) (same); Hannah Wiseman & Francis Gradijan, *Regulation of Shale Gas Development, Including Hydraulic Fracturing* 59 (Univ. of Tulsa Legal Studies, Research Paper No. 2011-11, 2012), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1953547 (comparing compressive strength requirements).

111. *See, e.g.*, Burger, *supra* note 10 (arguing that better regulations, potentially at the federal level, may be needed), Jefferies, *supra* note 10 (arguing for better regional and federal regulations); Wiseman, *supra* note 3, at 810–11 (listing the highest priority regulations to be updated).

112. The assumption in the literature tends to be that in the information age, states have abundant information about others' policy approaches. *See, e.g.*, Merrill & Schizer, *supra* note 12, at 151 ("Because state regulators observe each other, successful regulatory initiatives are likely to disseminate from one state to another."). But the area of oil and gas drilling and fracturing regulation is so complex that it took a national think tank and a law professor nearly two years to compare just 25 regulatory elements in this area—and this was just the tip of the iceberg. *See* RICHARDSON ET AL., *supra* note 64, at 1–2. Particularly in areas where risks are still not known, this makes the task of regulating even more difficult.

113. *See, e.g.*, *Bakken Helps North Dakota Surpass Oil Production Record*, BILLINGS GAZETTE (Nov. 25, 2011, 12:15 PM), http://billingsgazette.com/news/state-and-regional/montana/bakken-helps-north-dakota-surpass-oil-production-record/article_fa857924-1788-11e1-902a001cc4c032 86.html (showing record well numbers in North Dakota due to unconventional development in the Bakken Shale).

114. In Florida, for example, companies are proposing horizontal drilling through (and, if necessary, possibly hydraulically fracturing) mudstone in Collier County. Nissa Darbonne, *The Horizontal Cometh*, OIL & GAS INVESTOR, June 2012, at 38, 38–39, *available at* http://www.news-press.com/assets/pdf/A41958081013.PDF (describing horizontal wells in the Lower Sunniland formation); Jacob Carpenter & June Fletcher, *Special Report: Oil Drilling Company Has Leased*

but no interest, necessarily, in generating information about safer practices than those that regulations require or about risks that state regulators have not focused on.[115] In sum, there is very good reason to expect that command and control regulation for unconventional development will be characterized by insufficient background information, lags between regulatory change and actual change in industry practice and associated risks, and resistance by industry to development and disclosure of relevant information regarding risk. Indeed, industry has resisted, sometimes successfully, even disclosing the toxic chemicals it injects deep into the well (and then into a portion of the formation around it) as part of the fracking process.[116]

B. *Exclusive Versus Multiple Regulators*

One of the central debates in environmental regulation is whether there should be an exclusive or multiple, overlapping sources of regulation—whether there should be one set of regulators or multiple, in a sense, redundant, sets of regulators. The efficiency benefits of a single set of regulators are obvious: No redundancy may mean fewer actual enforcement costs, and for industry, dealing with a single set of regulators may take less time and money. Redundancy and overlaps in authority have indeed been criticized as inefficient in the environmental arena as well as in other regulatory arenas.[117]

However, redundancy can act as a corrective to certain pathologies that can result from a single set of regulators' ineffectively formulating and/or enforcing risk controls. In practice, historically, this debate has focused on: (1) whether there should be a role for federal regulators, state regulators or both with respect to the same set of risks; and (2) whether there should be a role for citizen suit regulators in addition to state and/or federal regulators.

In the U.S. system, even where federal statutes authorize a federal role, state regulators de facto are the frontline, most influential regulators. Some commentators argue that regulatory implementation and enforcement, especially at the state level, is subject to a public choice pathology whereby

115,000 Acres, Including Land Under Dozens of Homes, NAPLES DAILY NEWS (Oct. 27, 2013, 6:00 AM), http://www.naplesnews.com/news/2013/oct/27/special-report-oil-drilling-company-has-leased/.

115. *See supra* note 96 and accompanying text.

116. *See generally* Hannah Wiseman, *Trade Secrets, Disclosure, and Dissent in a Fracturing Energy Revolution*, 111 COLUM. L. REV. SIDEBAR 1 (2011).

117. *See* Todd S. Aagaard, *Regulatory Overlap, Overlapping Legal Fields, and Statutory Discontinuities*, 29 VA. ENVTL. L.J. 237, 239 n.6 (2011) (listing sources criticizing overlap); *cf.* Jody Freeman & Jim Rossi, *Agency Coordination in Shared Regulatory Space*, 125 HARV. L. REV. 1131, 1210 (2012) (suggesting ways in which overlap can be beneficial); Jason Marisam, *Duplicative Delegations*, 63 ADMIN. L. REV. 181, 184 (2011) (arguing that "[i]f all agencies availed themselves of the duplicative authority delegated to them, ceaseless duplication and interagency conflict would plague the regulatory system" but suggesting that institutions guard against "duplication and conflict").

industry, a concentrated interest with high stakes in regulatory outcomes, dominates the (typically) diffuse public interest. The same interest group pathology also can pervade the legislative process itself.[118] Moreover, especially with respect to agencies that are specifically dedicated to regulating a single or few industries, there is a marked pattern of "revolving door" movement between government service and industry employment that limits the enforcement effectiveness of government.[119] Single-industry agencies sometimes have such close ties to the industry that, material incentives of possible future employment aside, regulators and industry can develop a "groupthink" that makes regulators insufficiently attentive to areas in which industry can reduce risk.[120] Even if this capture-groupthink-insufficient-distance phenomenon does not systematically appear in state environmental regulation, as Richard Revesz has emphasized,[121] it is unquestionable, we think, that it is sometimes present. Moreover, a similar dynamic can occur in areas of exclusive federal regulation. Capture and groupthink appear to have been part of the dynamic that allowed the Deepwater Horizon disaster to occur.[122]

Even in the absence of legislative or agency capture or groupthink, legislative appropriation of too few resources for enforcement efforts constrains agencies. This pattern prevails at the federal and state level, and it may have several explanations. For one thing, funding enforcement may not be as "flashy" or yield as many salient political benefits as alternative initiatives.[123] There is a suspicion, which many treat as a truism, that

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118. *See, e.g.*, Thomas W. Merrill, *Capture Theory and the Courts: 1967–1983*, 72 CHI.-KENT L. REV. 1039, 1044 (1997) (describing public choice as a conception that "all governmental institutions—agencies, legislatures, the White House, and even the courts—are subject to manipulation by organized groups").

119. *See* PAUL J. QUIRK, INDUSTRY INFLUENCE IN FEDERAL REGULATORY AGENCIES 143–74 (1981) (describing repeated industry-agency relationships).

120. *See, e.g.*, Michael Barsa & David A. Dana, *Reconceptualizing NEPA to Avoid the Next Preventable Disaster*, 38 B.C. ENVTL. AFF. L. REV. 219, 227 (2011) (noting that "there is sufficient support for the notion that some form of groupthink leads to a predictable discounting of risks," which can occur in agencies and industry).

121. *See* Richard L. Revesz, *Federalism and Environmental Regulation: A Public Choice Analysis*, 115 HARV. L. REV. 553, 557 (2001) (arguing that public choice pathologies cannot be assumed to be systematically more prevalent at the state level than at the federal level).

122. *See* Zygmunt J.B. Plater, *Learning from Disasters: Twenty-One Years After the Exxon Valdez Oil Spill, Will Reactions to the Deepwater Horizon Blowout Finally Address the Systemic Flaws Revealed in Alaska?*, 40 ENVTL. L. REP. 11,041, 11,045–46 (2010) (discussing capture).

123. Indeed, there appears to be massive underfunding of enforcement in the unconventional oil and gas context. *See* Wiseman, *supra* note 8 (showing a large disparity between inspectors and well numbers). State-enforcement rates also differ. In 2009, Texas agency staff inspected more than 128,000 well sites, noted over 80,000 violations of state laws, and took more than 550 enforcement actions. R.R. COMM'N OF TEX., SUNSET ADVISORY COMMISSION: FINAL REPORT 8 (2011), *available at* https://www.sunset.texas.gov/public/uploads/files/reports/Railroad%20Commission%20Staff%20Report%202011%2082nd%20Leg.pdf. In Pennsylvania, between 2008 and 2013, staff conducted 44,564 inspections of unconventional wells, noted 4655 violations, and took 1401 enforcement

government expenditures are always wasteful and that more can always be done with less. And, in particular with a new industry that suddenly needs the allocation of more enforcement resources, the political economy of appropriations often is not up to producing sufficient allocations. For one thing, legislative inertia and the endowment effect combine to create great pressure against *reallocating* funds from a current use to a new use. Legislatures, moreover, may not appreciate the need to increase enforcement appropriations to match increases in a burgeoning new industry's scale of operations.[124] More generally, the current state of budgetary circumstances at the federal and state level, where there are long-term pressures from increasing entitlement and pension liabilities and almost no appetite for increasing tax rates, further complicates efforts to match enforcement resources to the scale of new industry operations.[125]

One de facto solution to federal and state enforcement problems is reliance on a third set of regulators—citizen regulators, acting via citizen suits. Citizen suits have been critical to addressing the under-enforcement problem in U.S. environmental regulation. Citizen suits, however, are only a viable means of supplementing regulatory efforts where statutes and regulations facilitate such suits.[126] Moreover, these suits are less likely to be filed and be effective in some situations where there are many facilities or sites at issue: where there are many sites of possible interest rather than a few salient ones, citizen groups cannot focus their limited resources and put them to their best effect.[127] Similarly, citizen suits require technical information, and unless operators accurately self-report this in a public and

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actions. PA. DEP'T OF ENVTL. PROT., *supra* note 33 (select "Yes" from "Unconventional Only (PF Inspections)," "No" from "Inspections with Violations Only," enter 01/01/2008 as "Date Inspected From," and 12/31/2013 as "Date Inspected To," then select "View Report").

124. In Texas, most oil and gas permitting fees, which fund enforcement (and the amount for which must be approved by the legislature), "have not been raised in nine or more years." R.R. COMM'N OF TEX., *supra* note 123, at 24. *See also* Wiseman, *supra* note 67 (describing legislative and regulatory habits of not anticipating and adjusting to increases of scale in regulated activities).

125. *See, e.g.*, Susan F. Tierney, Analysis Group, Remarks at the Workshop on Governance of Risks of Unconventional Shale Gas Development (Aug. 15, 2013) (explaining that even where states allocate funds for enforcement and require that the funds remain for enforcement purposes, they still get "raided" for other purposes). For a description of low numbers of agency inspectors compared to total wells in states, see Wiseman, *supra* note 8. *See also* Wiseman, *supra* note 67, at 284 (describing how Texas lacks money to hire more inspectors).

126. *See* David A. Dana, *The New "Contractarian" Paradigm in Environmental Regulation*, 2000 U. ILL. L. REV. 35, 55 (noting that the move to informal, site-specific, negotiated regulation increases citizen groups' monitoring costs and impedes their traditional role as checks on underenforcement).

127. *Cf.* Eileen Gauna, *Federal Environmental Citizen Provisions: Obstacles and Incentives on the Road to Environmental Justice*, 22 ECOLOGY L.Q. 1, 54–57 (1995) (describing citizen-group difficulties in filing suit, particularly when large amounts of data from multiple sources must be compiled).

readily understandable means, few groups will have the knowledge and expertise to mount effective litigation.

Turning to the unconventional development context, there has been a very limited federal regulatory role, in part because oil and gas development on-shore has traditionally been a state responsibility, and because several otherwise applicable federal pollution-control statutes specifically exempt unconventional development or oil and gas development more generally.[128] At the state level, both conventional and unconventional well development is often the responsibility of a state oil and gas commission or agency,[129] exactly the kind of industry-specific agency that past experience suggests will be prone to capture, groupthink, or generally too much closeness with the regulated industry to operate with full effectiveness.[130] Moreover, there is abundant evidence that state appropriations to address unconventional development have not and will not keep up with increases in its scale.[131]

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128. *See* 42 U.S.C. § 300h(d)(1) (2006 & Supp. V 2011) (excluding "hydraulic fracturing operations," with the exception of operations that use diesel fuel, from the regulation of underground sources of drinking water); 42 U.S.C. § 9601(14) (2006 & Supp. V 2011) (defining "hazardous substances" to exclude "petroleum, including crude oil or any fraction thereof [and] natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel" for clean-up-cost liability under the Comprehensive Environmental Response, Compensation, and Liability Act); Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25,446–47 (July 6, 1988) (exempting most oil and gas exploration and production wastes from the hazardous waste portions of the Resource Conservation and Recovery Act); *see also* 33 U.S.C. § 1342(*l*)(2) (2006 & Supp. V 2011) (exempting from the Clean Water Act stormwater permitting uncontaminated runoff from oil and gas sites).

129. *See* Thomas E. Kurth et al., *American Law & Jurisprudence on Fracing*, 47 ROCKY MTN. MIN. L. FOUND. J. 277, 286–287 (2010) (describing the agencies that regulate in the states with significant fracturing operations (or pending significant fracturing), with Arkansas, Montana, New Mexico, North Dakota, Ohio, Oklahoma, Texas, and Wyoming housing primary regulatory authority with oil and gas agencies that are independent or within a state regulated industries commission, not within an environmental agency); Mike Soraghan, *Protecting Oil From Water—The History of State Regulation*, E&E PUBLISHING LLC (Dec. 14, 2011), http://www.eenews.net/stories/1059957631 (describing state oil and gas agencies' historic mandates to encourage the production of oil and gas); GROUND WATER PROT. COUNCIL et al., STATE OIL AND NATURAL GAS REGULATIONS DESIGNED TO PROTECT WATER RESOURCES 14 (2009), *available at* http://www.gwpc.org/sites/default/files/state_oil_and_gas_regulations_designed_to_protect_water_resources_0.pdf (noting that "[t]hroughout the period 1946 to 1960, most oil and gas producing states established a regulatory agency to enforce oil and gas conservation practices" and that the focus was still primarily on preventing the waste of oil and gas).

130. *Cf.* Mike Soraghan, *Industry Pours Campaign Cash into State, Local Races*, E&E PUBLISHING LLC (Dec. 9, 2011), http://www.eenews.net/stories/1059957451 (noting that state oil and gas regulators at an Interstate Oil and Gas Compact Commission conference "could play golf or shoot skeet on the dime of the oil and gas industry"). This is not to say, however, that all or even almost all of agency staff are inattentive to concerns other than those of industry. The authors have spoken with a number of staff who seem very responsive to the concerns of a number of stakeholder groups and who work hard to fulfill their agencies' missions.

