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Article

FEDERALISM, REGULATORY LAGS, AND THE POLITICAL ECONOMY OF ENERGY PRODUCTION

David B. Spence[d1]

The production of natural gas from formerly inaccessible shale formations through the use of hydraulic fracturing has expanded domestic energy supplies and lowered prices and is stimulating the replacement of dirtier fossil fuels with cleaner natural gas. At the same time, shale gas production has proven controversial, triggering intense opposition in some parts of the United States. State and local regulators have scrambled to adapt to the boom in natural gas production, raising the question of whether federal regulators should step in to supplant or supplement state regulation. This Article takes a policy-neutral approach to the federalism questions at the center of that inquiry, asking which level of government ought to resolve these policy questions, rather than which level of government is likely to produce a particular favored policy outcome. Consequently, this analysis begins with four economic and political rationales typically used to justify federal regulation. Federal regulation is necessary (1) to address spillover effects that cross state boundaries, (2) to prevent economic forces at the state level from initiating a "race to the bottom" in environmental regulation, (3) to promote business efficiencies through uniform national standards, and (4) to respond to national interests in the development of natural resources through a federal licensing system. Applying these rationales to the regulation of fracking yields several important conclusions. First, while a few of the externalities of shale gas production cross state boundaries, most are experienced locally. Second, existing federal regulatory regimes offer ample ***432** *authority to address those few interstate externalities. Third, the race-to-the-bottom rationale does not justify federal regulation of shale gas production because shale gas states are not competing for quantity- or time-limited capital investment. Fourth, given that the impacts of fracking are still under study and the subject of considerable ongoing debate, there is currently no overriding national interest supporting the creation of a comprehensive federal licensing or regulatory regime for shale gas production.*

*433 Introduction

The American energy policy landscape is undergoing a revolution.[1] The production of natural gas from formerly inaccessible shale formations through the use of hydraulic fracturing[2] (also known as "fracking") has transformed American energy options. Only a few years ago, American policymakers foresaw a future increasingly dependent upon natural gas imports;[3] they now foresee that domestic production will be sufficient to serve the country's needs for as many as 100 years.[4] That ample supply, in turn, has tamed natural gas markets. Natural gas prices have always been volatile (and frequently high), but forecasters now predict low prices into the foreseeable future.[5] Low natural gas prices could stimulate the replacement of dirtier fossil fuels (coal and oil) with cleaner natural gas (in electricity generation and transportation, respectively), hastening the long-held dream of the industry's proponents that natural gas would serve as a bridge fuel to a renewable energy future.[6] According to the International Energy ***434** Agency (IEA), emissions of greenhouse gases in the United States fell in 2011, in large part because of shifts from coal-fired electric generation to gas-fired generation--a change that the IEA attributed to increased shale gas production.[7]

At the same time, however, shale gas production has proven very controversial. The rapid increase in this type of production has been driven in large part by production techniques (horizontal drilling and fracking) that are now in use on a much wider scale than ever before.[8] Use of these techniques produces negative externalities[9]--pollution and other byproducts borne mostly by the community in which shale gas production occurs--which have generated intense opposition to shale gas production in some parts of the United States and the world.[10]

State and federal regulators have scrambled to adapt to the boom in natural gas production and the controversy it has spawned.[11] That scramble has produced a significant amount of regulatory change in states from Texas to New York.[12] Some states have reacted cautiously, banning shale gas production pending further study of its risks.[13] Others have opened their shale gas formations ("shale plays" in the industry vernacular) to development ***435** under existing state regulatory regimes, adjusting those regimes to address new or newly recognized risks.[14] While the process of state regulatory adjustment continues, it has not quieted opponents of shale gas production.[15] At the national level, the Environmental Protection Agency (EPA) is engaged in a multi-year study of the industry, which may yield additional federal regulation.[16]

These observations raise important questions: What, if anything, should the federal government do about fracking? Should Congress pass comprehensive federal licensing rules or standards governing the industry? Should the EPA use existing regulatory authority to impose further restrictions on fracking or to fill gaps in state regulatory regimes? Or is the regulation of this industry better left to the states, whose varied regulatory approaches represent a series of experiments from which all can learn? These questions are located at the intersection of federalism and regulation. Specifically, Congress, the EPA, and state and local government actors may all have preferences regarding fracking policy, which raises the question of which level of government is the most appropriate regulator. This Article will address these questions by exploring the commonly employed theoretical rationales for regulating at the federal level, and applying those rationales to the risks associated with fracking and shale gas production. The analysis shows that a comprehensive federal licensing or regulatory regime for shale gas production is probably unnecessary--and, at least premature--but that the federal government might appropriately regulate specific aspects of shale gas production that implicate national or global interests.

Part I of this Article examines the process of fracking, including the technological advances that have made it cheaper to produce natural gas from shale, and the effect of fracking production in three states containing large shale gas plays--Texas, Pennsylvania, and New York. Part I also explores the external effects of shale production on air, water, groundwater, community character, and other public goods, and further notes the ongoing debate over their significance and magnitude.

Part II examines fracking's existing regulatory environment. It describes the major federal regimes that regulate fracking operations and notes that Congress has exempted the fracking process from some of those regimes. It then compares the state regulatory regimes governing fracking in Texas, ***436** Pennsylvania, and New York. The analysis notes differences in these states' regulatory strategies, including their coverage, stringency, and use of either detailed prescriptions or general performance standards. It is evident from this snapshot of state regulation that state rules have lagged behind the development of the industry. Part II also examines the effects of regulatory agency structure on a state's regulatory approach. Specifically, it explores the implications of assigning primary regulatory jurisdiction to an oil and gas commission (as in Texas), or to a state environmental agency (as in Pennsylvania and New York). While it is difficult to reach general conclusions in response to this question, it appears that the Texas regulations governing technical issues (such as construction) are more specific than those promulgated by the New York and Pennsylvania environmental agencies. Conversely, the New York and Pennsylvania agencies seem to focus more of their attention on environmental protection than does the Texas commission.

Part III addresses the federalism questions at the heart of the regulation of energy facilities. The federal government clearly has the power to regulate fracking under the Commerce Clause because of the industry's substantial effects on interstate commerce.[17] That observation, however, does not answer the question of where regulatory authority ought to lie. The analysis approaches this normative question in policy-neutral terms, placing the question of who ought to regulate prior to questions about what the regulation should be. This approach reveals four rationales that we typically use to justify federal regulation. Federal regulation is necessary (1) to address spillover effects that cross state boundaries; (2) to prevent economic forces at the state-level from initiating a "race to the bottom"[18] in environmental regulation; (3) to promote business efficiencies through uniform national standards; and (4) to respond to national interests in the development of natural resources through a federal licensing system.[19] Part III also ***437** explores how existing energy regulatory regimes are justified using one or more of these grounds.

Part IV applies the various rationales for federal regulation developed in Part III to the production of shale gas using fracking. It concludes that while some of the impacts of fracking cross state boundaries, most are local. Existing federal regulations offer ample authority to address those impacts that have national scope, and federal regulators are already using that authority to regulate shale gas production. The analysis does not support the race-to-the-bottom rationale for federal shale gas regulation because there is sufficient capital to develop shale gas wherever it is found. Nor does there appear to be a need for a comprehensive federal licensing regime, as shale gas development is proceeding apace without any such regime. The final Section discusses some of the implications of this analysis for future regulation of fracking and shale gas production, and recommends that the EPA limit new regulation of fracking to those elements of the process that pose national or global risks.

I. Shale Gas Production and Fracking

Over the last several years, there has been increasing controversy over the production of natural gas from shale deposits using fracking, most of which surrounds the environmental, health, and safety risks associated with the techniques employed. Indeed, opposition to fracking has led to permanent or temporary bans in France, South Africa, Vermont, New York, and various other communities throughout the world.[20] These bans and moratoria reflect the intensity with which some local communities, or subsections of those communities, have opposed fracturing operations on environmental, health, and safety grounds.[21]

*438 A. Fracking, Generally

Conventional natural gas production involves the drilling of wells into permeable or semipermeable formations in which natural gas (methane) is moved to the surface through a well. Conventional natural gas may be found dissolved in oil and as a cap on top of underground oil formations (so-called "associated gas," because it is associated with oil production); alternatively, it may be found between rock formations in the absence of oil ("unassociated gas").[22] Geologists have long known that a significant amount of natural gas is trapped in nonpermeable rock formations below the Earth's surface, including shale formations found at great depths (usually 4000-10,000 feet).[23] In the last decade or so, oil and gas production and service companies have perfected the use of fracking, an old technique, to produce natural gas from shale formations in a cost-competitive way.

Fracking involves the injection of fluids deep into the ground at high pressure to fracture rock, thereby creating openings that allow gas to flow into production wells.[24] A portion of these fracturing fluids returns to the surface as "flowback water"; by contrast, produced water is water that was already underground and that can float to the surface through the well before or after hydraulic fracturing.[25] The well is ready to produce natural gas once flowback water ceases flowing from the well. Advances in drilling technology, particularly horizontal drilling, and the development of more effective "fracking fluids" have significantly reduced the costs of producing natural gas through fracking, because horizontal drilling technologies permit producers to access more gas from fewer drilling sites. Using these technologies, producers first drill down to the shale layer and subsequently drill horizontally. Through this approach, multiple wells can be drilled from a single drilling pad, and each well can be separately "fracked" by injecting ***439** fracking fluids to fracture rock, thus enabling natural gas to flow to the surface.[26] Advances in fracking and horizontal drilling technology have stimulated a kind of "natural gas rush" into shale gas formations.[27] Notably, fracking was first used widely in Texas's Barnett Shale[28] and Louisiana's Haynesville Shale,[29] but quickly spread to other areas, including the Marcellus Shale[30] in the northeastern United States.