131. *See supra* notes 124–25 and accompanying text. There are some exceptions, however. Although staffing increases have not necessarily kept up with rising well numbers, Pennsylvania,

Finally, it is unlikely that citizen suits will provide helpful redundancy in regulators in the unconventional development context: This type of development involves tens of thousands upon thousands of sites,[132] and citizen groups cannot easily keep track of them or effectively address such a multiplicity of potentially problematic sites. Moreover, citizen groups lack the information they would need to act effectively, and these groups have even less information, in all likelihood, than the also-not-fully-informed state regulators. Finally, unconventional development is occurring in some regions in or near major American cities and close to areas of widely appreciated scenic beauty, but also in remote, relatively obscure rural areas in numerous states. The latter are not the kind of places that sophisticated citizen groups have always focused upon, presumably reflecting members' residency and interests.[133]

C. Regulation by Regulators Versus Regulation by Common Law Tort Liability

While government regulation has been the primary means of addressing environmental risk, some have called for a return to and greater reliance on common law torts of nuisance, trespass, and negligence to address environmental risk.[134] Imposition of tort or tort-like (as in Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA")[135]) liability for environmental harm by definition is an *ex post*, after the fact occurrence. However, liability can affect activity *ex ante* by inducing actors to conduct themselves in a way that avoids or minimizes the possibility of incurring liability. Proponents of reliance on liability as a tool to influence *ex ante* conduct focus on the advantages of court-shaped liability over legislative and agency-created rules. First, proponents argue that common law case-by-case adjudication is a highly flexible, fact-specific tool that allows for more ongoing adaptation to changing circumstances than (often static, rigid, command and control) regulations. Second, courts are

for example, has added substantial numbers of enforcement staff to its oil and gas agency in recent years. *See* PA. DEP'T OF ENVTL. PROT., MARCELLUS SHALE: TOUGH REGULATIONS, GREATER ENFORCEMENT (2013), *available at* http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-95071/0130-FS-DEP4288.pdf (explaining that the state's Department of Environmental Protection "more than doubled the number of inspectors" between 2009 and 2010 and increased well permitting fees in order to fund enforcement).

132. *See supra* notes 4, 67–73 and accompanying text.

133. *See* Mike Soraghan, *Enviro Groups Ignored Gulf Before BP Disaster*, N.Y. TIMES (Sept. 27, 2010), http://www.nytimes.com/gwire/2010/09/27/27greenwire-enviro-groups-ignored-gulf-before-bp-disaster-96055.html?pagewanted=all.

134. *See, e.g.*, Alexandra B. Klass, *Common Law and Federalism in the Age of the Regulatory State*, 92 IOWA L. REV. 545, 595–98 (2007) (arguing for the use of common law to progressively address modern environmental challenges).

135. Liability under the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA") is only "tort like" because it involves strict liability and does not require proof of a breach of standard of care. *See* 42 U.S.C. § 9607 (2006 & Supp. V 2011).

thought to be more independent from, and less susceptible to capture by, either industry or environmental interest groups.[136]

Environmental common law torts, however, have not been a particularly robust area of litigation in the United States. Although unconventional development suits based on tort theories are accumulating, there is good reason to think that, absent mandatory insurance of the sort we discuss below, tort law will be ineffective *ex post* in funding needed clean-ups or *ex ante* in encouraging risk reduction through safer choices by industry.[137] Tort law in the environmental context has two enormous problems that can reduce its effectiveness as an *ex ante* market mechanism, especially with respect to long-term risks that may not be identified for decades.

First, there is the "insolvent" defendant problem: Plaintiffs can only collect tort judgments from solvent, viable, ongoing entities. Thus, a corporation, corporate subsidiary, or limited liability company will radically discount expected costs from liability that plaintiffs might seek to impose after the expected "life" of the corporation, corporate subsidiary, or LLC.[138] Even if the entity anticipates operating over the very long term, it can effectively cap its liability by limiting its capitalization, even if its owner/shareholders hold massive amounts of capital.[139]

Second, there is the "clouded causation" problem: Common law tort liability requires that the plaintiff prove by a preponderance of the evidence that a given defendant specifically caused the harms. Where there are multiple possible causes for contamination, however, as where there is a cluster of potentially contaminating operations in a single area, or where a single operation has received waste or other potentially harmful materials from multiple actors, attributing specific harms to specific defendants and proving actual and "proximate" causation can be an uphill battle and certainly very expensive. Because the passage of time tends to correlate with the loss of direct evidence of what occurred and with the mixing and merging of pollutants from different sources, the clouded causation problem is particularly likely to impede liability with respect to claims brought many years after a defendant ceases operations.

Together, the insolvent defendant problem and the clouded causation problem thus tend to reduce dramatically the possibility that a corporate

136. Abram Chayes, *The Role of the Judge in Public Law Litigation*, 89 HARV. L. REV. 1281, 1310 (1976) (arguing that "[t]he premise of 'capture' does not apply in anything like the same degree . . . [as it does to agencies] in the contemporary judicial setting").

137. *See infra* notes 181–82 and accompanying text.

138. *See* Wendy E. Wagner, *Choosing Ignorance in the Manufacture of Toxic Products*, 82 CORNELL L. REV. 773, 811 n.143 (1997) (listing sources that describe how industries discount the costs of future accidents, injuries, and liabilities).

139. For a sophisticated model of how corporations might evaluate the costs and benefits of judgment-proofing strategies, see Richard R.W. Brooks, *Liability and Organizational Choice*, 45 J.L. & ECON. 91 (2002).

entity will face liability in the long term, years after its operations may have ended. These problems thus dramatically reduce the effectiveness of liability as a means of inducing *ex ante* risk avoidance or mitigation behaviors that would avoid or reduce long-term harms or harm only likely to be detected in the long term.

Unconventional development is a context in which both the insolvent defendant and the clouded causation problem are likely to arise. Unconventional well operations to date have involved many small LLC enterprises that could be defunct or insolvent if sued years after well abandonment or closure.[140] Even where large "brand name" corporations are involved in fracking and drilling operations, they may use subsidiaries that they might dissolve in a number of years or the corporations may limit the subsidiaries' capitalization to what is needed to conduct unconventional well operations.[141] Moreover, if courts begin to impose liability for unconventional well-related contamination, we would expect industry actors to reorganize their operations to protect themselves from liability even more than is now the case.[142]

We do not know precisely how many future unconventional oil and gas issues and disputes will involve difficult causation questions because of commingling of wastes or contaminants. We also do not know what the technical capacity of evolving science will be to overcome and sort out commingling and accumulation and reliably assign individual-actor responsibility. And perhaps most of all, we do not know what the attitudes and reactions of American courts will be to unconventional development messes: Will the courts require strict causation proof, or will they be willing to impose something like market share liability for (for example) contaminated aquifers? How narrowly or broadly will the courts construe the common law concept of joint and several liability? Even where there is firm evidence that a certain company contributed to some contamination, but

140. *See* Professor Jennifer Nash, Exec. Dir. Regulatory Policy Program, Harvard Univ. Kennedy Sch., Remarks at the Workshop on Governance of Risks of Unconventional Shale Gas Development National Research Council (Aug. 16, 2013), *available at* http://sites.nationalacademies.org/xpedio/groups/dbassesite/documents/webpage/dbasse_084368.pdf (noting that although large operators tend to be responsible for wells in the Marcellus Shale—79 companies operate 9458 unconventional wells, and 5 companies operate half of these wells—there are also a number of small companies involved, and service companies and other subcontractors conduct many site operations).

141. *See id.*; *see also* Robert E. O'Connor, Question and Comment at the Workshop on Governance of Risks of Unconventional Shale Gas Development National Research Council (Aug. 16, 2013) (providing anecdotal evidence that operators hire contractors or use subsidiaries for the highest-risk operations at well sites).

142. *See* Austin L. Mitchell & Elizabeth A. Casman, *Economic Incentives and Regulatory Framework for Shale Gas Well Site Reclamation in Pennsylvania*, 45 ENVTL. SCI. & TECH. 9506, 9509 (2011) ("The steep decline in production [after a well is established] may drive divestment of shale gas assets by primary exploration and production companies well before the expected closure of a shale gas well. The transfer of marginally producing assets to smaller independent operators or surface owners is a common practice in the oil and gas industry.").

other companies are insolvent, courts may hesitate to impose liability on the solvent company or at least, as a matter of fairness in our legal tradition, they may be hesitant to hold it jointly and severally liable for the contamination "soup."[143]

There is an additional possible problem with using the threat of tort liability to incentivize care on the part of industry participants in unconventional development. Under United States law, defendants can sometimes use regulatory compliance as a defense to tort liability.[144] It is unclear whether courts will afford defendants that defense in the unconventional development context, but there is at least some basis for thinking that some courts would be open to the defense. Moreover, two influential commentators, Tom Merrill and David Schizer, have argued for a "relatively robust version of [this] defense."[145] For contamination pathways covered by best practices regulation, operators who complied with this regulation under Merrill and Schizer's regime would benefit from a presumption of reasonable care, but plaintiffs could rebut this presumption by showing "that the relevant best practices rule deviates substantially from the rule followed in other oil and gas jurisdictions."[146] Merrill and Schizer suggest that best practices regulations are "[r]ules based on 'best available' technology" that require "state-of-the-art control measures,"[147] which they do not fully define. But regardless of how one defines them, in many cases, best available technologies have not yet been identified in the area of unconventional oil and gas development,[148] and it is not clear that any

143. These fairness concerns have led to some judicial hesitance to impose liability under CERCLA, even though that statute has long been read as creating a much more expansive joint and several liability than is recognized under common law tort principles. For a discussion of this judicial reaction, see generally John M. Hyson, *"Fairness" and Joint and Several Liability in Government Cost Recovery Actions Under CERCLA*, 21 HARV. ENVTL. L. REV. 137 (1997).

144. *Cf.* Michael P. Moreland, *Preemption as Inverse Negligence Per Se*, 88 NOTRE DAME L. REV. 1249, 1285–86 (2013) ("[O]nly a few states permit the regulatory compliance defense to serve as a complete defense to liability . . . .").

145. Merrill & Schizer, *supra* note 12, at 244.

146. *Id.*

147. *Id.* at 150.

148. Various groups have proposed control measures for oil and gas development and hydraulic fracturing specifically, but these measures differ, and many states have not implemented them. *See* CTR. FOR SUSTAINABLE SHALE GAS DEV., GEOGRAPHIC SCOPE AND APPLICABILITY OF CSSD PERFORMANCE STANDARDS (2013), *available at* https://www.sustainableshale.org/wp-content/uploads/2013/09/Performance-Standards-rev.-8.19.13.pdf; Memorandum from State Review of Oil & Natural Gas Envtl. Regulations to Persons Interested in the Hydraulic Fracturing Guidelines (Feb. 8, 2010), *available at* http://www.strongerinc.org/sites/all/themes/stronger02/downloads/HF%20Guideline%20Web%20posting.pdf; *see also* SEC'Y OF ENERGY ADVISORY BD., DEP'T OF ENERGY, SHALE GAS PRODUCTION SUBCOMMITTEE SECOND NINETY DAY REPORT 4 tbl.1, 7 tbl.2, 8 tbl.3 (2011), *available at* http://www.shalegas.energy.gov/resources/111011_90_day_report.pdf; *Overview of Industry: Guidance/Best Practices Supporting Hydraulic Fracturing*, AM. PETROLEUM INST. (2013), http://www.api.org/~/media/Files/Policy/Hydraulic_Fracturing/Hydraulic-Fracturing-Best-Practices.pdf.

group of oil and gas states has yet converged around a best practices regulation for a particular contamination pathway.[149] Indeed, state regulations often will not capture truly "best practices," certainly not best feasible practices from a safety perspective, for all the reasons already suggested—lack of regulator information, capture and undue influence, rigidity, climatic and geologic differences that might impede the adoption of uniform standards, and slowness of adaptation of command and control regulation. Merrill and Schizer additionally acknowledge that their proposed approach does not address or eliminate the risk of contamination that insolvent companies cannot pay for. And although they assume that this risk is low, they propose to require a "mixed liability/government insurance" regime if insolvency becomes a problem.[150]

The difficulty of imposing effective liability for unconventional development-related harms may explain why, reportedly, some of the actors in the unconventional oil and gas market have avoided purchasing environmental insurance,[151] and others have only purchased relatively modest coverage,[152] much less than the $200 million plus that analysts think a single major pollution accident would require.[153] It is possible, as some reports suggest, that the relatively limited investment in environmental insurance to date reflects the unavailability of suitable insurance products for purchase for unconventional development.[154] Other recent reports suggest that the industry is quickly developing unconventional-development-specific policies and products, and that for a price, and as long as potential

149. *See generally* RICHARDSON ET AL., *supra* note 64 (showing highly variable state regulations for a number of different activities that can cause contamination, including maintenance of waste pits and well casing).

150. *Id.* at 250.

151. *See, e.g.*, Robert Lewin et al., *Emerging Insurance Issues in the Debate over "Fracking,"* INS. COVERAGE L. REP., Dec./Jan. 2013, at 3, 13 (describing large gas companies' belief that it is not possible to obtain insurance coverage for catastrophic losses and their resulting use of self-insurance; "pollution and environmental risks generally are not fully insurable for accidents of a significant magnitude" according to Range Resources).

152. *See, e.g.*, *id.* (showing that Range Resources is "insur[ed] against some, but not all, potential risk and losses as a result of environmental damages"); Al Slavin, *Unearthing Profit: The Natural Gas Sector Generates High Hopes and Emerging Risks*, BEST'S REV., Dec. 2011, at 45, 45 (observing that "many operators aren't buying the type of [coverage] limits needed to withstand an onshore wellhead blowout, which can now range up to $100 million").

153. *See* Slavin, *supra* note 152, at 45 (suggesting that pollution events can require coverage of $200 to $300 million).

154. *See* Lewin et al., *supra* note 151, at 23; Slavin, *supra* note 152, at 46 ("To my knowledge, there's not a place in the U.S. to go and get $100 million in one fell swoop without involving other insurers on a subscription basis." (quoting Pascal Ray, AmWINS Brokerage of Texas) (internal quotation marks omitted)); Press Release, Nationwide, Nationwide Statement Regarding Concerns About Hydraulic Fracturing (July 13, 2012), *available at* http://www.nationwide.com/newsroom/071312-FrackingStatement.jsp (announcing that "we do not have a comfort level with the unique risks associated with the fracking process to provide coverage at a reasonable price").

insureds are cooperative, a range of coverages are available, and operators are purchasing them.[155] Certainly, we know that the insurance market develops products and coverage options in response to demand, and that with more demand, the insurance industry will have a stronger incentive to innovate and greater ability to provide innovative products at lower prices. Indeed, as discussed below, this is one of the central arguments for an insurance mandate.