In 2011, Americans consumed approximately 24 trillion cubic feet (Tcf) of gas.[31] American shale deposits hold a minimum of several hundred Tcf of gas.[32] One of the consequences of the relatively sudden availability of this multitude of gas is that American natural gas prices have fallen below three dollars per MMBtu,[33] as compared with prices exceeding ten dollars per MMBtu in Asia.[34]

*440 B. Environmental Impacts

The environmental impacts of fracking are disputed. Proponents of hydraulic fracturing, and of natural gas production more generally, sometimes claim that, despite fracking hundreds of thousands (or millions) of wells in the United States, fracking has not produced a single confirmed case of groundwater contamination.[35] Opponents of fracking, however, dispute that claim by pointing to several cases of alleged contamination of drinking water by methane or fracking fluid chemicals.[36] Disputes over the source of contamination in those cases have triggered a spate of new studies from governmental and academic sources.[37] Proponents of fracking also tout the relatively low air emissions from natural gas combustion, as compared with coal or oil. As Table 1 below indicates, on a per-Btu basis, natural gas combustion produces significantly fewer greenhouse gas emissions than either coal or oil. Moreover, natural gas combustion produces an even smaller fraction of the emissions of the other major pollutants associated with fossil fuel combustion. As a well-established and reliable fuel source for electric generation, inexpensive and plentiful natural gas could lead to the widespread substitution of natural gas-fired electric generation plants for coal-fired plants. Additionally, as coal combustion is associated with tens of thousands of premature deaths each year,[38] the substitution of natural gas-fired electric generation plants for coal-fired plants could yield substantial health benefits.[39] Taken together, these considerations underscore why some ***441** energy planners see natural gas as a "bridge fuel" in the process of moving from a fossil fuel economy to one fueled by renewable energy resources.[40]

Table 1: Fossil Fuel Emission Levels (Pounds per Billion Btu of Energy Consumed)[41]

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxide	92	448	457
Sulfur Dioxide	1	1122	2591
Particulates	7	84	2744
Hydrocarbons	<0. 001	0.007	0.016

The use of fracking to produce natural gas, however, does have a variety of important environmental impacts.[42] First, it uses enormous quantities of water. The typical fracking operation uses two to four million gallons of water.[43] Depending upon the particular characteristics of the formation in which the fracturing operation occurs, less than 30% to more than 70% of that water returns to the surface as flowback water.[44] That means that a ***442** typical fracking operation may leave millions of gallons of water deep below the earth's surface. In arid areas, such as the Eagle Ford Shale in southern Texas, fracking may strain existing water supplies.[45]

Second, fracking fluid mixtures contain toxic chemicals. These mixtures are carefully designed to fracture rock in predictable and efficient ways and to preserve open spaces so that gas can flow into production wells. Fracking fluid mixtures are more than 99% water and sand. Sand is a "proppant," which props open spaces in the rock after the water pressure is reduced and the water flows away from the fractures.[46] The remainder of the mixture consists of various chemicals deemed best for fracturing each particular formation. Some fracking fluid constituents are toxic,[47] and some mixtures contain known carcinogens.[48] Industry groups argue that the same constituents are commonly found in many other household products.[49] Nevertheless, because some of the fracking fluids that are injected into the ground remain there, some of the toxic chemicals in those fluids remain underground as well. The oil and gas industry is developing fracking fluid mixtures that contain nontoxic or less toxic constituents, but it does not appear that these alternatives are widely used at this point.[50]

***443** Third, fracking produces significant quantities of wastewater. Flowback water and produced water contain not only the original fracking fluid constituents, but also may contain contaminants introduced into the water during its time underground. These contaminants may include salts and naturally occurring toxic elements, such as arsenic, and some elements may be radioactive.[51] The disposal options for this wastewater depend upon the nature of the contaminants in the wastewater, the physically available disposal options in the vicinity of the operation, and the state and local legal regime. The disposal options include direct disposal into surface waters through a point source, injection into an underground formation, processing in a wastewater treatment facility, and recycling (i.e., reuse in other fracking operations).[52] Each of these disposal options poses different challenges. In some parts of the country, underground injection is neither easy nor available. Depending upon the characteristics of the produced water, it may be difficult or impossible to obtain the required permission under the Clean Water Act to discharge the wastewater directly into surface waters.[53] Similarly, some wastewater may contain radioactive elements or other contaminants that interfere with the operation of sewage treatment facilities, rendering discharge to such facilities impossible.[54] Finally, many ***444** believe that underground injection of wastewater from fracking operations in certain locations can trigger seismic events.[55] For all of these reasons, increasing quantities of flowback water and produced water are treated on site and reused in future fracturing operations.[56]

Fourth, fracturing operations involve large amounts of construction activity and truck traffic. Each operation involves the construction of a concrete drilling pad, on which the fracking operations take place. The construction of storage facilities required for water and chemicals used in fracking fluids changes the landscape. Trucks containing water, chemicals, and equipment move to and from multiple fracking operations. These activities produce air emissions and noise, sometimes for extended periods of time. These operations fundamentally change the character of an area for the duration of fracking activities.[57] The construction phase also creates ***445** socioeconomic effects associated with "boom towns," including rising prices and increased social dislocation.

Fifth, the production of natural gas can release methane into the atmosphere through leaks in gas capture, gathering, storage, and transmission equipment. Because methane is an extremely potent greenhouse gas, methane releases may obviate any greenhouse gas-emission gains associated with the substitution of natural gas for coal in electricity production or other industrial operations.[58] However, there remains considerable uncertainty about the extent to which natural gas production and transmission operations produce these so-called fugitive methane emissions.[59]

Finally, fracking operations can be associated with groundwater contamination. Critics of fracking have suggested that fracking operations cause the seepage of methane or fracking fluids into groundwater wells.[60] The vast majority of fracking operations fracture rock a mile or more beneath existing groundwater tables. In these situations, the probability of deep ***446** fractures causing methane or fracking fluids to migrate upward into groundwater tables seems very small.[61] However, a fracking operation may nevertheless cause groundwater contamination in any of three ways. First, if the natural gas well is poorly constructed, methane or fracturing fluids might leak from the well while passing through groundwater tables at shallow depths. Second, if fracking fluid constituents are improperly handled on the surface, they may be spilled and seep into groundwater tables.[62] Third, the disposal of wastewater or other wastes on site, if permitted by law or the lease, can result in groundwater contamination if and when lagoons or other disposal facilities leak.[63]

Much of the controversy surrounding fracking focuses on these impacts and the adequacy of the regulatory regimes available to minimize, mitigate, or prevent those impacts. In 2009, Cabot Oil and Gas Corporation entered into a consent decree in which it agreed to pay a $120,000 fine and to provide fresh water to residents of Dimock, Pennsylvania, whose drinking water wells were contaminated with methane.[64] While the settlement did not establish the cause of the methane contamination, the Pennsylvania Department of Environmental Protection subsequently banned Cabot from using fracking in the region.[65] The presence of methane in Pennsylvania wells inspired the Academy Award-nominated documentary GasLand, which has rallied opposition to fracking--particularly in the Marcellus ***447** Shale region.[66] More recently, the EPA concluded in late 2011 that fracking fluids had contaminated a drinking water aquifer near the town of Pavillion, Wyoming,[67] though the industry disputes that conclusion.[68] These and other incidents[69] prompted the EPA study of the environmental effects of fracking on water resources.[70] The EPA expects to announce the preliminary results of the study in late 2012, with final results anticipated in 2014.[71]

Thus, significant uncertainty remains regarding the magnitude and frequency of the negative effects of fracking. This uncertainty is reflected in the contrasting and evolving approaches taken by states in fracking regulation.

II. The Existing Regulatory Environment

A. Federal Regulation

1. Overview of Oil, Natural Gas, and Environmental Regulation

There is no comprehensive federal licensing regime for onshore oil and gas development. To the contrary, the regulation of oil and natural gas exploration and production in the United States has always been primarily a state matter. Economic motives drove the earliest government interventions into oil and gas production. From the discovery of oil in western Pennsylvania in the mid-nineteenth century, through subsequent discoveries in Texas, Oklahoma, and Louisiana in the late-nineteenth and early-twentieth centuries, the American oil and gas industry experienced a series of boom- ***448** bust cycles, accompanied by wild swings in oil prices.[72] These cycles were precipitated and exacerbated by the common law "rule of capture," which permitted any single owner of mineral rights in a multi-owner oilfield to produce as much oil as possible from that field.[73] In addition to its effects on prices, the rule of capture led to tremendous waste, because it provided a disincentive for owners to manage production (for example, by coordinating the placement of wells and production rates from those wells) and maintain pressure levels in the field. This disincentive resulted in production that was both physically and economically inefficient.[74] After the discovery of the massive east Texas field in 1930, which exacerbated over-supply problems and depressed prices, producers appealed to their governments to step in.[75] State legislatures in oil-producing states began enacting "conservation statutes," which authorized state regulators to organize production so as to promote efficiency.[76] This kind of state-managed production eventually grew to include some basic environmental, health, and safety standards governing well construction and other aspects of the work.[77] In states like Texas and Oklahoma, these state conservation commissions continue to regulate natural gas production today.

Most environmental regulation, however, is of more recent vintage. The modern environmental movement is a post-World War II phenomenon, which eventually led to the federal environmental regulatory regime in ***449** existence today. During the 1970s, Congress passed most of the major statutes that still regulate environmental health and safety,[78] including: (1) the Clean Air Act (CAA)[79] and the Clean Water Act (CWA),[80] which required permits and compliance with federal standards for air and water emissions respectively; (2) major hazardous waste regulatory legislation, such as the Resource Conservation and Recovery Act (RCRA);[81] and (3) public health and safety protection laws, such as the Safe Drinking Water Act (SDWA),[82] which established federal drinking water protection standards, and the Occupational Safety and Health Act (OSH Act),[83] which established health and safety standards for the workplace.

2. Regulatory Exemptions for Oil and Gas Development

However, this federal regulatory superstructure does not always regulate environmental, health, and safety risks associated with fracking in the same way it regulates other industries. Fracking operations enjoy some exemptions from federal environmental regulation.[84] For example, the SDWA regulates underground injections "which endanger[] drinking water sources"[85]--including underground injection of oil and gas wastes--through its underground injection well permitting program.[86] However, the definition ***450** of "underground injection" was amended to exclude "the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities."[87] This provision means that fracking operations do not require underground-injection-well permits under the SDWA. The history of the exemption can be traced to an EPA decision in the 1990s to exempt fracking because the principal function of fracking operations is not the injection of fluids into the ground (disposal), but rather gas production.[88] After an EPA study concluded that the injection of fracking fluids into coalbed methane[89] wells poses little or no threat to drinking water sources,[90] Congress enacted the statutory exemption. It should be noted, however, that underground injection of wastewater from fracking operations is subject to SDWA permitting requirements.

In addition, there is no federal law requiring the disclosure of the composition of fracking fluids to environmental regulators.[91] The Emergency Planning and Community Right-to-Know Act,[92] the primary federal hazardous chemicals disclosure law, requires that industries annually submit to the EPA a "Toxic Chemical Release Form" describing the specific toxic chemicals in their industrial processes and the methods of disposal for each.[93] However, the Toxic Chemical Release Form requirement only applies to industries within specific Standard Industrial Classification (SIC) ***451** Codes.[94] Oil and gas production operations fall within SIC code 13,[95] and are exempt from the requirement to file the form. Consequently, people concerned about the contamination of their groundwater by fracking fluids cannot use the Toxic Chemical Release Inventory[96] to determine whether their wells have been contaminated by a particular fracturing operation. On the other hand, some alternative forms of information are available. Federal law, for example, requires fracturing operators to file material safety data sheets for each hazardous chemical present at the job site with local governments.[97] Additionally, the website fracfocus.org--a voluntary industry disclosure effort--assembles and publishes information about the contents of fracking fluid mixtures from individual wells.[98] Furthermore, transportation of hazardous chemicals to and from the jobsite may be covered by reporting requirements under the Hazardous Materials Transportation Act.[99] Legislation to require disclosure of the specific fracking fluid mixtures used in each fracturing operation was introduced into the 111th Congress[100] but never came to a vote there.[101]

Finally, wastewater produced by fracking enjoys the same exemption from the RCRA's hazardous waste disposal regulations that applies to all oil and gas wastes. The RCRA regulatory regime requires generators, transporters, and disposers of hazardous wastes to comply with a variety of ***452** (sometimes very expensive) regulatory requirements.[102] RCRA delegated to the EPA the task of developing precise definitions of hazardous wastes covered by the regulatory regime.[103] In December 1978, the EPA issued proposed rules defining the types of hazardous characteristics that would bring solid wastes within the definition of hazardous wastes.[104] In so doing, the EPA indicated that "certain very large volume wastes," including "gas and oil drilling muds and oil production brines,"[105] may be hazardous but would be difficult to regulate because the EPA lacks information about their risks, which appear to be low.[106] This exemption was codified in the 1980 amendments to the RCRA.[107] Consequently, the disposal of wastewater from fracking operations is not subject to the regulation of hazardous waste under the RCRA.[108] That does not mean, however, that disposal of fracking wastes is entirely unregulated at the federal level. The CWA and SDWA regulate certain methods by which wastewater from fracking operations is disposed.[109]

Thus, despite federal regulation, the fact that fracking operations enjoy certain exemptions from some of these federal regulations has exacerbated fears surrounding those operations.

***453 B. State Regulation**

State regulation of fracking operations varies considerably but has grown beyond the mere regulation of property rights and production rates to include environmental (or quasi-environmental) regulation as well.[110] The two right-hand columns in Table 2 below illustrate the growth of natural gas production (driven primarily by fracking) in three American states containing large shale gas deposits.[111] Texas has been at the forefront of shale gas production, doubling the number of wells in the state between 2000 and 2009.[112] It has done so by exploiting the Barnett Shale in northern Texas[113] and other shale deposits within the state, most recently the Eagle Ford Shale in southern Texas.[114] Similarly, New York and Pennsylvania overlay the huge Marcellus Shale. Gas production in Pennsylvania has seen sharp increases over the last decade, but production in New York has not.[115] All three states have had, for some time, regulatory regimes governing the construction of oil and gas wells.[116] Why then have Texas and Pennsylvania seen a strong surge in natural gas production and fracking over the last decade while New York has not? Variation in these states' regulatory approaches to fracking accounts for the lion's share of this disparity. Texas and Pennsylvania have chosen to apply their existing regulatory regimes for natural gas production to fracking operations (though both states revised their rules in early 2012[117]). New York State decided to impose a moratorium ***454** on fracking while it studied the effects of the practice.[118] The Governor appeared poised to lift the moratorium in anticipation of the establishment of new regulatory standards proposed in the fall of 2011.[119] In the summer of 2012, there were reports that the ban could remain in place in all but a few New York counties.[120] As of this writing, the Governor of New York has restarted the rulemaking process, leaving the full ban in place pending its completion.[121]

***455 Table 2: Natural Gas Development and Regulation, Three States[122]**

	Regulator	Number of Wells (Production) 2000	Number of Wells (Production) 2009
Texas	Railroad Commission of Texas	48,609	93,507
Pennsylvania	Pa. Department of Environmental Protection	30,000	57,356
New York	N.Y. State Department of Environmental Conservation	5304	6628

A comparison of the regulatory regimes of these states illustrates important similarities and differences among them. With respect to operational requirements for gas production generally, the Texas rules are more specific and prescriptive than either the Pennsylvania or New York rules.[123] For example, the Pennsylvania well-construction rules are comparatively more general, and are expressed as performance standards. Casing, for example, must be "of sufficient cemented length and strength to attach proper well control equipment and prevent blowouts, explosions, fires and casing failures."[124] The New York rules are even more general, requiring simply that "sufficient surface" casing extends "below the deepest potable fresh water level."[125] All three states' regimes establish requirements governing well construction and include provisions to ensure that the cement casing is sufficient to prevent gas or other materials in the well from finding their way into the surrounding earth and groundwater. However, the Texas rules specify exactly where the well casing must be constructed within the well,[126]***456** the materials to be used,[127] and how the casing is to be cemented and pressure tested.[128]

Similarly, the Texas rules regarding blowout preventers are specific, requiring "a minimum of two remotely controlled hydraulic ram-type blowout preventers," with specified characteristics.[129] In contrast, the Pennsylvania and New York rules are less specific, and more likely to be articulated as performance standards.[130] These state regimes also differ with respect to other topics, including operational standards and waste disposal.

All three states now require that operators disclose, in some form, the contents of their fracking fluids. Texas requires disclosure of fracking fluid constituents on a well-by-well basis using the website fracfocus.org.[131] New York's proposed rules require that applications for fracking permits disclose fracking fluid constituents to the New York State Department of Environmental Conservation (DEC); the rules also prohibit the use of constituents not included in the permit application.[132] Pennsylvania's spill prevention guidelines require disclosure of fracking fluid constituents within six days following the conclusion of fracking.[133]

With respect to waste disposal requirements, however, the Pennsylvania and New York rules are more stringent than the Texas rules. For example, the Texas rules specifically permit operators to construct and utilize pits for the storage of various liquids used during natural gas production, but require a separate permit to dispose of liquid wastes in pits or underground.[134] In contrast, the Pennsylvania rules contain detailed construction requirements for pits used to store liquids during operations, such as the requirement that ***457** the pits contain a synthetic liner of specified thickness and integrity, and that the bottom of the pit be "at least 20 inches above the seasonal high groundwater table."[135] The rules for waste disposal include requirements for surface-water disposal, disposal to municipal sewage treatment plants, and on-site or underground disposal.[136] The New York rules prohibit the pollution of land, surface water, or groundwater from natural gas production activities,[137] and prohibit the storage or retention of oil in earthen reservoirs.[138] Moreover, New York's proposed rules would impose environmental requirements far more thorough and stringent than those of either Pennsylvania or Texas, including aggressive setback requirements from aquifers and other environmental resources and requiring the use of tanks rather than pits for onsite storage.[139]

One might speculate that the differences between these state regulatory regimes correlate with the variant natures of the missions of the agencies given primary jurisdiction over natural gas production operations in each state. In Texas, where the primary regulator is the oil and gas commission, natural gas operations regulations seem relatively detailed but less directly focused on environmental protection; in New York and Pennsylvania, where the primary regulators are environmental agencies, the operational rules are general but the waste-disposal rules seem particularly strong and detailed. A well-established literature within political science attributes substantive importance to these delegation decisions, arguing that politicians can steer an agency in particular policy directions by establishing its mission. In other words, those attracted to work for an agency will tend to exhibit policy preferences that are consistent with its statutory mission.[140] Agencies ***458** like the Federal Energy Regulatory Commission (FERC) or state oil and gas commissions were created explicitly to regulate and promote certain types of energy development, and we can infer that those agencies' missions influence difficult policy choices. We can further infer that politicians understand this dynamic, and allocate regulatory authority with it in mind.[141]

Based upon this idea of mission-orientation, it follows that the New York and Pennsylvania legislatures allocated responsibility for regulating natural gas production to their environmental agencies to emphasize environmental issues in the natural gas regulatory process, and to ensure that environmental values are not ignored or given inadequate consideration. Correspondingly, it also follows that the Texas legislature sought to promote natural gas development without an emphasis on environmental values by delegating regulatory responsibility to the Railroad Commission of Texas. New York's moratorium and stringent proposed rules appear to support these inferences. On the other hand, though Pennsylvania's environmental rules are more specific than Texas's, it does not appear that Pennsylvania's regulation of natural gas production (and of fracking in particular) is generally more environmentally stringent than regulation is in Texas. Furthermore, while Texas relies upon the Railroad Commission to regulate gas production, the law specifies a role for the Texas Commission on Environmental Quality (TCEQ) to manage waste disposal and other pollution-related aspects of gas production.[142] From this small sample, it is difficult to discern any correlation between agency mission and regulatory stringency when it comes to the regulation of fracking. Rather, this snapshot highlights the remarkable variety of states' regulatory approaches and ***459** their ongoing efforts to adapt to emerging information about the risks of shale gas production.

Alternatively, these different regulatory approaches may reflect different attitudes toward risk and regulation among the people in each state. Figure 1 below summarizes the results of the Spring 2012 University of Texas Energy Poll,[143] which asked respondents nationwide about their attitudes toward fracking. It is clear from the data that Texans think differently about fracking than do residents of New York or Pennsylvania. Not only are Texans more likely to support fracking than are New Yorkers or Pennsylvanians, but New Yorkers and Pennsylvanians also express far more support than do Texans for the notion that fracking needs more regulation.

Figure 1: University of Texas Energy Poll, Spring 2012

Q1: Based on what you know or have heard, please indicate the degree to which you support or oppose the use of fracking in the extraction of fossil fuels.