D. Placing Financial Assurance Bonds and Mandatory Insurance Within These Dichotomies: Command and Control Versus Market Regulation

In a financial assurance bond, there is an underlying command and control regulation—a regulation that requires that some activity be undertaken in accordance with the regulation. So, for example, in instances where mine companies are required to post mine closure bonds, the underlying regulations require inactive mines to be sealed according to techniques that (in theory) avoid seepage and continuing pollution from the mine. Bonds, in effect, are in place as an implicit recognition of what the empirical evidence overwhelmingly teaches: Once entities finish doing business at a site, their tendency is to act as amoral profit-maximizers and simply abandon the site rather than invest money in safe closure and site clean-up, as these activities have no obvious market return. Indeed, the statistics regarding such abandonment are staggering. Consider that, in the United States, there are:

An estimated 190,000 abandoned underground petroleum tanks;

An estimated 57,000 "orphan" unplugged oil or gas wells;

An estimated 557,000 abandoned mine sites;

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155. *See, e.g.*, WILLIS LTD., WILLIS ENERGY MARKET REVIEW 2012: ALL FRACKED UP? 24 (2012) (noting that "the upstream market remains keen to provide OEE cover for [fractured] wells"), *available at* http://www.willis.com/Documents/Publications/Industries/Energy/10396_EMR%20 2012_Complete.pdf; Heather Draper, *Colorado Companies See Fracking Practices Creating New Need for Insurance*, DENV. BUS. J. (Jan. 11, 2013, 4:00 PM), http://www.bizjournals.com/denver/print-edition/2013/01/11/colorado-companies-see-fracking.html?page=all (quoting an IMA, Inc., executive as stating that "[f]racking has caused the insurance market to really come up with some new products"); Gina Jones & Ivy Riggs, *"Fraccidental" Insurance Headaches Explained—Fracking: Understanding the Opportunities & Challenges of the Latest Environmental Liability Exposures*, PROP. CASUALTY 360 (July 29, 2011) ("With a long history of successfully tackling the difficult risks associated with very real pollution exposures, the excess-and-surplus markets are well-versed in creative methods for structuring coverage."). Companies that sell environmental insurance for fracking operations include XL Group, Chartis, Ironshore, and Zurich Insurance Group. Braden Reddall & Ben Berkowitz, *Analysis: Insurers Find It Tough to Price Fracking Risk*, REUTERS (May 11, 2012, 3:08 PM), http://www.reuters.com/article/2012/05/11/us-fracking-insurance-idUSBRE84A13R 20120511. Lloyd's of London is also "heavily involved in insuring US shale exploration and production." Julia Kollewe, *Shale Gas Fracking Risks Exaggerated, Insurance Broker Claims*, GUARDIAN (Apr. 17, 2012, 10:51 AM), http://www.theguardian.com/environment/2012/apr/17/shale-gas-fracking-risks-insurance-broker.

An estimated $7.9 billion dollars in high-priority, coal-related coal mining problems, including health, safety, and environmental problems; and

An estimated $150 million to $420 million in annual costs for "orphan" shares at CERCLA sites on the National Priorities List.[156]

As public attention to environmental problems grows and regulation improves, these abandonment rates will decline, but assurance bonds provide an additional financial incentive for corporations and other entities to not walk away and abandon sites, and to instead fulfill their command and control obligations. Bonds are not in themselves command and control instruments, because the bonds do not by themselves require performance, but rather simply set a price on noncompliance—the cost of the defaulted bond.

Financial assurance bonds, however, are not pure market instruments in that the bond price is set by legislation or regulation and not by a market. And that may be why bond prices are sometimes so ineffective in inducing performance: Bond prices are often set at what seems a low amount given the harms of non-performance, and bond prices are rarely adjusted over time to take account of changing circumstances. Many companies thus find bond forfeiture economically attractive.[157] Moreover, enforcement of bond provisions, perhaps reflecting the capture and inadequate public resources problems discussed above, is often insufficient. Indeed, bonds are sometimes returned solely on the part of the regulated entity's self-verification that it complied with the required regulations, and in other cases external verification is required but is too freely given.[158] In unconventional development, at least in theory, bond regimes could be constructed to assure more accurate and dynamic pricing and more trustworthy verification.

Mandatory environmental liability insurance (for tort or statutory liabilities) is closer than assurance bonds to a pure market mechanism of *ex ante* risk regulation. Some degree of mandatory insurance already exists

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156. JAMES BOYD, FINANCIAL RESPONSIBILITY FOR ENVIRONMENTAL OBLIGATIONS: ARE BONDING AND ASSURANCE RULES FULFILLING THEIR PROMISE? 5–8 (2001).

157. *See id.* at 42–44 (explaining that bond levels in general are too low and that the levels for mining bonds have long been less than the costs of safe mine closure); Mitchell & Casman, *supra* note 142, at 9508 ("In general, the dollar amount of state and federal bonds for oil and gas wells often do not reflect expected reclamation costs."); *cf.* Marshall Contractors, Inc. v. Peerless Ins. Co., 827 F. Supp. 91, 95 (D.R.I. 1993) (noting that "[u]nlike an insurance policy, a performance bond is not intended to compensate for indirect losses or to indemnify against liability to others" in the contracting, not the environmental liability, context).

158. Another problem is that owners and operators avoid decommissioning costs by delaying the formal closure of wells that are in fact no longer active. For evidence of this phenomenon, see LUCIJA MUEHLENBACHS, TESTING FOR AVOIDANCE OF ENVIRONMENTAL OBLIGATIONS 2 (2012).

regarding a range of potential environmental liabilities, including nuclear plant accidents and offshore oil spills.[159] There is a range in the minimum amount of coverage required as well as the kind of coverage—the type of harms or injuries covered varies, and claims must be made within the policy period (usually an annual period) or, alternatively, they may be brought at any time as long as the event occurred during a period of coverage (so-called occurrence coverage, as opposed to claims-made coverage). One form that mandatory insurance can take is as a direct substitute for a bond to assure safe site closure or sealing: That is, industry actors can be required to purchase insurance for liabilities arising from their non-closure and/or non-sealing of a site.[160]

At first blush, the claim that insurance, mandatory or not, can reduce risk levels *ex ante* may seem odd. That is, thinking of insurance, either voluntarily purchased or purchased because of a mandate, as an incentive for less risky behavior may seem counterintuitive. After all, the whole point of insurance, at its most basic level, is to allow entities to take on more risk and feel comfortable doing so. The economic rationale for insurance is that, without it, risk-averse entities would underinvest in risky activities to the detriment of overall social welfare. And, indeed, a well-known critique of some insurance regimes is that, by protecting insureds from downside risk, especially where premium levels are kept artificially low by regulation, the regimes invite "moral hazard" and excessive risk-taking.[161]

However, a well-designed mandatory insurance regime can help reduce the risks and hence harms associated with a risk-laden and not fully understood activity like unconventional development in two distinct ways. First, there is some inherent, irreducible risk associated with unconventional

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159. *See* Allan Ingelson et al., *Long-Term Liability for Carbon Capture and Storage in Depleted North American Oil and Gas Reservoirs—A Comparative Analysis*, 31 ENERGY L.J. 431, 461 (2010) (describing nuclear insurance requirements); Kenneth M. Murchison, *Liability Under the Oil Pollution Act: Current Law and Needed Revisions*, 71 LA. L. REV. 917, 932–33 (2011) (describing "financial responsibility" requirements for vessels and offshore facilities under the Oil Pollution Act (citing 33 U.S.C.A. § 2716(a), (c)(1)(A) (West 2011))); Marcus Radetzki & Marian Radetzki, *Liability of Nuclear and Other Industrial Corporations for Large Scale Accident Damage*, 15 J. ENERGY & NAT. RESOURCES L. 366, 376 (1997) (noting "compulsory" insurance in these industries).

160. Indeed, for contamination that occurs long after development and that was not initially detected, insurance might be the only tool to pay for clean up—and to incentivize the management of longer-term risks. Bonds, which are typically released when operators show that they have plugged or sealed a well, do not cover long-tail risks. Insurance will of course only cover long-tail risks, and incentivize *ex ante* reduction of future contamination, if implemented properly. As ownership of oil and gas operations and associated production equipment changes over time, governments would have to require that each new owner obtain insurance and have the financial resources necessary to pay the associated deductibles.

161. *See, e.g.*, KENNETH J. ARROW, *General Economic Equilibrium: Purpose, Analytic Techniques, Collective Choice*, *reprinted in* 2 COLLECTED PAPERS OF KENNETH J. ARROW 222 (1983) (observing that "[t]he very existence of insurance will change individual behavior in the direction of less care in avoiding risks" but that insurance companies can fix this problem).

development, however much the entities involved attempt to take care. Horizontal drilling and fracking have inherent features—proximity to aquifers, use of large amounts of water, and production of wastewater, among many others—that entail at least some non-reducible liability risk. Moreover, unconventional development in some areas (such as near major population centers, ecologically sensitive areas, or areas with more vulnerable groundwater supplies) is likely to involve more nonreducible risk than development in other areas. Mandatory insurance, to the extent it is able to price in such irreducible or inherent risk, will not change how unconventional development is done, but it may change how much of it is done and where it is done.[162]

That is a good thing, because from an allocative efficiency perspective, unconventional development that does not internalize even irreducible risks is likely to be overdone—to have too many resources devoted to it. Absent insurance, too much unconventional development is likely to occur in areas where the risks are greatest (again, highly populated and ecologically sensitive regions) and comparatively too little in areas where risks are lower. Both the net amount and distribution of this development would be changed—and made closer to the socially optimal level—if the development absorbed irreducible risks via insurance premium payments. For example, one consequence of an insurance requirement could be relatively less horizontal drilling and fracking in the Barnett Shale region, where exposures to major population centers are particularly high in some areas.[163]

This point is relevant to the debate about unconventional development's effect on the market for investment in energy efficiency technologies and renewable energy like solar and wind.[164] These energy (and energy-use reduction) sources do not carry anything like the irreducible environmental risk and potential liability unconventional development does: They are simply less fraught in that respect.[165] And to the

162. As Anthony Wagar of Willis's Environmental Practice comments, insurance will be more readily available in those "specific geographic regions" where unconventional development appears to pose relatively lower risks. WILLIS LTD., *supra* note 155, at 29.

163. *See* Hannah Wiseman, *Urban Energy*, 45 FORDHAM URB. L.J. (forthcoming 2014) (describing a Fort Worth resident's concerns about a well close to his back yard); *see also supra* note 4 (describing Fort Worth well numbers).

164. *See, e.g.*, Thomas L. Friedman, Op-Ed, *Get It Right on Gas*, N.Y. TIMES (Aug. 5, 2012), http://www.nytimes.com/2012/08/05/opinion/sunday/friedman-get-it-right-on-gas.html (worrying that gas could end up "sinking renewables"); Matthew L. Wald & Tom Zeller Jr., *Cost of Green Power Makes Projects Tougher Sell*, N.Y. TIMES (Nov. 7, 2010), http://www.nytimes.com/2010/11/08/science/earth/08fossil.html (describing a wind project rejected by Virginia energy regulators, which cited cheap natural gas); *cf.* Henry D. Jacoby et al., *The Influence of Shale Gas on U.S. Energy and Environmental Policy*, 1 ECON. ENERGY & ENVTL. POL'Y 37, 50 (2012) (concluding that cheap shale gas will delay the "market role" of technologies like carbon capture and storage "by up to two decades" and might "stunt[] these programs altogether").

165. *See* Garrick B. Pursley & Hannah J. Wiseman, *Local Energy*, 60 EMORY L.J. 877, 895 (2011) (concluding that "renewables have fewer negative impacts on human health, security,

extent that is true, absent mandatory insurance, the status quo, at least at the margin, will overproduce investment in new unconventional oil and gas relative to new solar and wind power and other fundamentally less risky forms of energy production.

Second, some of the risk associated with unconventional development at any site is not irreducible but rather *can be* mitigated and minimized through good safety practices. Command and control regulation may not produce regulations that mandate these practices, even putting aside issues of capture and inadequate enforcement appropriations, because it is too slow and inflexible, almost necessarily, and not fully informed by what industry knows or could know and share with the public. Private insurers have a strong incentive to encourage insureds to go beyond what command and control regulations require, at least where there is no strong regulatory compliance defense uniformly recognized, because insurers are economically better off if they can take actions that reduce the liabilities they are responsible to cover for any given policy period.[166] Insurers also have an incentive to gather information regarding safety that will be relevant to setting the next premium. Moreover, an insured in a regime where an entity can only operate if it is able to acquire insurance has a strong incentive to cooperate in producing information lest the insured be denied coverage and thus unable to operate. "Insurers" are thus "strategically well placed to gather information and engage in risk management, and reflect these costs through premium differentiation."[167]

At the same time, insureds have an incentive to gather information and implement practices that make their operations safer than what command and control regulations mandate because they can then use this information and practices as a basis for arguing for a rebate or reduction in premiums for the next policy period. For example, as Haitao Yin, Howard Kunreuther, and Matthew White document, there was a dramatic decline in leaks from underground fuel tanks in certain states when those states required gas stations to carry private clean-up and liability insurance.[168] They explain that "the price structure for market-based insurance gives tank owners economic incentives to invest in equipment that reduces the chance of accidental fuel tank leaks."[169] In sum, mandatory insurance aligns the incentives of both

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and the environment than do traditional fuels" and citing to studies that support this statement).

166. Omri Ben-Shahar & Kyle D. Logue, *Outsourcing Regulation: How Insurance Reduces Moral Hazard*, 111 MICH. L. REV. 197, 203–05 (2012) (explaining why insurers incentivize risk reduction despite receiving fewer premiums when "losses diminish").

167. BENJAMIN J. RICHARDSON, ENVIRONMENTAL REGULATION THROUGH FINANCIAL ORGANISATIONS 363 (2002).

168. Haitao Yin et al., *Does Private Insurance Reduce Environmental Accidents?*, REGULATION, Summer 2012, at 36, *available at* http://opim.wharton.upenn.edu/risk/library/J2012Summer_Regulation_HY-HK-MW_EnvironmentalInsurance.pdf.

169. *Id.* at 37.

insured and insurers in favor of learning about safety and trying to improve safety in the insured's operations.

There are, in fact, many realms where private insurers actively engage in supervising insureds and penalizing and rewarding them to minimize risks. As Omri Ben-Shahar and Kyle Logue argue, insurance is a market-based means of *ex ante* regulation of risk that is largely taken for granted in such fields as automobile safety, workplace safety, and household safety. As they explain, "workplace safety is regulated at least as much by workers' compensation liability insurers as it is by [OSHA] regulators; and household safety is regulated as much, if not more, by homeowners' insurance than it is by municipal regulators."[170]

More directly to the point of the unconventional development context, insurers have proven substantially effective as a force for *ex ante* market-based regulation in the hazardous waste industry, an industry that, like unconventional development, involves potential liabilities associated with both sudden accidents and gradual pollution, and that raises safety issues surrounding the use, storage, and disposal of toxic materials or materials (including wastewater) contaminated with toxins.[171] Outside the oil and gas context, "environmental liability insurers require, or offer significant premium discounts for, compliance with private environmental safety codes that are managed and audited by third parties and that are stricter than governmental environmental regulation."[172] Unlike safety codes derived from state regulations or formulated by industry itself, which may reflect industry interests in near-term cost containment at the expense of safety considerations, codes created by insurers acting in collaboration with industry and environmental NGOs are likely to represent what Merrill and Schizer called "best practices" and to come close to reducing that element of risk which is truly reducible with feasible safety measures.[173]

Moreover, environmental liability insurers outside oil and gas offer discounts for firms that implement environmental management systems that help detect and address possible risks and that also cumulatively generate firm knowledge as to actual conditions on the ground and possible means of operational improvement.[174] In the fracturing context, well operators could potentially receive insurance discounts for installing monitors and other devices to demonstrate a lack of pollution at their sites. And environmental liability insurers can become involved even prospectively in project planning

170. Ben-Shahar & Logue, *supra* note 166, at 202.

171. *See id.* at 199.

172. *Id.* at 211.

173. *See* WILLIS LTD., *supra* note 155, at 5 (quoting Willis Global Energy's CEO as stating that the insurance market is willing to cover fracking for those involved "that can demonstrate that they apply best industry practice[s]").

174. Benjamin J. Richardson, *Mandating Environmental Liability Insurance*, 12 DUKE ENVTL. L. & POL'Y F. 293, 315–16 (2002).

by insureds, in the interest of managing risk: "Major environmental insurance providers . . . now often include environmental engineering support, serving to improve project supervision and review project data relevant to underwriting decisions."[175] An environmental management system designed to achieve a strict insurer-approved code, and combined with internal firm auditing and external third-party auditing, may provide a far superior form of *ex ante* regulation of unconventional development than the current motley and often unrigorous mix of state regulations that are enforced, to the extent they are, by infrequent inspection by an overworked and possibly insufficiently independent corps of state inspectors.[176]

Insurers may not only supplement state-based command and control regulation but also improve it in several ways. First, to the extent that environmental liability insurers will operate in multiple states and multiple unconventional oil and gas regions, as it is reasonable to assume they would, they will have an opportunity and need to see how well state regulatory practices operate across the country. They could identify those regulations and practices that work best and those that are unhelpful, and they could serve as a force in disseminating that knowledge not just to industry but also to state regulators in the states where unconventional development occurs. Insurers thus can form a kind of national coordinating mechanism, picking and choosing among the best state approaches and publicizing them, in the way that democratic experimentalism scholars have advocated the federal government should do in areas dominated by state regulations.[177] The federal government could take on this coordinating role, but, unlike insurers, it lacks a profit-based reason to do so, and it has not consistently acted as a coordinator as a general matter. And in unconventional development, federal regulators at EPA often appear hesitant to do anything that might antagonize states regulators or industry.[178] Finally, it bears noting that redundancy can be a good thing: Both insurers and the federal

175. *Id.* at 315; *see also* DAVID J. DYBDAHL, AM. RISK MGMT. NETWORK, A USER'S GUIDE TO ENVIRONMENTAL INSURANCE 12 (explaining that underwriting for environmental liabilities allows insurers to compare companies' environmental management systems and suggest improvements in the companies with relatively less developed systems).

176. *See supra* note 123.

177. *See* Michael C. Dorf & Charles F. Sabel, *A Constitution of Democratic Experimentalism*, 98 COLUM. L. REV. 267, 340–56 (1998) (arguing that the "principal role of the national government in domestic affairs" "is to encourage and coordinate . . . decentralized decisionmaking" and exploring the functions of the national entities that play this role).

178. Draft Research Report: Investigation of Ground Water Contamination Near Pavillion, Wyoming, 78 Fed. Reg. 55694 (Sept. 11, 2013) (publishing an EPA report transferring authority to Wyoming to continue investigation of potential groundwater contamination from fracturing); Press Release, R.R. Comm'n of Tex., Railroad Commissioners: "EPA's Vacate Order in Range Case Confirms Railroad Commission's Findings Based on Scientific Evidence" (Mar. 30, 2012), *available at* http://www.rrc.state.tx.us/pressreleases/2012/033012.php (commending the EPA's vacating of an order against Range Resources for water contamination from drilling and fracturing).

government could act to coordinate state experiments in the interest of promoting a better, safer national approach.

E. Single Regulator Versus Multiple Regulators

Insurers, as discussed above, can be a kind of second regulator of unconventional development, a force in addition to state (and sometimes local) regulators. A system of mandatory insurance built on state regulation would have some of the same virtues as the system of federal–state cooperative federalism that we rely upon in many areas of environmental risk in that it provides a degree of regulatory overlaps, duplication, and redundancy that guards against the risk of regulatory failure by an exclusive regulator.

As compared to state regulators, insurers as regulators have a number of distinct advantages. First, they can act much more nimbly than state regulators in adopting new rules and incentives because they do not operate so completely in the context of a cumbersome, politically influenced, due-process-sensitive regulatory and legislative process. In that sense, insurers are better poised to be adaptive, even reflexive, "regulators"—promoting more fluid regulation than even the best-intentioned state regulators. As several commentators have argued, insurers have advantages "over administrative regulation in the context of rapidly changing or widely varying risks . . . as insurers generally are able to make adjustments to policies, conditions and premiums more flexibly and efficiently than administrators."[179]

Second, risks of capture or undue influence are much less significant in the context of insurance than state regulation. State oil and gas agencies cannot help but be closely tied to the industry they regulate. Environmental liability insurers, by contrast, are generally part of national, and indeed international, corporations that regulate a variety of enterprises. While they may hire some people from the oil or gas industry, and some insurers may enter the energy industry, insurance corporate managers are bound to reflect the risk-sensitive, profit-driven, and cautious culture and interests of the insurance industry rather than the culture and interests of insureds. On the other hand, it is true that industries operating within the state, especially major industries, may heavily affect state insurance agencies. But the agencies, too, regulate across a range of industries, and thus a single group or industry of insureds is somewhat less likely to "capture" the state insurance agency than other agencies within the state.

Third, insurers do not face the same monitoring and enforcement constraints as state regulators because they have the flexibility to require as a precondition of coverage that insureds reliably document compliance

179. RICHARDSON, *supra* note 167, at 330; *see also* Jeffrey Kehne, *Encouraging Safety Through Insurance-Based Incentives: Financial Responsibility for Hazardous Wastes*, 96 YALE L.J. 403, 410–11 (1986) (arguing that "[i]nsurance-based incentives offer a distinct advantage over regulation").

through an auditing system, and because they can pass on whatever enforcement and monitoring costs they directly bear through premiums. It is true that market competition may limit how much of these costs insurers can take on and then pass on to the insured, but insurers certainly have much more flexibility than state agencies that require political or even legislative approval to raise a simple fee or hire a single new inspector.

F. Mandatory Insurance and Ex Ante *Regulation Versus* Ex Post *Liability*

Mandatory insurance also fits into the dichotomy between *ex ante* regulation and *ex post* liability as a means of influencing *ex ante* conduct. Absent mandatory insurance, the effectiveness of *ex post* liability to effect risk management *ex ante* in the unconventional development context is uncertain because of defendants' ability to judgment-proof themselves using corporate structure and causation problems, especially as to long-tail liability. The possibility that courts will robustly apply the regulatory compliance defense also contributes to the uncertainty.[180] A regime of mandatory insurance, which would require insurance for both near-term coverage during periods of active well operation, as well as for long-tail risks of liability stemming from active or abandoned wells where the harm surfaced only many years later, would increase the likelihood of liability being imposed for harms and thus increase the robustness of liability as a means of improving *ex ante* risk reduction. But the best way to think about the relationship of liability and insurance regimes for unconventional development is to think of these regimes not as distinct, or as one simply affecting the other, but rather as being engaged in continual, co-adaptive evolution.

This is not a standard way to think about liability regimes. Usually, legal scholars speak of liability regimes and insurance regimes as wholly separate; often questions of the role of insurance receive slight attention altogether. But it is more realistic to think that the availability and adequacy of insurance affects lawyers, judges, and even legislators when they make decisions regarding the imposition of liability. Lawsuits based on accidents at unconventional wells or gradual seepage will not be easy cases to win, and they will not be inexpensive cases to litigate.[181] The plaintiffs' lawyers and government lawyers who consider bringing such cases will only want to do so if there is a reasonable possibility of recovery, and if the defendants are

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180. *See supra* text accompanying notes 144–47.

181. Experience to date suggests as much. *See, e.g.*, Keith B. Hall, *Hydraulic Fracturing Contamination Claims: Problems of Proof*, 74 OHIO ST. L.J. FURTHERMORE 71, 73–76 (2013) (describing plaintiff difficulties); SMITA WALAVALKAR, CTR. FOR CLIMATE CHANGE LAW, COLUMBIA LAW SCH., DIGEST OF HYDRAULIC FRACTURING CASES (2013), *available at* http://www.law.columbia.edu/null/download?&exclusive=filemgr.download&file_id=622373 (summarizing lawsuits associated with fracturing, and showing no plaintiff victories).

insolvent and lack insurance, there will be no rational reason to proceed with litigation and no reason to invest in testing the contours of liability.[182]

Judges, too, may be affected by the availability of insurance. In cases involving unconventional oil and gas-related harms where there are allegedly multiple contributing industry entities but only one or a few that have insurance or can otherwise cover liabilities, considerations of fairness and proportionality may dissuade courts from finding joint and several liability. Courts also might be unlikely to apportion liability based on some proxy, such as the amount of production of gas or oil or years of active drilling of each of the entities involved in the geographic area at question. But if all of the entities, even insolvent ones, have insurance and courts could hold them financially responsible *ex post* with insurance proceeds, courts may be more likely to find liability for harms where a number of unconventional well operations were underway in a concentrated space (which describes many unconventional oil and gas settings).[183]

If this analysis is correct, then mandatory insurance is important not just to ensure that whatever liability is imposed is satisfied in the form of recovered judgments. Mandatory insurance will affect the amount of liability that is imposed—that is, it will lead to, on the margin, more suits and more and larger judgments or settlements made in light of anticipated judgments. Realizing this, the actors in the unconventional oil and gas industry *ex ante* may anticipate more liability, and so too will their insurers. This will mean higher premiums to account for the higher risks of liability but also even greater measures to try to mitigate risk through effective safety practices on the ground. The ambiguity as to the exact contours of liability at any time will translate into what Kunreuther and other scholars have called an ambiguity premium—a premium that reflects insurers' ambiguity aversion—and as long as insurers may charge for such ambiguity, the co-evolution of the liability and insurance regimes is feasible.[184]

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182. *See, e.g.*, Stephen G. Gilles, *The Judgment-Proof Society*, 63 WASH. & LEE L. REV. 603, 606 (2006) ("Knowing that they can collect at best a fraction of the plaintiff's claim even if they litigate and win, plaintiffs' attorneys typically decline to litigate meritorious tort claims against uninsured or underinsured individuals.").

183. It is of course true that insurers could respond to such judicial moves by turning to the state legislatures in order to obtain legislation specifying a traditional, and strict, causation standard for claims based on unconventional drilling. However, it is very much unclear whether such efforts would result in legislation, and even if they did in some states, they might not in others. Such efforts by insurers would come up against the political opposition of the plaintiffs' bar, which has had successes in opposing certain tort reforms, and would come up normatively against the argument that development and application of common law causation and other liability concepts generally should be left to the state courts.

184. *See* Howard Kunreuther & Robin M. Hogarth, *How Does Ambiguity Affect Insurance Decisions?*, *in* CONTRIBUTIONS TO INSURANCE ECONOMICS 307, 321 (Georges Dionne ed., 1992); *see also* Laure Cabantous et al., *Is Imprecise Knowledge Better Than Conflicting Expertise? Evidence from Insurers' Decisions in the United States*, 42 J. RISK & UNCERTAINTY 211 (2011) (summarizing the literature regarding insurers' ambiguity aversion).

Insurers, of course, will have to continually update their assessments of liability risks as the liability regime evolves, and what insurers do will in turn affect judgments by relevant actors regarding liability risks. As in the nuclear power industry, which has mandatory insurance requirements,[185] the industry as a whole may coalesce around a shared interest in making insurance more efficient by working as an industry to formulate safety ratings that can be used to set comparative premiums.[186] Thus, the co-evolution of an insurance and liability regime may include a corresponding regime of industry self-organization and self-governance.

In sum, a mandatory insurance regime for unconventional well development sites that use hydraulic fracturing would require each operator connected to a site to obtain the environmental liability insurance that may be necessary to address contamination. Each new owner would be required to obtain coverage—and to prove its ability to pay what would likely be very large deductibles. This regime, combined with liability rules, would incentivize *ex ante* risk reduction, provide needed funds for *ex post* clean up, and improve both private controls of risk as well as public regulations as a result of pressure for regulatory change from insurance companies.

III. OBJECTIONS TO MANDATORY INSURANCE AND RESPONSES

There are, of course, several possible objections to mandatory insurance schemes generally and mandatory environmental liability insurance in particular. Scholars, policymakers, operators, and others will no doubt voice these objections if, as we advocate, there is a move to adopt insurance mandates for unconventional development. These objections, although valid and important to recognize and address, are in some respects self-contradictory, and in any case, they are largely rebuttable. The objections rely to a large degree on speculation about how private and public actors will act, which, although important to monitor over time, does not have a great deal of empirical basis. Moreover, the benefits of mandatory insurance as a regulatory mechanism cannot be judged in reference to an idealized alternative but rather must be assessed pragmatically based on this question: Would mandating insurance improve *ex ante* risk management as well as *ex post* harm remediation as compared to the status quo, given that the status quo could leave areas with unconventional oil and gas development, ten or

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185. *See* 42 U.S.C. § 2210(b)(1) (2006 & Supp. V 2011) (providing that "[t]he amount of primary financial protection required shall be the amount of liability insurance available from private sources" and, for large reactors, the "maximum amount available at reasonable cost and on reasonable terms from private sources"); Allan Ingelson et al., *supra* note 159, at 461 (noting in 2010 that U.S. law "requires an individual nuclear plant to obtain primary insurance coverage up to a mandated level (currently $300 million) from private sources").

186. *See* Simon Litten, *Shale Gas, Hydrofracking, and Managing Risk*, HUDSON RIVER ENVTL. SOC'Y (Oct. 6, 2011), http://www.hres.org/joomla/index.php?option=com_content&view=article&id=78%3Ashale-gas-hydrofracking-and-managing-risk-&catid=54%3Aopinion&Itemid=64.

twenty or fifty years hence, deeply degraded and without sufficient resources to remediate what can be cleaned up?

A. *Whether Insurance Will Be Commercially Unavailable*

Commercially viable insurance can only work if insurers can calculate and obtain premiums that are, on average and over time, equal to or greater than their expected payouts. However, as noted below, insurers have ways of insuring themselves against unusually large payouts. Even so, there is no question that insurers must have a perceived capacity to reasonably and accurately adjust premiums to risk in order to be willing to enter and able to stay in the market.