	Total	Tex.	Pa.	N.Y.
Support	48%	57%	48%	39%
Oppose	36%	22%	41%	45%
Neither	15%	16%	10%	17%
Don't Know	2%	4%	1%	0%

Q2: Which of the following best describes your feelings about regulation for fracking?

	Total	Tex.	Pa.	N.Y.
More regulation needed	38%	17%	58%	49%
Sufficient regulation, but need more enforcement	22%	35%	30%	17%
Sufficient regulation	16%	21%	10%	9%
Too much regulation	14%	20%	1%	23%
Don't know	10%	8%	2%	3%

***460 III. Federalism and Energy Regulation**

Different states have responded to the shale gas rush in different ways, and the EPA's study of fracking may yield proposals for new federal regulation. Meanwhile, the question remains: is new federal regulation necessary or even advisable? Should the EPA establish comprehensive risk-regulation governing fracking operations (while permitting states to impose more stringent standards)?[144] Should Congress create a federal licensing regime for fracking operations, one that preempts state and local laws? Or should the federal government leave these issues to the states? Of course, Congress retains the constitutional right to regulate activities that have a substantial effect on interstate commerce.[145] There seems little doubt that natural gas production and its environmental externalities have a sufficient connection with interstate commerce to justify federal regulation. That question of legal authority, however, is distinct from the normative question of whether states or federal regulators are better suited to regulate in any particular instance.[146] This federalism problem can be conceptualized by putting policy first--that is, by determining the "right" policy and then determining which level of government can better implement it. Alternatively, one can take a policy-neutral approach and ask which level of government is better suited to determine the "right" policy. This Article follows the latter approach because it puts the federalism question first, and there remains significant disagreement over the correct answers to the factual questions on which a "right" policy would be based.

A. Federalism and Regulation, Generally

1. Logical Rationales for Federal Regulation

The scholarly literature on American regulatory federalism is diverse.[147] Some scholars approach this issue in rational choice terms, modeling it as a ***461** problem of aggregating preferences and responding to market failure.[148] Others reject the rational choice approach, arguing that it misses important values that ought to be considered in addressing questions of federalism.[149]***462** This analysis begins with four traditional rationales used to justify federal regulation of externalities[150] and proceeds on the assumption that federal regulation is appropriate when one or more of those rationales applies.[151]

Consistent with the public economics literature on federalism, the first rationale for federal regulation focuses on the geographical scope of the externalities in question and argues for regulation at the lowest level of government that geographically encompasses the costs and benefits of the regulated activity.[152] Thus, for example, federal regulation of air pollution under the Clean Air Act is justified, in part, by the fact that air pollution routinely spills over state boundaries.[153] Provisions in the statute authorizing downwind states to petition the EPA to regulate upwind emissions, for ***463** example, are evidence of that rationale.[154] Conversely, where the effects of the to-be-regulated activity are entirely or primarily local, we might expect state or local government to be best equipped to balance those costs and benefits.[155]

A second rationale (or set of rationales) for federal regulation focuses on the ability or willingness of state governments to regulate. Even when externalities fall primarily on local governments, they may not be prepared to handle the job. These local governments may lack the ability to regulate effectively, due to a lack of resources or scientific competency.[156] Detecting the presence of this problem is difficult, however, because the absence of regulation may signify either (1) an inability to regulate despite the desire to do so or (2) the lack of any desire to do so. Thus, it might be presumptuous to assume the desire to regulate in the absence of regulation. On the other hand, the so-called "race to the bottom" hypothesis suggests that states may under regulate because they must compete with one another for jobs and economic development by reducing environmental or other regula-tory requirements.[157] This race-to-the-bottom argument is often framed as a ***464** kind of prisoners' dilemma[158] in which local governments collectively would prefer more stringent regulatory standards, but cannot sustain any cooperative effort to maintain those standards in the face of temptation--namely, the opportunity to attract businesses and jobs by lowering regulatory standards. Not everyone accepts the race-to-the-bottom hypothesis,[159] and it has sparked interesting literature examining the logical and normative implications of state and local decisions to reduce environmental standards in order to promote development.[160]

A third rationale for federal regulation applies to the manufacture of products that produce externalities and emphasizes the need for uniform standards in certain circumstances. Proponents of federal regulation argue that it is inefficient and unfair to subject manufacturers to fifty different sets of standards, one for each state. Instead, proponents argue that it would be far more efficient to establish a single federal standard,[161] which suggests a need to preempt state regulation of manufacturing standards in particular. Thus, for example, the Clean Air Act regulates the emission of pollutants from automobiles so that automobile manufacturers need not comply with ***465** fifty different state standards.[162] Similarly, the U.S. Department of Energy administers federal standards regulating the energy efficiency of appliances.[163]

A fourth rationale for federal regulation emphasizes an important national interest in the regulated activity and the need to control or stimulate its development through federal regulation, irrespective of the geographic distribution of costs and benefits. For example, the Federal Power Act of 1935 sought to promote and regulate hydroelectric development as part of the New Deal.[164] Likewise, the Atomic Energy Act of 1954 sought to promote and regulate the development (both peaceful and military) of nuclear energy.[165] In these two examples, Congress declared the promotion and close regulation of these industries to be in the national interest, and granted broad licensing and regulatory powers to federal agencies (FERC and the Nuclear Regulatory Commission (NRC), respectively).

These four rationales for federal regulation--to address pollution spill-over issues, to prevent a race to the bottom, to address a need for uniform standards, and to promote the national interest--are the most persuasive logical arguments for federal action. Of course, regulation is a political process, and any normative analysis of regulatory federalism should not ignore the interest group politics of regulation.[166]

2. Political Rationales for Federal Regulation

Within the political science literature, traditional interest group-pluralism explanations of policymaking portray groups as representatives of ***466** broader societal interests. Public choice explanations,[167] by contrast, reject the notion that group pressure represents broader social preferences accurately, instead emphasizing the ways in which powerful groups can control the policy process.[168] One variant of this argument emphasizes the advantages business interests have in organizing and pressuring political actors.[169] Because businesses have more at stake and face fewer transaction-cost impediments to organizing, they find it easier to form pressure groups (compared to broader mass interests, many of whose potential members either do not find it worth their while to contribute to the formation of groups or are content to free ride on the efforts of others).[170] Another public-choice idea, capture theory, articulates ways in which business interests can capture the regulatory process (and regulatory agencies) for their own benefit to erect barriers to entry, capture rents, and otherwise pursue their own interests.[171] Capture theory has both an insidious version ***467** and an innocent version. According to the insidious version, industry uses its money and other political resources to control regulatory agencies through their congressional overseers (particularly congressional committees).[172] According to the innocent version, regulatory agencies gradually adopt the point of view of the industries they regulate as a consequence of repeated interactions with those industries.[173] However, there is a rejoinder to capture theory as well. "Republican moments" refer to situations in which intense public interest in a particular social problem leads politicians to organize mass interests for their own political gain. In this way, politicians represent these mass interests in the policy process despite their disadvantages, enabling these interests to overcome the advantages businesses otherwise have in influencing policy decisions.[174]

***468** What do these political explanations have to do with federalism? Perhaps advocates of the race-to-the-bottom rationale for federal regulation fear that the likelihood of capture is greater at the state level than at the federal level. There is a plausible argument to that effect. If so-called "republican moments" can overcome pro-business biases in the policy process, and if the probability of a republican moment is a function of the amount of public attention devoted to a particular policy decision, then capture should be more prevalent at the state level, where there tends to be less policy transparency and where the policy process tends to attract less press attention.[175] Table 3 below summarizes these rationales for federal (rather than state or local) regulation.

Table 3: Rationales for Federal Regulation

Logical (Nonpolitical) Rationales	Political Rationales
Managing spillover effects when externalities cross state lines	
Lack of state willingness to regulate/ Race to the bottom	State governments possibly more susceptible to capture by industry than the federal government
Need for uniform national standards	
Important national interest at stake	

B. Federalism and Energy Facilities, Generally

Most federal energy-permitting and regulatory regimes are justified by some combination of the first, second, and fourth logical rationales described ***469** in the previous Section, though many of these regimes apply to a variety of industries, of which energy is just one. Some energy facilities are subject to a variety of risk-based regulations that focus not on a particular industry, but on controlling interstate/spillover externalities, like air or water pollution, or preventing a race to the bottom across a variety of industries (including energy). These types of regulatory regimes are the product of republican moments, driven by public concern over the risks at issue.[176] Coal-fired power plants and oil refineries, for example, are subject to risk-based regulation by a variety of federal agencies under several federal statutes, each focused on managing a particular set of environmental, health, and safety risks. Thus, new or modified coal-fired power plants and oil refineries must obtain air and water discharge permits under the Clean Air Act[177] and Clean Water Act,[178] respectively.[179] Because air and surface-water pollution cross state boundaries,[180] federal regulation makes sense; similarly, federal regulators have stopped short of regulating entirely intrastate water pollution for the most part.[181] At the same time, coal-fired power plants must comply with OSHA worker-protection regulations[182] and hazardous waste ***470** management requirements under RCRA[183] that may involve relatively few interstate impacts, but which might be justified on race-to-the-bottom grounds. That is, in the absence of federal regulation of these risks, one might imagine states competing for mobile capital investment (and resulting jobs and economic development) by lowering their regulatory standards.[184]

Many of these risk-based regulatory regimes address federalism issues head-on by employing a system of "cooperative federalism,"[185] under which federal agencies establish national standards[186] and permitting requirements, but delegate to the states the authority to administer regulatory programs,[187] including the authority to issue or deny permits.[188] This structure may reserve for the states the authority to impose more stringent requirements than those found in the federal standards; in those cases, the federal standards act ***471** as a regulatory minimum to which states can choose to add.[189] Some of these risk-regulation regimes limit regulators' ability to balance environmental, health, and safety concerns against economic or energy security concerns. For example, OSHA and EPA regulators may not consider costs when establishing air pollution standards for the ambient air or for workplaces, respectively.[190] Thus, for coal-fired power plants and oil refineries, no single regulator is charged with comprehensively examining the environmental, health, and safety risks associated with a facility. Moreover, federal regulatory responsibility for these facilities is diffuse in that each regulator focuses on only one aspect of an energy facility's operations, such as workplace safety or air emissions.[191]