The two biggest impediments to risk-based pricing are adverse selection and moral hazard. Adverse selection refers to the process by which the most risk-prone entities select themselves for insurance coverage (or more coverage) and, because the insurers cannot distinguish potential customers based on risk, the pool of insureds at any given premium level comes to consist of disproportionately high-risk entities. Indeed, the lowest-risk entities might seek no insurance at all, in the way young adults without health problems might avoid purchasing health insurance.[187] Mandatory insurance eliminates or substantially reduces adverse selection: Since all entities must obtain a certain insurance coverage or the equivalent, there is no reason to think that only the most risk-prone entities will seek coverage.

The second obstacle to a well-functioning insurance market is moral hazard, the phenomenon in which insureds needlessly take on risk after receiving insurance or avoid mitigating risk after receiving insurance because they can rely on insurance to cover any resulting harms.[188] Moral hazard assumes an inability on the part of insurers to monitor insureds' activities and calculate risks associated with them and reward risk reductions. However, environmental liability insurers have demonstrated monitoring capacities, as discussed above, and there is little reason they should be unable to do so in the unconventional development context, a context that is not inherently less susceptible to monitoring or auditing mechanisms than the other settings in which insurers actively operate. Although there are difficulties in establishing the cause of underground contamination, in particular, technologies like tracers are emerging that will allow a better understanding of the pollutants that migrate into underground aquifers and where they originated, such as in a surface waste impoundment at an oil and

187. *See* Jennifer B. Wriggins, *Mandates, Markets, and Risk: Auto Insurance and the Affordable Care Act*, 19 CONN. INS. L.J. 275, 290 (2013) ("People who know they are most at risk for a particular harm will tend to buy insurance, while those who are at lower risk will tend not to buy it.").

188. *See* Mark V. Pauly, *Overinsurance and Public Provision of Insurance: The Roles of Moral Hazard and Adverse Selection*, 88 Q.J. ECON. 44, 48 (1974) (discussing moral hazard and its effect on individual behavior in the insurance context).

gas site or in the fracturing fluid injected underground.[189] Pre- and post-drill and fracturing testing of water resources can also help to address this challenge.[190]

Nonetheless, whenever insurance mandates are proposed in an area where insurance has not been widely employed and long-used, some raise what we might call "the uninsurability of new industries argument." According to this argument, environmental liability insurance (or insurance broadly) is impossible for partially new industries like unconventional oil and gas where insurers lack substantial past data upon which to calculate risks and assess risk-based premiums. Those who raise this concern suggest that insurers need a precise track record to set premiums and without it they will not insure.

Because mandatory insurance requires an industry to internalize social costs, especially when liability is impractical for one reason or another (such as judgment-proofing), industry has an interest in claiming that the insurance markets will not produce the coverage needed to meet mandates. This argument serves as an argumentative tool against a new regulatory cost and can be powerful precisely because until there is an insurance mandate, no one can say with certainty how the insurance markets will or will not respond.[191]

The main problem with this argument is that, although it is an empirical argument, it lacks empirical support. As Mark Cohen has observed, "[T]he insurance industry has a history of adapting to new liability caps and attracting the necessary capital to provide a market where demand exists."[192] Despite the predictions made in the face of mandatory insurance proposals, insurance markets have consistently produced adequate insurance capacity once a mandate was enacted. For example, after the Exxon Valdez oil spill, Congress enacted a mandatory insurance or financial assurance requirement as part of the Oil Pollution Act of 1990, which requires companies engaged in offshore oil exploration to provide evidence of financial responsibility equivalent to their liability for a discharge of 1000 barrels of oil.[193] There was talk then of the insurance market being unable to

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189. *See, e.g.*, BASETRACE, http://www.basetrace.com (last visited Mar. 15, 2014) (describing tracer technologies for environmental monitoring).

190. *See* Wiseman, *supra* note 14 (describing baseline and post-operation testing requirements).

191. *Cf.* John D. Graham, *Saving Lives Through Administrative Law and Economics*, 157 U. PA. L. REV. 395, 510 n.499 (2008) (collecting sources that describe why industry overstates the costs of proposed regulations).

192. Mark A. Cohen et al., *Deepwater Drilling: Law, Policy, and Economics of Firm Organization and Safety*, 64 VAND. L. REV. 1853, 1901 (2011).

193. 33 U.S.C. §§ 2701–61 (2006 & Supp. V 2011) (providing the mandate); Eric Biber, Note, *Exploring Regulatory Options for Controlling the Introduction of Non-Indigenous Species to the United States*, 18 VA. ENVTL. L.J. 375, 416 (1999) (noting that the Oil Pollution Act "requires tankers and other oil transport and production facilities in the waters of the United States to

produce the coverage needed to meet this mandate.[194] But that has not been the case. Rather, the insurance industry worldwide has produced $1.5 billion in capacity to cover offshore drilling,[195] and insurers have employed a variety of sophisticated techniques to assess and control the risks associated with the corporations they insure, including reviewing "insureds' safety practices and procedures," "using outside consultants," and employing "sophisticated computer-based modeling."[196]

Moreover, insurers have several means of dealing with uncertainties in addressing unconventional development risk. They can provide insurance via a pool of insurance companies to protect any single company from a huge payout, as is the practice in the coverage of nuclear power plants;[197] they can tap into reinsurance markets;[198] and they can further leverage

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meet minimum financial responsibility requirements, usually through the purchase of insurance").

194. This concern was rekindled after the BP oil spill. *See* Kenneth S. Abraham, *Catastrophic Oil Spills and the Problem of Insurance*, 64 VAND. L. REV. 1769, 1771 (2011) (arguing that "there is a mismatch between the losses resulting from oil spills, the insurance available to the victims of spills, the liability of the parties responsible for losses caused by spills, and the insurance available to the parties who face such liability").

195. BOOZ ALLEN HAMILTON, THE OFFSHORE OIL AND GAS INDUSTRY REPORT IN INSURANCE—PART ONE 5 (2010), *available at* http://www.eoearth.org/files/172301_172400/172373/insurance_report_part-one_oct_5_4-pm_r1.pdf. Moreover, there are proposals from insurers offering far greater coverage if there is corresponding demand. For example, in 2010—just three months after the industry testified it would be impossible to insure at that level—Munich Re proposed to provide insurance of up to $10 to $20 billion on a rig-by-rig basis for offshore wells. Press Release, Munich Re, Munich Re Develops New Insurance Solution for Oil Catastrophes (Sept. 12, 2010), *available at* http://www.munichre.com/en/media_relations/press_releases/2010/2010_09_12_press_release.aspx.

196. BOOZ ALLEN HAMILTON, *supra* note 195, at 7–8.

197. *See* Michael G. Faure & Tom Vanden Borre, *Compensating Nuclear Damage: A Comparative Economic Analysis of the U.S. and International Liability Schemes*, 33 WM. & MARY ENVTL. L. & POL'Y REV. 219, 248–49 (2008) ("The insurance of nuclear risks through nuclear insurance pools could be regarded as a bundling of resources at a national level. Such bundling allows the creation of a supply to meet the demand for insurance coverage for damage resulting from nuclear incidents." (footnotes omitted)); Helmut J. Heiss, *Legal Protection Against Transboundary Radiation Pollution: A Treaty Proposal*, 4 FORDHAM ENVTL. L. REP. 167, 191 (1993) (describing pools as instruments through which "all insurers share the losses of single accidents").

198. *See, e.g.*, *Catastrophe Bonds: Spreading Risk: Hearing Before the Subcomm. on Oversight and Investigations of the H. Comm. on Fin. Servs.*, 107th Cong. 4 (2002) (statement of Davi D'Agostino, Director, Fin. Mkt. & Cmty. Inv., Gen. Accounting Office) (describing reinsurance "to diversify and transfer . . . risk," in which "the reinsurer agrees to compensate all or part of an insurer's claims as they are incurred"); Bhavini Kamarshi et al., *Fracking: Considerations for Risk Management and Financing*, MILLIMAN (June 21, 2012), http://www.milliman.com/insight/insurance/Fracking-Considerations-for-risk-management-and-financing (proposing an insurance pool for fracturing companies that "would access reinsurance markets for capacity up to the limits required for a catastrophe event, and the reinsurance premiums would be allocated back to the companies in a manner consistent with the risk exposure of each member's operations").

investor capital by securitizing and marketing so-called catastrophe bonds.[199] Sophisticated techniques, such as catastrophe models and exceedance probability curves, can also assist insurers.[200]

The other evidence that the market can produce insurance capacity for unconventional development is that it already does—insurers are selling some commercial insurance, even without a mandate.[201] A mandate should only open and deepen the market. Of course, it is true that insurers may find that some unconventional oil and gas enterprises do not have the right safety record or practices to be insurable, but a mandatory insurance regime can function well only if some potential insureds are uninsurable based on risk. Indeed, in that way, the mandatory insurance regime controls *ex ante* risk by limiting unconventional development to those areas, enterprises, and projects that pose acceptable, albeit significant, risk.

B. Whether Premiums Will Be Too High and Chill Economic Activity

Another objection to mandatory insurance is that the premiums will in some sense be too "high" and chill investment in unconventional development. On its face, this is a more plausible objection than the objection that insurance will simply be unavailable, because that will almost certainly not be the case. But the notion that premiums will be high or too high requires unpacking: too high compared to what? Moreover, the claim that premiums will chill investment in unconventional development itself raises the question—what is the socially optimal level of this development? And that raises the question of how much certainty or uncertainty we have not only about unconventional oil and gas risks, but also about the promised benefits of this development.

In assessing the environmental and other social risks from unconventional development, participants in the oil and gas industry are likely to discount or ignore many of these risks because of the practical barriers to imposing liability, as discussed above. Moreover, even if industry actors tried to factor in such risks, the reality is that such risks are somewhat ambiguous because certain risks and harms from unconventional development are ambiguous *ex ante*. There is no reason to believe companies in the oil and gas business are generally averse to ambiguity;

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199. *See, e.g.*, Ronald J. Gilson & Charles K. Whitehead, *Deconstructing Equity: Public Ownership, Agency Costs, and Complete Capital Markets*, 108 COLUM. L. REV. 231, 246–47 (2008) ("Through 'catastrophe bonds,' investors can now take on risks as diverse as earthquakes in Southeast Asia, flooding in Great Britain, and windstorms in Japan.").

200. *See* Howard C. Kunreuther & Erwann O. Michel-Kerjan, *Climate Change, Insurability of Large-Scale Disasters, and the Emerging Liability Challenge*, 155 U. PA. L. REV. 1795, 1840 (2007). An exceedance probability curve "specifies the probability that a certain level of losses will be exceeded in a specific location (or in its entire portfolio) over a specific period of time (for example, one year, ten years, etc.)." *Id.* at 1814.

201. *See* Slavin, *supra* note 152, at 45 (discussing the pollution coverage insurance purchased by Chesapeake Energy and other natural gas companies); *see also supra* note 155.

quite the contrary, it is, generally speaking, an industry with something of a cowboy culture reputation, and we might think that would result in translating ambiguities into assessments of relatively minor or modest risk, or even no risk. That is certainly how the oil and gas industry has, for the most part, stridently spoken of unconventional development in public fora: There is a constant barrage of claims that fracking is as well-established and as safe a practice as baking apple pie.[202] From a psychological perspective, and especially from the perspective of cognitive dissonance theory, one might also believe that actors in an industry that are economically enriched by unconventional development would conclude that ambiguous risks are really no risks at all. All of us perceive that which benefits us as safe and low-cost, and even more so when we will not bear most of the safety risks and costs. That's human nature.[203]

If insurers are willing to insure for ambiguous risks, but also charge an ambiguity premium, as past practice suggests, then we would argue that mandatory insurance allows for a kind of implementation of the precautionary principle that is relatively flexible and more accommodating of new risky ventures than "hard" or "strict" forms of the precautionary principle. But at the same time, the mandatory insurance approach is more robust and precaution-producing than soft forms of the precautionary principle. We call this conception of the precautionary principle the precautionary insurance principle.

The precautionary principle ("PC") counsels precaution in the face of uncertain health, safety, and environmental risks and potentially irreversible health, safety, and environmental costs.[204] In its hard or strict form, the PC means moratoria on activities, practices, or products until evidence establishes them as safe. Unconventional development has not been proven safe, but then again we have rarely as a nation waited for proof of safety before reaping economic and other benefits from a practice or product. And waiting for proof of safety can be a long, long wait, which itself carries risks in terms of foregone opportunities to invest the gains generated by the

202. *See, e.g.*, Rock Zierman, Op-Ed., *Why Such Hysteria over Fracking?*, L.A. TIMES (June 21, 2013), http://articles.latimes.com/2013/jun/21/opinion/la-oe-zierman-california-fracking-moratorium-20130621 (arguing, in an op-ed by the chief executive of the California Independent Petroleum Association, "that hydraulic fracturing is a fundamentally safe technology" and "is being done" in a manner that "doesn't present environmental or public health problems").

203. On the phenomenon of motivated reasoning, reasoning motivated not by objective external facts but by our own personal stake in a particular conclusion, see April Strickland et al., *Motivated Reasoning and Public Opinion*, 36 J. HEALTH POL. POL'Y & L. 935, 938 (2011).

204. For a discussion of this and other formulations of the PC, see David A. Dana, *A Behavioral Economic Defense of the Precautionary Principle*, NW. U. L. REV. 1315, 1315–16 (2003); David Dana, *The Contextual Rationality of the Precautionary Principle*, 35 QUEEN'S L.J. 67, 69–70 (2009).

new activity or product, as Cass Sunstein and others have argued.[205] In the softer forms of the PC, the PC calls for an open, democratic, non-technocratic discussion of risks and uncertainties but does not necessarily translate into any restrictions on or impediments to a new activity or product. These versions of the PC focus on democratic discourse and deliberation, as most thoughtfully explicated in a recent work by Douglas Kysar.[206]

Our version of the precautionary principle does not prohibit new, risky activities, but because our principle requires insurance of these activities, insurers will charge an extra "ambiguity aversion" charge. As a result, actors may not engage in the activity quite as quickly and comprehensively as they otherwise would, and they will pay more attention to gearing the activity to its ostensibly least risky settings and to developing ways to mitigate risk. We think the precautionary insurance approach makes sense not just for unconventional development but also for other risk-laden, emerging industries such as nanotechnology.[207] This is not to say that bonding and insurance would be the best approach for all industries—indeed, those opposed to regulatory intervention (even market-based regulation) might view this as a slippery slope. Although most human activity, industrial or not, poses some level of contamination risk, widely distributed activities with uncertain risks and high potential for cumulative pollution would benefit most from bonding and insurance regimes.

One might argue that precautionary insurance in effect outsources precaution to a private industry (the insurance industry) and is thus inconsistent with a democratic conception of the PC. But there is a democratic aspect of this conception of the PC, as insurance mandates must and should be debated in democratic fora, including how much and what kinds of insurance should be mandated. Nor must precautionary insurance crowd out a PC-oriented debate over traditional safety regulation, including regulation requiring more information disclosure and safety testing. Rather, as a force for generating risk assessments and risk mitigation measures, precautionary insurance can work in tandem with traditional regulation.

Of course, if the maximum and fastest unconventional development conceivable produced absolutely essential national benefits, indeed, met essential needs, then anything that slowed its pace or limited its range at all

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205. Cass R. Sunstein, *Irreversible and Catastrophic*, 91 CORNELL L. REV. 841, 850–52 (2006); Cass R. Sunstein, *The Paralyzing Principle*, REGULATION, Winter 2002–2003, at 32, 37.

206. *See generally* DOUGLAS A. KYSAR, REGULATING FROM NOWHERE: ENVIRONMENTAL LAW AND THE SEARCH FOR OBJECTIVITY (2010).

207. *See* David Dana, *When Less Liability May Mean More Precaution: The Case of Nanotechnology*, 28 UCLA J. ENVTL. L. & POL'Y 153, 197–98 (2010) (discussing subsidized insurance for producers of nanotechnology); s*ee also* THE NANOTECHNOLOGY CHALLENGE: CREATING LEGAL INSTITUTIONS FOR UNCERTAIN RISKS (David A. Dana, ed., 2012) (including contributions exploring information deficits regarding nanotechnologies and exploring mandatory bonds, insurance, and other means to promote greater information production regarding risk).

might be questionable, including precautionary insurance. However, there is no basis to claim that exploiting unconventional oil and gas deposits as fast and fully as physically possible is a matter of national exigency. Rather, while it is true that unconventional development produces lower-cost energy and generates a great deal of tax revenue and some employment, it also has economic costs, in terms of activities such as agriculture that may be limited or made less productive by intense unconventional development. Apart from environmental, health, and safety risks, there are clearly social dislocations and social costs in unconventional well hot spots.[208] Moreover, unconventional development may not be a good long-term development strategy for the areas where it is being undertaken: Twenty years from now, economically depressed areas where this development happened may be left with no sustainable job base or infrastructure.[209]

The benefits of unconventional development from a climate change perspective are also at best contestable. On the one hand, natural gas—which is abundant in unconventional formations—produces far less CO_2 when burned than coal, and thus to the extent that fracked gas displaces coal, we may see a net greenhouse gas ("GHG") emissions reduction.[210] But unconventional development itself, and pipeline transportation, entails releases of methane, a potent GHG.[211] It appears that this leakage rate is sufficiently low to make gas far superior to coal and oil from a climate perspective, at least when used in power plants,[212] but unconventional

208. *See, e.g.*, Christopherson & Rightor, *supra* note 25, at 11 ("Individual counties and municipalities within the region are likely to experience accelerated boom and bust cycles.").

209. *Cf.* Arthur Berman, *Lessons from the Barnett Shale Play Suggest Caution in Other Shale Plays*, WORLD OIL, Aug. 2009 ("Production rates [from hydraulically fractured wells] commonly exhibit abrupt, catastrophic departures from hyperbolic decline as early as 12-18 months into production and, more commonly, in the fourth or fifth years for the control group."); Susan Christopherson & Ned Rightor, *The Boom-Bust Cycle of Shale Gas Extraction Economies*, *in* THE ECONOMIC CONSEQUENCES OF MARCELLUS SHALE GAS EXTRACTION: KEY ISSUES 4, 4 (2011), *available at* http://www.greenchoices.cornell.edu/downloads/development/shale/Economic_Consequences.pdf (describing how "high initial production rates dropped off rapidly" in the Barnett and Haynesville Shales).

210. *See, e.g.*, *Monthly Coal- and Natural Gas-Fired Generation Equal for First Time in April 2012*, U.S. ENERGY INFO. ADMIN. (July 6, 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=6990.

211. Jeff Tollefson, *Methane Leaks Erode Green Credentials of Natural Gas*, NATURE, Jan. 3, 2013, at 12, 12, *available at* http://www.nature.com/polopoly_fs/1.12123!/menu/main/topColumns/topLeftColumn/pdf/493012a.pdf (noting methane leakage estimates as high as 9%). On this point, and more broadly on the downsides of unconventional development, see Ingraffea, *supra* note 75.

212. *Compare* David T. Allen et al., *Measurements of Methane Emissions at Natural Gas Production Sites in the United States*, PROCEEDINGS OF THE NAT'L ACAD. OF SCI. OF THE U.S. (2013), *available at* http://www.pnas.org/content/110/44/17768.full (estimating leakage rates at the wellhead of 0.42%), *with What Will It Take to Get Sustained Benefits from Natural Gas?*, ENVTL. DEF. FUND, http://www.edf.org/methaneleakage (last visited Mar. 20, 2014) (explaining that leakage rates of 3.2% or lower would make natural gas superior to coal and oil from a climate perspective). *But see* Ramón A. Alvarez et al., *Greater Focus Needed on Methane Leakage from Natural*

development is also increasingly common for oil found in shales and tight sandstones.[213] Further, to the extent unconventional development and resulting low natural gas prices crowd out investment in wind and solar, this development may mean a net increase in GHG emissions.[214] Finally, slowing unconventional development to allow for improvements in safety, whether via traditional regulation or mandatory insurance requirements or a combination, does not eliminate the nonrenewable natural resource that is unconventional oil and gas. The oil and gas remains in the formation underground, even if some of it ends up being exploited at a later day, and, perhaps, in a much safer way.

C. *Whether the Premiums Will Be Too Low and Invite Moral Hazard*

As introduced above, one of the criticisms of compulsory insurance schemes is that they can invite moral hazard—more risk-taking, and less risk mitigation than would occur without compulsory insurance. This argument, which Steven Shavell has most fully developed, builds on the idea that if insurers cannot monitor the risk-creating activities of insureds, they may under-charge premiums. Indeed, Shavell argues that forbidding insurance sometimes is socially optimal. As Shavell explains his argument:

> Suppose first that liability insurer cannot observe levels of care. In this situation, forbidding the purchase of coverage will tend to increase incentives to reduce risk. The reason is that any insurance coverage that injurers purchase will reduce their incentives when insurers do not link premiums to their level of care. By preventing the purchase of coverage, an injurer's entire assets are made vulnerable to collection, and this will induce him to increase his level of care.[215]

Shavell's analysis does not apply, for the most part, to unconventional development. Insurers can monitor insureds' risk precautions, if not perfectly, to an extent, and it will be in both insureds' and insurers' interests to find increasingly better ways to communicate and verify that information. Shavell's analysis is static and ignores how potential changes in premiums and other terms of insurance will motivate insurers and insureds to change their practices. Moreover, Shavell's analysis ignores the effect of insurance

Gas Infrastructure, PROCEEDINGS OF THE NAT'L ACAD. OF SCI. OF THE U.S. (2012), http://www.pnas.org/content/109/17/6435 (estimating that it would take at least 80 years for the climate benefits of using natural gas in lieu of oil-based fuels in transportation to emerge).

213. *See supra* note 113 and accompanying text.

214. *See, e.g.*, Wald & Zeller, *supra* note 164 (describing a public utility commission's rejection of a wind project due to cheap natural gas).

215. Steven Shavell, *On the Social Function and the Regulation of Liability Insurance*, 25 GENEVA PAPERS ON RISK & INS. 166, 175 (2000).

on the likelihood of the imposition of liability and the effects, in turn, of increasing incentives for precaution.

In reality, the issue of too low premiums seems like a non-problem, given not just the ability of insurers to monitor but also ambiguity aversion on the part of insurers. Insurers will resist any governmental efforts to deflate premiums, and indeed the risk of inadequate premiums would seem to come not from inability to monitor but rather from political control over the terms of insurance and prices. This risk could arise in the event of a government takeover of the insurance program, in response to lobbying by the oil and gas industry for relief from the demands of private insurers. In this connection, one need look no further than federal and state flood insurance, in which political pressures have long led to too lenient conditions and requirements and too low premiums.[216] Thus, while there may be a role for government support of an unconventional oil and gas insurance market, it is important to limit as much as possible government involvement in the terms and price of insurance.[217]

D. *WHETHER INSURANCE REQUIREMENTS WILL UNFAIRLY DISADVANTAGE SMALL BUSINESSES*

Another common objection to financial assurance requirements is that they advantage big firms at the expense of small ones, and are thus inconsistent with principles of fairness and open competition.[218] Beyond this, small business in U.S. culture is often portrayed as a force for especially robust job growth and social mobility, and celebrated as the equivalent of the yeoman farmer of Jeffersonian democracy.[219]

The small-business-and-unfair-competition objection usually has three components. First, to the extent that self-insurance is cheaper than buying third-party insurance, small businesses lack an option that may be open to only large, heavily capitalized firms. Second, small firms simply have less buying power or leverage to strike a favorable deal with third-party insurers

216. *See, e.g.*, Eric Lipton et al., *Flood Insurance, Already Fragile, Faces New Stress,* N.Y. TIMES (Nov. 12, 2012), http://www.nytimes.com/2012/11/13/nyregion/federal-flood-insurance-program-faces-new-stress.html (explaining that premiums are too low to cover flood costs and will remain too low for years even with proposed increases).

217. Nonetheless, monitoring for private market failure in the insurance market will be important to check for problems like moral hazard and insufficiently large premiums. If these problems do arise, which we think unlikely, then that would be the point at which some greater government involvement in mandatory insurance would become appropriate.

218. *See, e.g.*, Daniel W. Pugh, *Insurer Liability for Environmental Clean-up: Do Contract Principles Excuse Performance?*, 48 BUS. LAW. 1707, 1714–15 (1993) ("Although very large businesses can afford to set funds aside as a form of 'self-insurance' if environmental liability insurance becomes unavailable or prohibitively expensive, most small firms lack both the resources and the ability to spread risk over diverse business operations to the extent needed in order to self-insure effectively.").

219. *See* George L. Priest, *Small Business, Economic Growth, and the Huffman Conjecture,* 7 J. SMALL & EMERGING BUS. L. 1, 2, 17 (2003) (describing the "veneration" of small businesses).

to the extent there is room for negotiation. Third, small firms may lack the resources to engage in risk reduction and to document risk mitigation, which insurers will require in order to offer insurance at all or to offer premium discounts or other favorable terms.

As to the self-insurance objection, our response is that unconventional oil and gas mandatory insurance legislation should not allow self-insurance or should only allow it to the limited extent political exigencies require. In theory, a corporation that must pledge and hence self-insure against (say) $100 million in future liability should act to reduce risks in order to avoid or reduce the risk of having to make the eventual payout. But in reality, corporate culture often is factionalized and political, and management may be more attuned to production divisions of the corporation and less to risk management divisions. Moreover, top management often is extremely focused on share price, and public investors, who are extremely short-term oriented, are much more likely to be able to discern and reward a company for upping production growth than they are able to discern and reward investments in safety and risk management.[220] Objective third-party monitoring by an insurer is thus essential here. It is plausible that a third-party insurer will simply refuse to cover a producer that has not invested in safety, but it is almost impossible to imagine that risk management personnel at (say) Exxon or BP would ever feel so empowered that they could simply order production on a broad scale to cease until the production managers instituted risk avoidance and management practices. As Cohen suggests, the incentives of key actors within large corporations with unconventional oil and gas divisions or subsidiaries are simply not as uniformly risk-mitigation oriented as those of key actors in insurance companies, even when the large corporations pledge to reserve funds to cover future liabilities.[221] Further, even when a self-insuring corporation attempts to engage in risk management, that corporation does not have access to information and practices regarding risk that an insurer that works with many companies can glean and disseminate through informational campaigns and premium incentives.

As to small firms' buying power, one way of addressing this limitation is to allow small firms to buy coverage as a pool. The pooling might dilute risk mitigation incentives for each firm to an extent, but even in insurance pools, insurers can adjust premiums to reflect individual pool member behavior to

220. *See, e.g.*, Gunter Festel et al., *Importance and Best Practice of Early Stage Nanotechnology Investments*, 7 NANOTECHNOLOGY L. & BUS. 50, 65 (2010) (noting that "[p]ublic investors focus often on fast returns . . . .").

221. Cohen et al., *supra* note 192, at 1873 (describing how the "'principal-agent' relationship between owners and managers or between firms and subcontractors causes a divergence of interests that may result in more (or fewer) precautions to prevent a catastrophic event than the owner of the firm would prefer").

some extent or decline to renew a pool member's insurance if its behavior suggested risk in excess of that of other pool members.[222]

Finally, to the extent small firms simply cannot afford to comply with the kind of risk minimization and mitigation insurers may require, it could, potentially, be socially optimal for larger firms to replace them. Some kinds of highly risky industries may require, for risk reasons, a certain economy of scale. With increased pressure for safety in unconventional oil and gas areas, even without an insurance mandate, we are, perhaps for this reason, seeing some evidence of a shift toward a greater role for large corporations.[223] That said, large corporations have some of the largest numbers of violations.[224] While this might simply result from the larger number of wells they own, economies of scale alone will not solve risk problems.

E. Whether Insurance Is Unnecessary Because Ex Post *Industry Taxes Will Encourage* Ex Ante *Safety and (Along With Tax Revenues) Fund Any Necessary Cleanups*

One alternative to *ex ante* insurance would be *ex post* taxes on the oil and gas industry that would be used to fund unconventional oil and gas-related clean-ups. In broad strokes, this is what Congress did with industrial dumps under Superfund and with defunct coal mines under the Surface Mining Control and Reclamation Act ("SMCRA"). The Superfund statute created an industry-funded trust to pay for clean-ups where responsible polluters could not be located.[225] SMCRA imposes a tax on the coal industry to fund reclamation of areas, land, and waters degraded by coal mining.[226] *Ex post* taxation has *ex ante* risk mitigation benefits to the extent that industry actors anticipate that, down the road, after operations cease, they will be subject to a tax to fund clean-ups. In order to minimize that tax liability, industry actors would take *ex ante* risk mitigation measures. However, the *ex ante* effects of a tax, if any, are likely modest or minimal because each industry actor will know that the tax will be based on collective industry-wide damage

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222. *See* Kamarshi et al., *supra* note 198 (noting that small fracturing companies could establish a pool).

223. *Cf.* Timothy Fitzgerald, *Frackonomics: Some Economics of Hydraulic Fracturing*, 63 CASE W. RES. L. REV. 1337, 1354 (2013) (noting that "[a] few large firms dominate the fracking business"); PA. DEP'T OF ENVTL. PROT., JULY TO DECEMBER 2012 PRODUCTION UNCONVENTIONAL WELLS ONLY (spreadsheet on file with authors) (showing that a few large companies dominate the production industry). *But see* Nash, *supra* note 140 (noting the involvement of small firms). Large operators might also sell production to smaller operators once well production is stable or declines.

224. *See* Nash, *supra* note 140 (showing large violation numbers for Chesapeake and EQT in the Marcellus region).