Other energy facilities are subject to regulations focused not on specific risks but on the energy industry itself. For these facilities, Congress has decided that it is in the national interest to center most environmental, health, and safety reviews in unified federal licensing processes administered by lead federal agencies. Often, this allocation of power is the product of a congressional decision that the national interest requires development of a particular kind of energy. Examples of this kind of approach include the licensing processes for hydroelectric facilities under the Federal Power Act,[192] nuclear power plants under the Atomic Energy Act,[193] liquefied ***472** natural gas terminals under both the Natural Gas Act[194] and the Deepwater Ports Act,[195] surface mining of coal under the Surface Mining Control and Reclamation Act (SMCRA),[196] and offshore oil and gas production under the Outer Continental Shelf Lands Act (OCSLA).[197] Under these types of regimes, Congress tends to grant the federal licensing agency wide latitude to balance economic and energy security concerns against environmental, health, and safety risks. For example, the Atomic Energy Act authorized the NRC (formerly known as the Atomic Energy Commission) to grant or deny licenses for nuclear power plants in accordance with such procedures and "subject to such conditions as . . . [it] may by rule or regulation establish."[198] Similarly, the Natural Gas Act authorizes the FERC to approve onshore LNG facilities "upon such terms and conditions as the Commission may find necessary or appropriate . . . ."[199] Compared to risk-based regulatory regimes, it is more common for comprehensive federal licensing regimes to preempt state and local regulation under the Supremacy Clause.[200] Thus, for example, the Supreme Court has determined that the Federal Power Act preempts most state and local regulation of hydro-electric power facilities under the Supremacy Clause.[201] Likewise, the Atomic ***473** Energy Act impliedly preempts state and local regulation of radiation hazards,[202] and the Natural Gas Act expressly preempts local law when it comes to siting natural gas facilities, including LNG terminals.[203]

However, while comprehensive licensing statutes grant wide latitude to federal regulatory agencies, and often preempt local law, this does not mean that states have no influence in these licensing processes. In fact, most comprehensive federal licensing statutes require a federal licensing agency to consider state concerns in the licensing process. This is true of the offshore oil and gas leasing process under the OCSLA,[204] the nuclear power plant-licensing process under the Atomic Energy Act,[205] and the hydroelectric licensing process under the Federal Power Act.[206] Moreover, states can often exert independent leverage in the licensing process through authority delegated to the state under other federal laws. For example, the CWA requires that federally approved projects that "may result in any discharge into . . . navigable waters" secure a certification from the applicable state that the discharge will comply with the Act's water quality-protection requirements.[207] Many energy facilities are subject to this provision.[208]***474** Similarly, if a proposed energy project may affect the coastal zone of a state with an approved coastal zone management plan under the Coastal Zone Management Act (CZMA), the federal agency with jurisdiction must make a determination that the proposed project is consistent with the state's coastal zone management plan before moving forward.[209] This kind of leverage through federal law is limited, however. When federal law grants states real leverage over an energy project, that authority is usually narrow. For example, states cannot use their authority to issue or deny certification under the CWA to oppose a hydroelectric project based on aesthetic or neighborhood character issues, because the certification process is limited to protecting water quality.[210] Similarly, the CZMA does not give the final word to the states whose coastal zone is affected. In the event a state disagrees with a federal agency's determination of a proposed energy project's consistency with the state's coastal zone management plan, the final decision rests not with the state but with the Secretary of Commerce.[211]

Table 4 below summarizes the kinds of federal licensing and permitting regimes that apply to various types of energy facilities and the routes of state or local influence over the approval process for each facility. As that summary indicates, some types of energy facilities must overcome more regulatory barriers than others. Nonetheless, most energy facilities are subject to a wide variety of regulatory regimes designed to regulate environmental, health, and safety risks. All of those regimes can be explained using some combination of the four rationales for federal regulation described in Section III.A.

***475 Table 4: Selected Energy Facility Siting/Regulatory Regimes**

Energy Facility Siting	Comprehensive Federal Licensing Program?	State Regulation	Other Federal Regulation
Nuclear Power Plants	Atomic Energy Act/NRC	Preempted by federal regulation	National Environmental Policy Act (NEPA)[212]
			Endangered Species Act (ESA)[213]
			CWA § 401 Cert.
Hydroelectric Plants	FPA/FERC	Preempted by federal regulation	NEPA
			ESA
			CWA § 401 Cert.
Fossil Fueled Electric Power Plants	No	Licensing regimes in some states (e. g., California)[214]	NEPA
		Add-on pollution regulation[215]	CAA
			CWA Nat'l Pollutant Discharge Elimination System (NPDES)
Wind and Solar Farms	No (Department of Interior (DOI) approval under Outer Continental Shelf Lands Act (OCSLA) for offshore wind only)	Licensing regimes in some states (e. g., California)	ESA
		Local zoning requirements	NEPA (if federal approval required)
Electric Transmission Lines	FPA/FERC	State approval required	ESA
			NEPA
Onshore Oil and Gas Wells	No	State conservation regulation	NEPA (if federal approval required)
			CWA NPDES (wastewater disposal)
			Waste disposal exempt from RCRA coverage

			SDWA underground injection well-permitting (fracking is exempt)
Offshore Oil and Gas Wells	OCSLA/DOI	No jurisdiction beyond state waters	CZMA
			NEPA
			ESA
			CWA NPDES
			CWA § 401 Cert.
LNG Terminals	Onshore: Natural Gas Act (NGA)/FERC	Onshore: preempted by federal regulation	NEPA
	Offshore: Deepwater Ports Act/Dep't of Transp.	Offshore: no jurisdiction beyond state waters	CWA NPDES
			CWA § 401 Cert.
			CZMA
			ESA
Oil Refineries	No	Add-on pollution regulation	CAA
			CWA NPDES
			CWA § 401 Cert.
Natural Gas Pipelines	NGA FERC	Preempted by federal regulation	NEPA
			ESA
Coal Mining	Surface Mining Control and Reclamation Act (surface mining)	States may regulate only through a federally approved plan	NEPA
	Federal Mine Safety and Health Act (underground mining)		ESA
			CWA § 404 (dredge and fill program)

*477 IV. Federalism and Fracking

A careful examination of Table 4 reveals that the federal government regulates fracking, like other onshore oil and gas operations, relatively lightly. There is no federal licensing requirement for fracking operations and few other federal approvals are required as part of a fracking operation. Federal regulation may be triggered if the fracking operation risks harm to an endangered species,[216] will result in a discharge to surface waters[217] or a ***478** pretreatment facility,[218] or will result in underground injection of wastewater for disposal.[219] The transport of hazardous chemicals requires compliance with Hazardous Materials Transportation Act's labeling and manifest requirements.[220] However, it is not uncommon for fracking operations to avoid regulation under many of these provisions.[221] Critically, if the operation requires no federal approvals, then it will not trigger ancillary federal regulations, such as the requirement to obtain certification from the state under the CWA[222] or undertake an environmental review under the NEPA.[223]

On the other hand, fracking is subject to a growing and varied list of state regulatory requirements.[224] Given the ongoing controversy over the sufficiency of existing regulation, is there a case for comprehensive federal regulation of fracking operations? Turning once again to the rationales for federal regulation developed in Section III.A, we might ask how persuasively each rationale applies to the case of fracking, while keeping in mind the influence of politics in the regulatory process. The next section will explore those questions.[225]

A. Spillovers and the Geographic Scope of Fracking Externalities

Do the environmental, health, and safety externalities of fracking tend to cross state lines? If so, that fact might suggest an increased role for federal regulation of fracking. There remains considerable uncertainty about fracking's environmental consequences. However, an examination of what we know about fracking's environmental impact suggests that much of that impact is local.

***479** 1. Water Supply

Fracking consumes enormous quantities of water, much of which remains in the ground after the completion of the fracking process.[226] Widespread fracking operations, then, pose the potential to strain water supplies in arid parts of the country. Traditionally, water supply issues[227] have been a matter of state concern. Federal regulatory jurisdiction over water has historically been confined to navigable surface-water bodies and associated wetlands.[228] For example, federal Commerce Clause jurisdiction under the CWA is tied to the navigability of affected surface waters,[229] and the Federal Power Act expressly reserved to the states the power to control water supply issues.[230] Indeed, most interstate conflict over the use or management of bodies of water on state boundaries has been resolved through voluntary compacts between the affected states, though those compacts are subject to ratification by Congress.[231] On the other hand, most water supply conflicts pit local uses or users against one another. Characteristic disagreements involve farmers seeking irrigation water and homeowners seeking drinking water or conflicts between communities using the same aquifer. These battles generally do not implicate national interests and rarely spill across state lines. Taken together, all of these considerations suggest that water supply issues should be treated as a state and local matter.

On the other hand, many commentators predict that water supply issues will become more contentious in the future as growth and the effects of climate change strain water supplies, particularly in the Southwest.[232]***480** Fights over water supplies could lead to increased incidence of interstate conflict, which could in turn trigger federal regulation as an adjudicatory response to conflict. Indeed, many of the regional compacts that exist today were the result of this kind of interstate water dispute[233] and some were specifically created to resolve cross-border conflict over the use and protection of the water resource.[234] Notably, the significance of water-supply issues for fracking varies greatly by region. For example, in the Eagle Ford and Barnett Shales of Texas, where drought is a problem, these issues may ultimately loom large.[235] In contrast, in the Marcellus Shale of New York, where water is more plentiful, water supply seems unlikely to constrain development.[236] Thus, while water-supply concerns may become a national issue, the threats to water supply posed by fracking vary considerably throughout the country.