225. *See* 42 U.S.C. § 9631, *repealed by* Pub. L. No. 99-499, § 517(c)(1) (1986) (establishing a trust fund); Superfund Amendments and Reauthorization Act of 1986, Pub. L. No. 99-499, 100 Stat. 1613, 1772 (creating the Hazardous Substance Superfund in 26 U.S.C. § 9507).

226. *See* 30 U.S.C. § 1232(a) (2012).

and not tied to its particular conduct. Perhaps even more important, the industry actors who operated *ex ante* may be defunct *ex post*, when the government seeks to impose and collect a tax (and, *ex ante*, industry actors will know that and act accordingly).

Our two main experiences with *ex post* clean up taxes—the Superfund tax under CERCLA and the coal reclamation tax under SMCRA—underscore why we cannot rely on *ex post* industry taxes to adequately fund clean-up and why an alternative mechanism, such as mandatory insurance, is essential. The Superfund tax was never adequate to cover orphan Superfund site clean-ups, and due to industry pressure, was repealed, with the result that the clean-up of contaminated sites has now slowed to a trickle.[227] The coal reclamation tax has been a political football in the annual congressional appropriations process. The result was the allocation of grossly insufficient funds to radically degraded areas in the eastern United States where mining is no longer very active, and most federal funds for reclamation have in fact come from general tax revenues, not taxes on the coal industry.[228] Coal mining reclamation is a dramatic demonstration of why we cannot rely on *ex post* tax dollars to clean up the environmental damage that may flow from the intense unconventional development we are now witnessing and will witness in the next few decades.

Consider Pennsylvania, in particular, a state that experienced a coal-mining boom and is contending even now with its enormous environmental aftermath,[229] and that is currently the epicenter of another extractive boom driven by horizontal drilling and fracking. The remnants of the coal industry have cost Pennsylvania enormous environmental and other damage, some

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227. *See* RENA STEINZOR & MARGARET CLUNE, THE TOLL OF SUPERFUND NEGLECT: TOXIC WASTE DUMPS & COMMUNITIES AT RISK 12 (2006) (explaining that "funding shortages" have been responsible for "lagging cleanup" of severely contaminated sites); *Oversight Hearing on the Federal Superfund Program's Activities to Protect Public Health: Hearing Before the S. Subcomm. on Superfund & Envtl. Health, the S. Comm. on Env't & Pub. Works*, 110th Cong. 6 (2006) (statement of Sen. Barbara Boxer, Chairman, S. Comm. on Env't & Pub. Works) (explaining that in recent years "the pace of listing toxic waste sites for cleanup, and of actually cleaning up these sites, has slowed to nearly a crawl").

228. *See* STUART BUCK & DAVID GERARD, POLITICAL ECON. RESEARCH CTR., CLEANING UP MINING WASTE 14 (2001), *available at* http://perc.org/sites/default/files/rs01_1.pdf (noting that Reclamation Fund "[f]unding remains extremely limited compared to the scope of the problem," which, among other factors, has caused problems for state budgets); OFFICE OF SURFACE MINING RECLAMATION & ENFORCEMENT, U.S. DEP'T OF THE INTERIOR, BUREAU HIGHLIGHTS, at BH-28 (2011), *available at* http://www.osmre.gov/resources/budget/docs/FY11_Proposed_Budget.pdf (noting that "2011 AML mandatory grant payments will total an estimated $259.5 million" for certain states, and proposing "to focus all AML payments toward high-priority coal mine reclamation"); BRYDON ROSS, COUNCIL OF STATE GOV'TS, ABANDONED MINE LAND FUNDING AND TRENDS FOR STATES 1 (2011), *available at* http://knowledgecenter.csg.org/kc/content/abandoned-mine-land-funding-and-trends-states (noting that "[s]tates rarely received the promised 50 percent rate of return" from payments into the fund).

229. *See* Robinson Twp. v. Commonwealth, 83 A.3d 901, 959–62 (Pa. 2013) (discussing a history of natural resource extraction and the damage it caused).

still unremediated and some unremediatable.[230] And while we do not suggest that coal mining and unconventional development are environmental equivalents, coal mining was for much of its history thinly regulated or not regulated at all. Unconventional development, while regulated, is incompletely so, with a minimal federal role and a state regulatory role of varied quality.[231] The parallel has not been lost on astute observers in Pennsylvania; consider the following editorial from a Pennsylvania newspaper:

> Much of the environmental focus in Pennsylvania these days naturally is on the as-yet unknown long-term consequences of the Marcellus Shale natural gas development.
>
> The environmental impact of resource extraction is a particularly pressing matter in Pennsylvania because evidence abounds of the environmental havoc wrought by large-scale coal mining—more than half a century after the industry's demise.
>
> Part of the pressure to hold the gas industry responsible for environmental stewardship flows from the failure to hold the coal industry responsible. The government has been primarily responsible for cleaning up the portion of the coal industry's mess that has been attended so far, but now, its ability to continue doing so has been compromised . . . .[232]

Or, as David Biello has similarly observed, "Ultimately, the question becomes: What will be the long-term legacy of these [unconventional] wells? After all, the now-moribund coal industry left the Keystone State a toxic legacy it is still coping with today."[233]

Nor are Pennsylvania and other old-mining, eastern seaboard states alone in having borne massive damage from coal mining, and in having found industry-funded tax revenues far from sufficient to address that damage in a meaningful way.[234] Much of the damage from defunct or

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230. *Id.*

231. *See, e.g.*, Wiseman, *supra* note 3 (discussing regulatory gaps); RICHARDSON ET AL., *supra* note 64 (describing regulatory variation among the states).

232. *Restore Funds for Mine Land Reclamation*, TIMES TRIB. (Aug. 13, 2012), http://thetimes-tribune.com/opinion/restore-funds-for-mine-land-reclamation-1.1357734.

233. David Biello, *Fracking Can Be Done Safely, but Will It Be?*, SCI. AM. (May 17, 2013), http://www.scientificamerican.com/article.cfm?id=can-fracking-be-done-without-impacting-water. In its decision that held unconstitutional portions of a state act requiring municipalities to allow unconventional gas development in all zones, including residential ones, the Pennsylvania Supreme Court noted the legacy of coal. *See also Robinson Twp.*, 83 A.3d at 961 ("In the mid–1960s, the Commonwealth began a massive undertaking to reclaim over 250,000 acres of abandoned surface mines and about 2,400 miles of streams contaminated with acid mine drainage, which did not meet water quality standards." (citing PA. DEP'T OF ENVTL. PROT., PENNSYLVANIA'S COMPREHENSIVE PLAN FOR ABANDONED MINE RECLAMATION (1998))).

234. *See supra* note 228 and accompanying text.

abandoned coal mines remains unaddressed even in the states where coal mining remains active and where the industry is more willing to fund reclamation and support the use of tax dollars for reclamation. Indeed, according to a Natural Resources Defense Council report, "[s]trip-mined lands are not being fully or contemporaneously reclaimed and strong inspection and enforcement programs are not in place to fulfill the [Surface Mining Control and Reclamation] Act's promise to protect communities and the environment."[235]

The Coal Mining and Superfund site examples are relevant to the unconventional oil and gas debate not only in that they suggest that neither *ex post* industry taxes nor general tax revenues will be available in sufficient amounts for adequate remediation, but also because they underscore the environmental justice issues raised by unconventional development but rarely addressed by commentators. Environmental justice scholars have amassed significant evidence that environmental remediation happens less often, less fully, and less speedily in poorer areas, presumably because poor communities lack the clout of wealthier ones.[236] The pattern of relative neglect of contamination in poor coal counties and in poor counties with Superfund sites likely would, in the absence of an *ex ante* funding mechanism such as mandatory insurance, be reproduced in poor areas currently experiencing fracking.[237]

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235. HARRIS EPSTEIN ET AL., NATURAL RES. DEF. COUNCIL & W. ORG. OF RES. COUNCILS, UNDERMINED PROMISE: RECLAMATION AND ENFORCEMENT OF THE SURFACE MINING CONTROL AND RECLAMATION ACT 1977–2007, at 18 (2007), *available at* http://www.worc.org/userfiles/file/SMCRA%20Report.pdf.

236. *See, e.g.*, Alan Ramo, *Environmental Justice as an Essential Tool in Environmental Review Statutes: A New Look at Federal Policies and Civil Rights Protections and California's Recent Initiatives*, 19 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 41, 49 (2013) (noting that "low-income communities may face multiple exposures to toxic hazards with few resources to mitigate these exposures"); Linda D. Blank, Comment, *Seeking Solutions to Environmental Inequity: The Environmental Justice Act*, 24 ENVTL. L. 1109, 1130 (1994) (noting that "when it comes to cleaning up environmental hazards, poor and minority communities often lack the money and influence needed to litigate and get timely action"); *see also* Dana, *supra* note 18, at 92, 105 (noting that most new clean-ups are state led and describing differences among clean-ups, in part due to local budgets).

237. The sheer number and dispersion of wells makes it difficult to identify any firm correlations between income and well location, but anecdotal evidence suggests that a substantial number of wells are appearing in disadvantaged areas. The county with the most Marcellus Shale wells drilled and fractured in Pennsylvania between 2008 and 2012 had a median household income of $44,650 and 14.1% persons below the poverty level from 2008 to 2012 (even with the help of the gas boom), as compared to the Pennsylvania median household income of $52,267 and 13.1% persons below the poverty level. *See* TIMOTHY W. KELSEY ET AL., MARCELLUS SHALE EDUC. & TRAINING CTR., ECONOMIC IMPACTS OF MARCELLUS SHALE IN BRADFORD COUNTY: EMPLOYMENT AND INCOME IN 2010, at 4 (2012), *available at* http://www.marcellus.psu.edu/resources/PDFs/EI_Bradford.pdf (explaining that the county had the most Marcellus wells); *State & County QuickFacts, Bradford County, Pennsylvania*, U.S. CENSUS BUREAU, http://quickfacts.census.gov/qfd/states/42/42015.html (last visited Mar. 20, 2014).

IV. THE POLITICAL ECONOMY OF ENACTING UNCONVENTIONAL OIL AND GAS INSURANCE MANDATES

If (as we have argued) mandatory insurance for unconventional oil and gas would improve both *ex ante* risk management and assure equitable funding for *ex post* remediation, then it seems clear that policymakers should enact these mandates. But how, exactly, should that happen? Or more to the point, what are the most likely paths for that to occur?

There is not much support at the federal level to extend federal regulation even to the aspects of unconventional development, such as wastewater and solid hazardous waste disposal, which are as a general matter part of the federal domain. Since environmental insurance requirements are a much less common (although, as noted, not unknown) part of the traditional menu of federal regulatory requirements, we think it would be unlikely that Congress would embrace insurance requirements before it has at least moved to remove loopholes and exemptions that now shield unconventional development from otherwise applicable federal environmental laws and regulations. Thus, while federal insurance requirements are possible, we would envision they are more likely to emerge after movement at other levels of government.

That brings us to the states. States are a natural forum for the enactment and implementation of unconventional oil and gas insurance mandates for several reasons. First, states are currently the front-line, indeed close to exclusive, regulator of how and where unconventional development happens.[238] They are thus in the best position to build on and mesh insurance requirements onto command and control, substantive regulatory requirements that are already in place. Second, states are the traditional primary insurance regulator in the United States, and every state has an insurance bureaucracy and expertise that could be deployed in the formulation and implementation of unconventional oil and gas insurance requirements. Third, because pooling of insureds operating in distinct hydrological sub-regions may make sense for both insurers and insureds, and because generally such pools could be constructed within a single state's borders, a state would be well-positioned to set any necessary requirements or guidelines related to pooling.

However, only two states (Maryland and Illinois), and no major unconventional oil and gas state that we are aware of,[239] has enacted a mandatory insurance requirement. Moreover, some state legislatures and agencies have been highly responsive to industry arguments against anything that would add to industry costs and lessen the unconventional oil and gas

238. *See* Wiseman & Gradijan, *supra* note 110, at 4–8, 14 (explaining why states have core authority over most drilling and fracturing risks).

239. *See supra* note 22.

boom,[240] and insurance mandates would indeed add some costs. Environmental and citizen groups could begin to advocate for insurance requirements for unconventional development at the state legislative level, but they are engaged in so many battles on the unconventional oil and gas front—fighting, still, for example, such basic requirements as reasonable disclosures of the sometimes toxic chemicals used in fracking—that one can understand why they might lack the energy for yet another, new fight.[241] Insurers could be a powerful lobby for insurance requirements, but until the insurance industry develops a large stake in the unconventional oil and gas industry, and knows that it has substantial money at stake and more to be made, it may not make any sense for it to make a speculative investment in unconventional well-related politics. Once mandatory unconventional development requirements were in place, we would expect insurers to lobby to keep them there and ensure they are formulated in ways that allow insurers to function profitably. But that still leaves the question of how unconventional oil and gas insurance mandates can come into being in the first place.

Our answer: The localities where unconventional oil and gas development currently exists and where it is possible could begin the legal innovation, to be followed by states. While we think it possible that a state like New York could adopt a state-wide unconventional oil and gas insurance requirement without being pushed by its localities that already have done so, we think that the most plausible scenario is that localities first enact insurance mandates, those mandates are the subject of litigation and deemed not-preempted by state law, and then the politics at the state level will change sufficiently that legislatures will more easily enact statewide unconventional oil and gas insurance mandates.

There are a number of reasons why localities are the likely first movers on unconventional development insurance mandates—indeed, several cities already have been.[242] First, and most simply, there are far more localities involved or potentially involved in this development than states, so there are more opportunities for advocates to press for such mandates at the local level than at the state level. One of the basic rationales for federalism is that fifty states will, as a matter of course, yield more diverse approaches than one single federal government does; by the same reasoning, hundreds upon

240. *See, e.g.*, John Murawski, *Fracking Giant Halliburton Nixes NC's Chemical Disclosure Rule*, NEWS & OBSERVER (May 2, 2013), http://www.newsobserver.com/2013/05/03/2866836/fracking-giant-halliburton-nixes.html (discussing a fracking-industry giant's opposition to chemical disclosure laws).

241. *See, e.g.*, NATURAL RES. DEF. COUNCIL, *State Hydraulic Fracturing Disclosure Rules and Enforcement: A Comparison*, http://www.nrdc.org/energy/fracking-disclosure.asp (last visited Mar. 20, 2014) ("It is essential that the public, and health and safety professionals, have full access to information on the constituents of hydraulic fracturing fluids and waste, and the details of how and where fracturing was performed."); *see also* Murawski, *supra* note 240.

242. *See supra* note 21.

hundreds of localities will yield even more diverse approaches than the fifteen or so state governments that have and soon will address unconventional development.[243] Second, localities have (or should have, once informed) an intense interest in insurance because, while the effects of this development may cross local or even state lines, the property owners and public systems most at risk from unconventional development are those physically nearest, which is to say, those generally in the same locality as where the unconventional operations are located. Third, drafting an insurance mandate requires relatively little technical knowledge about unconventional oil and gas and thus would be within the competence of localities (unlike drafting regulation for the actual fracking process and well operation). Fourth, requiring insurance, which is a market-based, non-command and control approach, could have appeal even in localities where there is a general ideological aversion to government regulation and where there is a strong belief in the value and role of markets. To date, many local proposals regarding unconventional oil and gas involve bans or partial bans on oil and gas drilling or fracking in a locality[244] which are likely to alienate landowners and others who think unconventional development will bring economic benefits and, as an ideological matter, may strike others as simply too heavy-handed government control of the use of private property.

There are two impediments to local adoption of insurance mandates—one economic and strategic and one legal, but, in the end, we do not think either is insurmountable. First, oil and gas companies are likely to argue to local governments that, if they enact insurance mandates, they will locate new wells elsewhere. In other words, despite what David Spence has suggested in his argument against a federal role for fracking regulation,[245] race to the bottom dynamics are conceivable in the unconventional oil and gas context. There are, however, several limits to industry's ability to play one locality off another here: Industry will be drawn heavily to sites that geologically and hydrologically would seem most fruitful, and those physical considerations generally should outweigh the likely modest costs of obtaining and maintaining insurance. Local leaders, however, sometimes

243. *See generally* Richard Briffault, *"What About the 'Ism'?" Normative and Formal Concerns in Contemporary Federalism*, 47 VAND. L. REV. 1303 (1994) (arguing that federalism should focus on the states); Nestor M. Davidson, *Cooperative Localism: Federal-Local Collaboration in an Era of State Sovereignty*, 93 VA. L. REV. 959, 990–1000 (2007) (examining the tradition of federal empowerment of local governments).

244. *See* Joseph De Avila, *'Fracking' Goes Local*, WALL ST. J. (Aug. 29, 2012), http://online.wsj.com/news/articles/SB10000872396390444327204577617793552508470 (describing local bans and proposed bans); Shaun A. Goho, *Municipalities and Hydraulic Fracturing: Trends in State Preemption*, 64 PLAN. & ENVTL. L., July 2012, at 3, 4 (noting that "it appears that well over 100 municipalities have imposed either permanent bans or temporary moratoria on fracking"), *available at* http://blogs.law.harvard.edu/environmentallawprogram/files/2013/03/Municipalities-and-Hydraulic-Fracturing-Trends-in-State-Preemption.pdf.

245. *See generally* Spence, *supra* note 10.

may be persuaded by industry "bluffs" or may use industry arguments as a rationale for not adopting mandates out of loyalty to the industry, in a form of local "capture." Second, industry almost certainly will sue to invalidate localities' adoption of insurance mandates on the ground that state law expressly or impliedly preempts them.[246]

There are, however, very strong arguments against such preemption claims, although the strength of the claims will, to an extent, turn on the particulars of the law of the state at issue and even more certainly on the mindset of state judges and perhaps ultimately state supreme courts. On the one hand, localities are creatures of the state, and a state generally may overrule what a locality does. On the other hand, most states, as a matter of state constitutional law, afford localities home rule status, which constitutionally limits the extent to which state law can expressly or impliedly preempt local law.[247] Thus, even where there is a state law expressly preempting local oil and gas regulation (as was enacted in Pennsylvania and Ohio, among other states)[248] that law may be constitutionally void as applied to some kinds of local oil and gas or fracking-specific regulation. Moreover, in other instances, where there is no express preemption legislation at the state level, industry will need to rely on implied preemption, and by some accounts, courts should not find implied state preemption unless the regulation at issue would conflict with or pose a real obstacle to state regulation.[249]

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246. *Cf.* Complaint, Colo. Oil & Gas Ass'n. v. City of Longmont, Colo. (D. Colo. Dec. 17, 2012) (arguing that a ban is preempted), *available at* http://ourlongmont.org/wp-content/uploads/2013/01/20121218_010338_COGAfiling.pdf.

247. All of the states that currently have hydraulic fracturing, with the exception of Arkansas, grant home rule authority to municipalities. *See Appendix: Home Rule Across the Fifty States, in* HOME RULE IN AMERICA: A FIFTY-STATE HANDBOOK 471, 476–77 (Dale Krane et al. eds., 2001). Some states that purportedly grant home rule authority, however, grant only weak authority. In Pennsylvania's Act 13 case, for example, in which Pennsylvania required municipalities to allow drilling and fracturing in all zones, with the exception of fracturing within 500 feet of buildings, the municipalities did not raise the issue of their home rule authority, but instead focused on an alleged substantive due process violation caused by the state statute. *See* Pa. Act of Feb. 14, 2012 (H.B. 1950) (2012), http://www.legis.state.pa.us/WU01/LI/LI/US/HTM/2012/0/0013..HTM, *rev'd* Robinson Twp. v. Commonwealth, 52 A.3d 463 (Pa. Commw. Ct. 2012), under review by state supreme court. Further, states in some cases may simply preempt the authority of home rule governments. *See* Norse Energy Corp. v. Dryden, 961 N.Y.S. 714, 718 (N.Y. App. Div. 2013) (noting that "[t]he doctrine of preemption, however, represents a fundamental limitation on home rule powers" (internal quotation marks omitted)).

248. John R. Nolon & Victoria Polidoro, *Hydrofracking: Disturbances Both Geological and Political: Who Decides?*, 44 URB. LAW. 507, 515 (2012). Note that the Pennsylvania Supreme Court held that the portion of Pennsylvania's legislation that required municipalities to allow unconventional oil and gas development in all zones violated the state's constitution. Robinson Twp. v. Commonwealth, 83 A.3d 901, 990 (Pa. 2013).

249. *See, e.g.*, Cipollone v. Liggett Grp., Inc., 505 U.S. 504, 545 (1992) (explaining that, in the state-federal, non-energy context, courts should only find that a federal law impliedly preempts a state law when the state law "is in actual conflict with federal law," "stands as an

Under home rule constitutional principles, a state law cannot preempt, even via an express preemption clause, local action on issues of direct local concern.[250] Using insurance mandates to ensure funds for local clean-ups and remediation from unconventional development would seem to fall squarely within the rubric of local action directed at local concerns. While we are likely to see some range of judicial views on whether insurance mandates fall within the protected home rule sphere, and while there is generally a dearth of relevant precedent, a few recent decisions suggest state courts would be open to holding that states cannot bar municipalities from enacting unconventional oil and gas insurance mandates.[251] Of all of the states, Texas has been the most tolerant of municipal insurance policies. It appears that the state has not questioned Fort Worth's and Arlington's requirements that operators have $5 million environmental liability coverage.[252]

Where (as, for example, in Texas or New Mexico) there is no state statute expressly preempting local oil and gas measures, localities should be able to mount a powerful argument that local insurance mandates do not conflict with state regulation, at least where the state regulation simply says nothing about insurance. Nor are insurance mandates obviously an obstacle

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obstacle to the accomplishment and execution of the full purposes and objectives of Congress," or "where the nature of Congress's regulation, or its scope, convinces us that Congress left no room for the States to supplement it" (citations omitted) (internal quotation marks omitted)). Robert H. Freilich & Neil M. Popowitz, *Oil and Gas Fracking: State and Federal Regulation Does Not Preempt Needed Local Government Regulation*, 44 URB. LAW. 533, 549–50 (2012) (noting that in New Mexico, for example, "[a] number of decisions allow counties and cities to impose regulatory controls on activities that are more restrictive than the state statute" and that the mere fact that local and state regulations both address the same activity does not by itself lead to conflict or a finding of preemption).

250. *See, e.g.*, Freilich & Popowitz, *supra* note 249, at 545 (noting that one home rule power involves "protecting local government decisions from displacement by state action in matters of purely local concern"); *id.* at 546 (noting that "[m]ost state courts do not apply the doctrine of implied preemption when dealing with home rule entities"); Nolon & Gavin, *supra* note 10, at 1015 (noting that home rule "provisions calling for liberal interpretation of local power and extolling the importance of local land use powers create an implicit presumption against preemption").

251. *See, e.g.*, Anschutz Exploration Corp. v. Town of Dryden, 940 N.Y.S.2d 458, 466 (2012) (allowing towns to ban drilling and fracturing under their land use authority despite state preemption of laws "relating to the regulation of oil [and] gas" (citing N.Y. ENVTL. CONSERV. LAW § 23–0303 (McKinney 2012))); Cooperstown Holstein Corp. v. Town of Middlefield, 943 N.Y.S.2d 722 (2012) (same). Because these courts relied on towns' land use authority, however, municipal insurance regulations might be more questionable. *Cf. Robinson Twp.*, 52 A.3d at 497 (finding that a state regulation requiring municipalities to allow unconventional oil and gas development in all zones violated substantive due process, although not citing to home rule authority). The Pennsylvania Supreme Court also found that the requirement violated the Pennsylvania Constitution, but only the concurrence relied on due process. *Robinson Twp.*, 83 A.3d at 990. The majority relied on environmental and public trust provisions within the state constitution. *Id.* at 1001 (Baer, J., concurring).

252. *See supra* note 21.

to other kinds of state oil and gas regulation, since requiring insurance would in no way prevent an insured from fully complying with state regulation. Quite the contrary, insureds are more likely to comply with state regulation because they could be penalized for any noncompliance that is reported with a premium increase. Unlike local fracking or drilling bans, local unconventional oil and gas insurance requirements could not even be seriously thought to conflict with official state policy goals to promote safe and responsible development in the interest of overall economic development, as insurance mandates do not operate to bar well development—and at the very most, they may act to limit it in particularly unsafe locations, or with very particular industry operators who cannot demonstrate a commitment to safety. No state has an official goal to promote unconventional development no matter what, whether safe or not, no matter how unsafe. Thus, when courts consider claims of implied preemption, they should find that local insurance mandates do not impliedly conflict with state law.

If a significant number of localities in a state were to enact insurance mandates, and the mandates were held not to be preempted, the oil and gas industry within the state might prefer to support a single state insurance mandate as an alternative to keeping track of a number of local ones. The insurance industry, too, might then view state-level regulation as offering advantages, and the result may well be state insurance mandates that take the place of local ones. And once a number of states enacted an insurance mandate, the salience and visibility of the issue conceivably could garner support for an insurance mandate even at the federal level. Given the compelling need for insurance as a means of *ex ante* risk mitigation and *ex post* funding of remediation, these would all be beneficial developments.

CONCLUSION

The time for preventing and mitigating the risks of unconventional oil and gas development is now. Although thousands of unconventional oil and gas wells have been drilled and fractured, tens of thousands more remain to be developed: Some formations are still in the early exploration stages, at best. At this critical juncture, we must quickly yet intelligently implement mechanisms to address the substantial risk of short- and long-term contamination of substantial portions of our soil and water. A range of approaches will be necessary, including better command and control regulation and, perhaps, a clarification of liability regimes. But scholars and lawmakers have ignored an essential, market-based approach. Bonding requirements combined with mandatory liability insurance will, in tandem with better regulations, control both *ex ante* and *ex post* risks and provide necessary remediation funds for long-term risks.

The benefits of the insurance-based approach are numerous, and they could easily overcome the likely objections. States, which currently have the primary responsibility for managing risks, lack adequate regulations and enforcement resources. A liability-based regime, in the absence of mandatory insurance, cannot work effectively because plaintiffs cannot collect from—and hence will not even sue—judgment-proof entities. A liability regime, in the absence of mandatory insurance, is especially unlikely to address the many cases where pollutants will have mixed and dispersed over time and causation may be difficult to assess. While claimants must also establish underlying tort liability in the insurance context, lawsuits are potentially more viable because of the availability of funds, and judges are more likely to find liability in the event of multiple operators causing harm in a concentrated area.[253]

An insurance regime is thus key to controlling risks in the unconventional oil and gas area: It will incentivize insurers to gather information about risks from those most familiar with risks—the industry—and to transform this information into effective risk standards. By producing a real threat that operators and insurance companies will have to pay out in large amounts to cover a catastrophic event, it will encourage risk prevention. The insurance industry is likely to produce stringent environmental standards that insureds must follow, and insureds will monitor their activities to prove that they are following best practices and merit insurance discounts. This system will also place a new set of eyes on the industry, causing insurance companies to act as the primary rule monitors and enforcers. Finally, a market-based regime will act in tandem with, not against, command and control regulation: Insurers will likely lobby for better regulation in order to control risks to an efficient level. And it will avoid many of the inevitable capture and group-think problems associated with a public regulatory regime that is closely connected to the one regulated industry for which it is responsible. Insurance companies tend to insure a large range of industries, even if they operate within just one state.

The objection that it is impossible to insure a new, highly risky activity for which the risks are not fully known is an old one, and has been disproven in the offshore oil drilling context. And to the extent that insurers lack risk information to set adequate premiums, they will likely gather this data from industry, providing a useful cross-well comparison that individual plaintiffs—and even regulators, with whom industry is reluctant to share risks—are unlikely to see. If this information is still not enough, states have begun to require industry testing and disclosure of pollution at sites,[254] thus providing further information on risks to a potentially reluctant insurance industry. Furthermore, to the extent that an insurance mandate would push the industry toward larger, highly capitalized operators, if we think that including small operators in this business is important, these operators

253. *See supra* notes 16, 24 and accompanying text.

254. *See* Wiseman, *supra* note 14.

could pool their resources to purchase insurance. And we have not proposed to allow large operators to self-insure—a policy that would indeed slant the industry toward certain types of firms. Self-insurance removes the objective third-party assessment and monitoring of risk that is essential to the regime proposed here.

The bonding and insurance requirements that we propose here must have detailed measures to ensure adequate risk protections. They must be site-specific and apply to each party that owns the mineral interests or associated facilities, thus requiring state supervision to ensure that insurance coverage continues along with changes in ownership. States, or insurance companies, must also review operators' financial integrity prior to the purchase of insurance to guarantee that the companies will be able to pay relatively large deductibles. Bonds provided by industry to ensure proper well plugging and abandonment also must cover all potential costs, and must be stringently enforced.

There will inevitably be kinks to work out in this proposed market-based regime, but the opportunities that it provides for controlling certain and uncertain risks are immense. This system will harness the synergies between self-governance—strong financial motivations to avoid large catastrophes and associated costs—and regulation, another essential factor in lowering risks. The regime's provision of a stable pool of money for reclamation is also essential. No matter the degree of *ex ante* risk prevention, mistakes will happen, and thousands of sites with low levels of contamination could contribute to a massive, collective pollution problem. Without a bonding and insurance system we risk repeating past mistakes for which we are still paying, in the form of human health and social impacts and unremediable environmental damage. The market-based approach proposed here—an essential tool within a larger, emerging regulatory framework—could prevent this modern energy revolution from leaving a negative legacy as large and lasting as previous industrial booms.