2. Neighborhood Character Issues

Neighborhood character impacts are, by definition, local. Nevertheless, they are perhaps the most significant consequences of fracking. From the beginning of site preparation through the completion of the fracking job,[237]***481** fracking is an industrial process. Like other such processes, it can affect the air quality, water quality, and visual aspects of the nearby environment. It may also result in noise, social disruption, and other consequences of industrialization. Following well completion, the production phase is much quieter, but the cumulative effects of fracking are profound and atypical, regardless of whether they take place in urban or rural settings. These impacts can pose difficult political problems for state and local governments. In rural areas, fracking has divided small towns, pitting longtime residents (seeking additional sources of income) against more recent arrivals (seeking a peaceful refuge from the city). It also can divide those who stand to earn production royalties against those who do not.[238] In urban and presumably wealthier areas, fracking can provoke opposition from better-funded and more-sophisticated NIMBY ("not in my backyard") groups. When fracking meets political resistance, elected local government leaders may respond with ordinances banning or restricting fracking. The City Council of Pittsburgh passed an ordinance banning fracking within the city limits in late 2010,[239] and other communities within the Marcellus Shale and beyond have taken similar actions.[240] Most local communities have zoning codes which specify where industrial uses may or may not take place. However, because towns, villages, and counties are political subdivisions of the state, state law may preempt local law just as federal law sometimes preempts state law.[241] On the other hand, some states have so-called "home rule" provisions which expressly reserve to local governments the power to regulate property use.[242]

***482** Despite New York's home-rule provision, the New York State Environmental Code expressly preempts local laws regulating oil and gas production (while permitting local control over roads and real property taxes).[243] In at least one case, a New York court invalidated a local zoning ordinance that imposed a bond requirement and permit fee on prospective natural gas producers, citing the statutory-preemption provision.[244] However, there is contrary precedent as well,[245] including a February 2012 New York State trial court decision upholding a local ban on fracturing in the town of Dryden, New York, under the state constitution's home-rule provision.[246] In Pennsylvania, the gradual migration of fracturing operations from rural to more urban settings has provoked legislation limiting the ability of local communities to control fracking operations through zoning laws.[247] By contrast, the New York legislature is now considering legislation that would expressly permit local communities to use zoning laws to limit or exclude ***483** fracking within their borders.[248] In Texas, some of the Barnett Shale communities use zoning laws to steer fracking and other gas production activities to areas zoned for industrial uses.[249]

These stories indicate that states and local governments are continuing to grapple with the question of how (and how much) to regulate fracking based on its local impacts. As difficult as these issues are, they are issues of state and local concern. Ongoing battles over local ordinances, and over whether state regulatory requirements ought to preempt local requirements are understandable, and even appropriate. Local governments are political subdivisions of the state, and ultimately these issues will and should be resolved at the state level.[250]

3. Fugitive Greenhouse Gas Emissions

At least one of the impacts of fracking is not solely a local concern: the emission of methane from natural gas-gathering and -processing operations. Research into this issue is in its infancy, and there is a great deal of disagreement about the actual level of emissions. However, as noted previously,[251] some analysts contend that gas production operations release significant amounts of methane into the atmosphere. These emissions are not merely of local concern because methane is a potent greenhouse gas. Indeed, it is far more potent than carbon dioxide.[252] Methane emissions thus contribute to a problem that not only extends beyond state boundaries, ***484** but also beyond national boundaries. Even small amounts of methane can have significant climate-change impacts.[253] These effects can, if significant enough, cancel out any climate-change benefits associated with replacing coal combustion with natural gas combustion (for example, in electricity production). Indeed, concern about the effects of fugitive methane emissions from natural gas production has led some environmental groups to reverse their policies in support of natural gas as a bridge fuel to help the economy wean itself from fossil fuels.[254]

How might federal regulation address methane emissions from fracking operations? Fugitive methane emissions are one focus of the ongoing EPA study of fracking. Assuming the agency concludes that fugitive methane emissions are a significant problem worthy of federal attention, does it have existing authority to regulate those emissions? As a preliminary matter, it seems clear that methane is a pollutant subject to EPA regulation under the CAA. The Supreme Court's 2007 decision in Massachusetts v. EPA[255] established that greenhouse gases fall within the CAA's statutory definition of "air pollutant."[256] That decision led eventually to the EPA's 2009 greenhouse gas-tailoring rule, which regulates methane as a greenhouse gas.[257] The tailoring rule will require new or modified major sources of methane to obtain a permit and to employ best available control technology (BACT) to control their emissions of greenhouse gases.[258] Major sources are those emitting 25,000 tons or more of carbon dioxide equivalent (CO_2e) annually.[259] Approximately 1000 tons of methane emissions are the CO_2e of 25,000 tons ***485** of carbon dioxide emissions.[260] Thus, if a natural gas production facility emits more than 1000 tons of methane per year, it is covered by the EPA rule. The Congressional Research Service estimates that methane emissions from natural gas-production facilities comprise a very small percentage of American greenhouse gas emissions annually,[261] but natural gas systems are the third largest source of methane emissions in the United States.[262] It is not clear, however, that fracking operations or subsequent production from fracked wells will be covered by the EPA rule.[263] While it remains to be seen how many fracking operations or fracked production wells would be covered by the existing tailoring rule, it appears that the EPA has the authority to set its regulatory threshold at a level lower than 25,000 tons per year of CO_2e, if it concludes that doing so is necessary to protect public health and the environment.[264] Thus, if after completion of its fracking study the EPA concludes that fugitive methane emissions pose such a risk, it could address those emissions directly by expanding the tailoring rule to cover emissions from fracking operations or fracked production wells.

In addition to the possibility of direct regulation of methane emissions under the tailoring rule, it appears that the EPA has another way to reduce climate change risks from fugitive methane emissions. The EPA has long regulated fugitive emissions of volatile organic compounds (VOCs) and sulfur dioxide from natural gas processing units,[265] and recently finalized a ***486** suite of new rules strengthening the regulation of those emissions.[266] VOCs are organic chemical substances whose compounds allow them to vaporize under normal temperatures and conditions.[267] The EPA regulates VOCs as precursors of ozone, and therefore defines VOCs as organic chemical compounds that "participate . . . in atmospheric photochemical reactions."[268] The Agency's list of VOCs includes several methane compounds; accordingly, measures taken to reduce emissions of these listed compounds will reduce methane emissions.[269] The EPA recently proposed rules that would apply to fracking operations, in hopes of achieving a 95% reduction in VOC emissions from fracked gas wells.[270] These regulations neither require individual permits nor impose a technology-based emissions standard. Instead, they impose operational performance standards--specified procedures designed to minimize emissions, including standards governing well completion[271] following fracking operations. For example, the rules require "green" well completion, a series of measures that separate salable natural gas from liquids and provide combustion of gas that would otherwise be vented.[272] The rules also specify leak control equipment for compressors and mandate emissions reductions from storage tanks, among other ***487** things.[273] The EPA projects a reduction in methane emissions of about 62 million metric tons as a result of its proposed rules, which represents about a 26% reduction in emissions from the natural gas sector.[274]

Presumably, the EPA's ongoing study of fracking will continue to examine fugitive methane emissions from fracking operations and methane production from fracked wells. Given that the Agency has yet to finalize its rules on fugitive emissions from natural-gas production operations, it seems likely that it will have ample opportunity to incorporate lessons learned from the fracking study into its final rules. The EPA may choose to strengthen existing requirements governing fugitive methane emissions, or it could establish model standards for states to follow, similar to model building codes established by the Department of Energy to promote energy efficiency.[275] Thus, it appears that the EPA is already well-equipped to address the impacts of fracking operations on climate change should its study of the industry dictate that existing emissions control measures are insufficient.

4. Wastewater Disposal

Some methods of disposing of fracking wastewater, such as direct or indirect disposal in interstate waters, have a direct interstate effect. These disposal methods are already subject to federal regulation under the CWA.[276] Similarly, disposal of fracking wastewater (either flowback water or produced water) that does not satisfy CWA disposal requirements because of the radiation in the wastewater[277] is also subject to existing federal regulatory ***488** regimes governing the disposal of low-level radioactive wastes.[278] Outside the Northeast, operators may dispose of wastewater using underground injection wells. This process is federally regulated under the SDWA.[279]

In spite of this federal regulation, there remain some troubling regulatory issues associated with wastewater disposal. Some of the worst reported contamination associated with fracking operations is associated with on-site disposal of wastes, such as covering and leaving in place waste lagoons that leaked into groundwater.[280] Some of these methods may have been permitted by state rules in effect at the times of disposal.[281] The effects of these externalities are certainly felt locally, and states have every incentive to address them. Indeed, it appears that states have amended their laws to prohibit these sorts of on-site, surface-disposal options.[282] New York's proposal to require the use of lined tanks rather than pits for liquid storage at drill sites aims at this problem.

An additional concern is that underground injection of wastewater may be associated with seismic activity (i.e., earthquakes) in some locations, though some fear that fracking operations (rather than underground wastewater disposal) are to blame.[283] If an underground injection well is placed in the wrong location, injecting increasing quantities of wastewater into the well can result in seismicity. The ability of underground injections to trigger seismic events is well-documented.[284] Recent earthquakes linked to fracking operations in Ohio,[285] Oklahoma,[286] and Arkansas[287] all appear ***489** to be the products of disposal of wastewater from gas-production operations. The SDWA underground injection well regulations authorize EPA to consider seismicity and proximity to faults when permitting various classes of underground injection wells, but there is no such admonition specifically in connection with Class II wells, the class of wells governing disposal of oil and gas wastes.[288] The EPA and state agencies to which it has delegated permitting jurisdiction do have the power to shut down permitted underground injection wells in the event the well is triggering earthquakes.[289] However, the EPA may wish to consider adding seismicity to the lists of reviews it undertakes for Class II wells. Furthermore, some experts believe that "micro-seismicity" can result directly from fracking operations under certain conditions,[290] though fracking-induced tremors ought to be far smaller in magnitude than those associated with underground injection for disposal, all else equal.[291] The SDWA cannot address the seismic risks (if any) associated with the injection of fracking fluids underground, since fracking operations are exempt from SDWA permitting requirements.[292] Should the exemption from SDWA underground injection well-permitting requirements for fracking operations be revoked?

***490** Certainly, earthquakes can be felt across state lines, depending upon their locations and magnitudes. On the other hand, there have been tens of thousands of fracking operations per year over the last several years,[293] with very few associated incidents of seismicity. Of those few, the weight of the evidence so far supports the inference that wastewater disposal through underground injection is the more likely culprit. States are beginning to take action: Ohio recently announced its intention to strengthen its underground-injection-well rules to address the seismicity problem.[294] Like many issues associated with fracking, this one requires further study. At the present time, the seismic risks associated with fracking do not seem large enough to warrant a requirement that each fracking operation undergo SDWA permitting. If further analysis reveals a stronger connection between the fracking process and earthquakes, an appropriate response could be for states or Congress to restrict fracking operations near known fault lines.

5. Groundwater Contamination

Perhaps the highest-profile risk--the one that has garnered the most public attention--is the risk that fracking operations will contaminate groundwater, particularly drinking-water wells.[295] Fracking fluids may be mixed and stored onsite in lagoons; flowback and produced water also accumulate onsite before disposal. If operators manage chemicals and water at the surface improperly, they can spill and leach into groundwater. Likewise, during the production phase methane can find its way into groundwater through leakage, if the production well is improperly constructed. Public fears, however, center on the possibility that the fracking operation itself may pose risks to groundwater.

As noted previously, the regulation of groundwater contamination has traditionally been left to the states; the CWA's permitting jurisdiction extends only to navigable surface waters and adjacent wetlands, and leaves to the states the task of regulating discharges into groundwater.[296] The SDWA does protect sources of drinking water in a number of ways, including ***491** through the establishment of the EPA's underground injection-well permitting requirements, but fracking operations are exempt from those requirements.[297] Presumably, the race to the bottom provides the primary rationale for federal regulation under the SDWA.[298]

Because of public concern about groundwater contamination, the EPA, other regulatory agencies, and various research institutions have begun to study the risks fracking operations pose to drinking water wells. A 2011 Cornell University study found a higher incidence of methane contamination in drinking-water wells located close to natural gas wells,[299] though that study's methodology did not permit the authors to determine whether the contamination preceded or followed the drilling of the gas wells nearby.[300] On the other hand, a 2011 Pennsylvania State University study sampled drinking-water wells before and after nearby fracking operations, and found no significant increase in well contamination from either methane or fracking fluid constituents.[301] Earlier findings by MIT researchers reached similar, though tentative, conclusions,[302] and preliminary findings from an ongoing University of Texas study echo the Penn State study.[303] Additional research has produced yet more room for debate. A National Academy of Sciences (NAS) study reached mixed conclusions, finding no evidence of groundwater contamination by fracking fluids or wastewater,[304] but some evidence that levels of thermogenic methane (usually found in deep shale ***492** formations) were higher in shallow groundwater aquifers near natural gas-production wells than elsewhere in the same aquifers.[305] Finally, a recent analysis by researchers at the State University of New York at Stony Brook sought to quantify the risks of groundwater contamination due to fracking operations, finding them "substantial."[306]

How can one reconcile these conflicting analyses? One possibility is that some of the studies released to date are simply failing to note instances of actual contamination that can, under the wrong circumstances, result directly from fracking. Different regions have different geological characteristics, and perhaps some regions are particularly susceptible to groundwater contamination from fracking in ways that those examined in the Penn State and Texas studies are not. However, because of the great vertical distance between fracking operations and drinking water aquifers--usually over one mile--and the relative dearth of evidence of fracking-induced contamination, the more reasonable inference is that the fracking process does not directly cause incidents of groundwater contamination. Rather, it seems more likely that incidents of contamination result from poor well construction or sloppy chemical handling at the surface. If so, these incidents can be viewed as problems of compliance with existing regulations, since state laws require wells to be constructed so as to prevent leakage and chemical spills. Poor compliance, in turn, could be a function of inadequate enforcement or deterrence at the state level. Given that fracking operations over the last decade have numbered at least in the tens of thousands,[307] some incidents of contamination from noncompliance (including significant noncompliance) are statistically likely. In any case, these groundwater issues represent mainly local, not interstate, concerns.

In sum, it appears that most of the externalities of fracking are experienced locally. Shale gas production can produce some risks that cross state boundaries, such as those associated with disposal of wastewater into interstate waters or fugitive emissions of methane. Some of these risks are ***493** already adequately addressed by federal law. Others, such as the risk of fugitive methane emissions, may not be. However, water supply issues, impacts to local character, and groundwater contamination are risks that locals almost always bear. Theoretically, then, states ought to be best suited to address those concerns through regulation--particularly since most of the direct economic benefits of shale gas production are realized by locals as well. In such situations, we might infer that those costs and benefits should be balanced within the confines of the state's political system. That inference should be true if the state is willing and able to translate popular preferences into policy efficiently, a topic that is the subject of the next Section.

B. State Capacity and the "Race to the Bottom"?

If most of fracking's effects are local, states should be in the best position to balance costs and benefits and ought to build their regulatory infrastructures accordingly. However, some people, including at least a few government officials, have challenged the capacity of states to manage the regulatory process adequately.[308] For example, commenting on the recently proposed New York fracking regulations, EPA Region II Administrator Judith Enck questioned whether the New York State Department of Environmental Conservation (NYSDEC) had sufficient staffing and other resources to handle the job.[309] While states have reacted differently to the fracking rush, New York seems a particularly unlikely candidate for capture, since its government is controlled by Democrats and the state's environmental agency maintains regulatory authority over gas production.[310] Indeed, New York has moved cautiously for the most part, studying the ***494** problem and revising its regulations prior to permitting new fracking wells.[311] This approach has resulted in the relatively slow growth in the number of gas wells drilled in New York over the last decade, at least in comparison to Pennsylvania and Texas.[312] Those latter two states have been less cautious. Both have recently produced considerably more natural gas than New York,[313] but their experiences with growth in this industry have been different from one another: fracking seems to have produced more problems and controversy in Pennsylvania than in Texas.[314] Do these differences reflect a race to the bottom in which local policymakers regulate less than they would otherwise like to in an effort to attract natural gas industry jobs and dollars?

A recent University of Texas study examined state enforcement capacity in shale gas-producing states and found "wide variation" in the ratio of enforcement staff to the number of shale gas wells.[315] Yet it concluded that "most states with current shale gas and related development have enforcement capacity necessary to address at least some complaints associated with oil and gas development and to conduct independent enforcement actions."[316] This statement is relatively circumspect, to say the least, and the University of Texas study took a close look at only four states, including Texas (but excluding New York and Pennsylvania).[317] Given that regulatory agencies routinely face budgetary constraints and information asymmetries in their efforts to regulate and monitor, it may very well be that rapid expansion in shale gas production has overwhelmed regulators in some states, particularly those without significant experience regulating natural gas production. Is this simply part of the regulatory lag problem? Can we assume that, as locals experience the externalities of fracking, they will expect their political leaders to regulate?

We might infer that this is so, because decisions governing shale gas regulation are unlike the typical race-to-the-bottom scenario, such as a decision to locate a new manufacturing plant in one of several candidate states. In the latter case, multiple states compete for a single (or small number of) large and long-lived capital investments. One (or a few) can win; the rest will lose. While the manufacturing plant can be constructed ***495** almost anywhere, absent legal impediments, fracking occurs only where shale gas deposits are found, and companies will invest in natural gas production wherever gas can be produced profitably. Investment in production in one state does not preclude simultaneous investment in another; to the contrary, companies will invest simultaneously in hundreds of wells. States are not chasing limited investment capital, as in the usual race-to-the-bottom scenario. Rather, in shale gas production, investment capital is chasing production opportunities. Thus, a state does not risk losing the economic benefits of shale gas development unless the regulatory costs it imposes on production are sufficient to render otherwise profitable production unprofitable.[318] Even then, the state does not lose that capital to another state forever; the capital may return if natural gas prices increase sufficiently to make production profitable within the state. Thus, a race to the bottom should not characterize state regulation of natural gas production.

On the other hand, there is at least a theoretical argument that, unless the costs and benefits of shale gas production are evenly distributed throughout the state, state regulators may tend to underregulate because those who do not bear the costs of fracking outnumber those who do. Consider Figure 2 below which depicts a potentially productive shale gas area within the hypothetical "ABC State." Consistent with the discussion in the previous Section, most of the external costs of shale gas production will fall primarily on the residents of Alphaville, though we might imagine some costs falling beyond the boundaries of Alphaville. Of course, Alphaville will capture some of the benefits of shale gas development as well, in the form of royalty payments to landowners, jobs, and the indirect economic benefits of production. The residents of Betaville, Gammaville, and Deltaville may also capture some of the benefits of shale gas production, including some of the ripple effects (secondary economic effects and state budgetary effects). If the costs are more closely concentrated than the benefits near the shale gas-production area in Alphaville, then it may be that the more numerous residents of Betaville, Gammaville, and Deltaville will vote in favor of relatively light regulation, outvoting their Alphaville counterparts. In that case, the residents of Alphaville may suffer from externalities that would have been outlawed or more closely regulated had they fallen upon a majority of the residents of ABC State.

***496 Figure 2: ABC State**

TABULAR OR GRAPHIC MATERIAL SET FORTH AT THIS POINT IS NOT DISPLAYABLE

One solution would be to permit local governments to retain vetoes over shale gas production within their borders. That way, those closest to the costs and benefits would be able to dominate the policy decision. Indeed, there are countless local debates taking place nationwide over whether to permit shale gas development. While heated, these debates seem to reflect the very sort of political conflict over the relative merits of development versus environmental protection that one might expect to see in well-functioning local democracies.[319] On the other hand, providing local jurisdictions with vetoes over shale gas production creates the potential for over-regulation because locals who bear most of the costs of development might veto development with positive net social benefits. The real problem is that the distribution of the costs and benefits of production will never fall neatly within the boundaries of any political jurisdiction.[320]

***497** How, then, to address the risks of under- or overregulation caused by geographically mismatched costs and benefits? One possible solution to the problem of underregulation is for the winners (those who benefit from development) to compensate the losers (those who bear the external costs of development). However, compensation is a much neater solution theoretically than practically, in part because of moral hazard problems and political distortions.[321] Another possible solution is first to determine whether underregulation or overregulation is the bigger problem. If the regulation of shale gas development is left to states and their political subdivisions, the danger of overregulation appears to be fairly remote because most of the costs and benefits of production will be experienced by voters within the (potentially) regulating jurisdictions. Despite some states' home-rule provisions, states can preempt local law, and it seems unlikely that local vetoes will prevent positive-net-benefit shale-gas development for long. If underregulation is likely to be the more common problem, it is difficult to see how federal regulation can help, since the mismatch between the people who bear the costs and those who reap the benefits is even greater at the national level.[322] Moreover, in some shale gas-producing states, like those containing the Marcellus Shale, producing areas are fairly widely distributed, reducing the intrastate geographic mismatches among the relative distributions of costs and benefits pictured in Figure 2. For all of these reasons, a race-to-the-bottom rationale for federal regulation of fracking is not a persuasive one.

C. National Interest in Shale-Gas Development?

Is there a national interest in regulating or promoting natural-gas production from shale using fracking, like the national interests previously articulated by Congress in promoting hydroelectric and nuclear energy development? In the past, national-interest rationales for comprehensive ***498** energy facility licensing regimes have been predicated on important national needs (akin to national emergencies) or important security objectives arising around a particular industry. Thus, for example, the Atomic Energy Act was passed to control and regulate the development of the most potentially destructive force then known to humankind.[323] Congress's decision to consolidate the regulation of that development in a single federal agency (the NRC) was based, in significant part, on safety and national security reasons.[324] The Federal Power Act was one of several New Deal laws aimed at promoting energy infrastructure and development in rural areas during the Great Depression.[325] It was part of a pro-development response to a national emergency, which in Congress's view necessitated the delegation of strong powers to the Federal Power Commission to preempt state regulation of hydropower.[326] Congress has also tended to apply the national interest rationale to energy facilities that produce externalities extending across state lines or into national waters. Thus, the centralized regulatory system governing leasing of oil exploration on the Outer Continental Shelf addresses not only energy security but also high-magnitude environmental risks in national waters.[327]

The last decade has seen tens of thousands--and possibly hundreds of thousands--of fracking operations conducted nationwide.[328] While there is no comprehensive registry of reports of environmental, health, and safety problems caused by fracking, their number appears to be quite small when compared to the number of fracking operations conducted. We cannot be certain yet whether those reports reflect serious problems pervading the industry or the expected incidence of compliance failures with otherwise adequate regulations. Numerous government agencies and NGOs are studying the environmental, health, and safety impacts of fracking operations. Many of the problems studied seem likely candidates for technical or ***499** procedural solutions, which can be implemented by states or existing federal regulatory authorities. In this setting, it seems unnecessary, and certainly premature, to conclude that shale-gas production has created the kind of pressing national need that would justify a centralized federal licensing or regulatory regime.

On the other hand, it appears at first glance that regulation promoting natural gas development might be justified on energy security grounds, since natural gas is a plentiful domestic resource.[329] Historically, natural gas markets have been characterized by price volatility,[330] reflecting a market in which (1) demand has varied considerably over the short term,[331] particularly in colder climates where natural gas was used as the primary heating fuel; and (2) there was (and is) insufficient storage capacity[332] to cope with large, short-term variations in demand. After the mid-1980s, natural gas demand in the United States increased steadily[333]-- as did imports--until 2005.[334] Around that time, natural gas price movements began to diverge from those of oil ***500** prices, and imports began to decline.[335] A large part of the reason for these developments was the new availability of plentiful, domestically produced shale gas.[336] The availability of large quantities of domestically produced gas has stabilized natural gas markets, reducing prices from more than $13 per MMBtu in 2006 to less than $3 per MMBtu in January 2012.[337] This ample supply offers American policymakers and consumers the increased energy security that comes with the knowledge that the United States has domestic reserves sufficient to meet consumer demand for a long time to come.[338]

However, the nature of the energy security gains provided by this source of domestic supply depends upon a number of factors. Currently, Americans use natural gas primarily for electricity generation and domestic heating and cooking.[339] A reliable supply of inexpensive natural gas could alter the profile of natural gas in the American electric generation mix. Natural gas-fired generation currently comprises a little more than 20% of the American electric generation mix,[340] and natural gas has been the ***501** fastest-growing electric generation fuel (by total generating capacity added) over the last decade.[341] Increasing our natural gas-fired electric generating capacity does little or nothing to increase energy security, since the fuels that natural gas would displace are domestically produced. Coal-fired power generation (a little less than 50% of the current generation mix), nuclear power (about 20%), and renewable power (about 10%) all rely on domestically available sources.[342] However, if the United States were to expand its uses of natural gas to include transportation, domestic natural gas might displace some petroleum imports, enhancing the country's energy security. An examination of the possible conversion of the United States' vehicle fleet from gasoline to natural gas is beyond the scope of this Article, but it is clear that such a conversion is technically feasible. Many government and corporate vehicle fleets currently run on natural gas,[343] and at least one commercially available consumer automobile model runs on natural gas.[344] On the other hand, a larger-scale conversion would require an enormous investment in infrastructure for refueling a natural gas-powered consumer vehicle fleet, an investment that seems unlikely in the near term given the dearth of such proposals in Congress and the lack of any encouragement for such a move from the federal energy bureaucracy.[345] Absent a national commitment to such a conversion, the energy security argument for a national regulatory regime to ensure natural gas production remains an unpersuasive one.

However, such a regime might be justified in furtherance of another national objective--the protection of public health and the environment ***502** through the reduction of air pollution. Two 2011 studies--one by public health and medical professionals, and another by economists--are illustrative of a larger literature pointing toward the conclusion that the displacement of coal-fired electric generation by natural gas-fired generation would yield enormous public welfare benefits. The first study, reported in the Annals of the New York Academy of Sciences (a multidisciplinary scientific journal), examined the health effects of the coal industry on a lifecycle basis, estimated health impacts (premature deaths, illness, and injuries) from the extraction, processing, transport, and combustion of coal, and sought to quantify the value of these external costs.[346] The authors, a large group of researchers from various public health and academic institutions,[347] estimated that these externalities cost the American public as much as half a trillion dollars each year,[348] and "conservatively" estimated that if these costs were internalized (that is, borne by the industry), the price of electricity generated from coal would double or triple.[349]

The second study, reported in the American Economic Review, offered a framework for integrating environmental externalities into national economic accounts, by quantifying damages associated with air pollution emissions from 820 industries (including all of the major polluting industries) and comparing the harm with the value added to the economy by those industries.[350] The authors concluded that the ratio of environmental damage to value added for eight of those industries, including oil- and coal-fired power plants, but not natural gas-fired power plants, was greater than one.[351] The authors concluded further that coal-fired combustion created by far the largest amount of environmental damage of any industry in the United States, which they estimated at approximately $53 billion per year.[352] By contrast, they estimated environmental damages from natural gas-fired production to be less than $1 billion per year.[353] The authors estimated the ***503** costs of coal-fired generation to be approximately 2.8 cents per kilowatt hour (cents/kwh), from oil-fired generation to be 2 cents/kwh, and from natural gas-fired generation to be approximately 0.1 cents/kwh.[354]

According to both of these studies, the bulk of the harm from coal combustion is attributable to mortality resulting from emissions of conventional air pollutants, primarily sulfur dioxide, fine particles, and nitrogen oxides. Environmental harm from greenhouse gas emissions pales in comparison, representing well under 1% of the harm estimated in the American Economic Review analysis. Stated differently, these studies imply that "the regulated levels of emissions from the industr[ies]" where environmental damage exceeds value added "are too high."[355] Other studies have reached similar conclusions,[356] and offer further support for the notion that coal combustion imposes very large mortality, morbidity, and environmental costs on American society--costs that dwarf those associated with natural gas-fired power.[357] In fact, in 1970, Congress established a national policy aimed at this type of harm when it resolved to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population" through the passage of the CAA.[358]

Does the existence of a national policy in favor of cleaner air imply the need to use federal regulation to promote shale gas development? Not necessarily, for two reasons. First, there are institutional measures in place regulating harmful emissions. For example, the CAA already provides an adequate vehicle for addressing coal-fired power plant emissions. Existing ***504** EPA rules regulate emissions of sulfur dioxide, particulate matter, and ozone precursors from coal-fired power plants,[359] and the Obama Administration is moving forward with new rules aimed at reducing emissions of mercury,[360] carbon dioxide,[361] and nitrogen oxides[362] from coal-fired power plants. While regulatory action to address emissions from coal-fired power plants has been contentious and halting,[363] these new rules are apparently stringent enough to have attracted the intense opposition of industry.[364] Second, the market seems to be providing sufficient incentives for shale gas development on its own, without federal help, at least for the time being. The excess supply of shale gas has, in fact, caused prices to fall to unprecedented lows.[365] Nor does it seem likely that a cascade of state and local bans on shale gas production will constrain supply any time soon. To the contrary, each state is addressing local conflicts over shale gas production on its own terms. Under current conditions, then, comprehensive federal licensing legislation for shale gas production seems unnecessary, at least for the time being.

Finally, it should be noted that there are two existing regulatory regimes that proponents of comprehensive federal regulation of shale gas production might point to as precedents. More specifically, these are regulatory ***505** regimes that were based upon stated national interests in regulating despite the local nature of the externalities involved. One such regime is the SDWA, which is difficult to justify on national emergency or interstate pollution externalities grounds.[366] The protection of groundwater--even for drinking purposes--seems primarily a local concern, yet Congress made its protection a matter of federal responsibility. Why? As a risk-regulation regime covering multiple industries, the SDWA (including its underground-injection-well program) can be justified on race to the bottom grounds in ways that federal regulation of fracking cannot. That is, in the absence of federal regulation protecting drinking water wells, one can at least imagine a narrowly self-interested waste disposer forum-shopping for a state in which disposal is unregulated.[367] As a matter of historical reality, it seems that the SDWA was Congress's response to a perceived instance of state regulatory failure. The statute authorizes light-handed regulation, designed to push states to ensure that drinking water is safe. Congress made a policy judgment that the SDWA was necessary to protect public health, and that it had the constitutional power to regulate it.[368] There is an ongoing process of documenting and measuring the environmental, health, and safety impacts of fracking, as well as its benefits, including environmental ones, and its costs. We do not yet have a clear picture of either side of the balance, and the SDWA's regulation of similarly localized activities does not seem reason enough to federalize the regulation of shale gas production.

A second useful precedent for proponents of federalizing the regulation of shale gas production is the SMCRA.[369] This act created a federal licensing regime for coal mining, one Congress deemed necessary because of the importance of the coal industry to the national economy and because state environmental regulation had failed.[370] The regulatory program established by the SMCRA set up federal standards that states can administer by federally approved programs, thus providing minimum federal standards to ***506** which states must adhere.[371] Most of the impacts of surface mining are felt locally in the form of denuded land and changes in the character of the area, just as in the fracking context.[372] The coal industry was certainly a nationally important industry (even a strategic one) at the time of the SMCRA's enactment, but one could argue that the natural gas industry is becoming equally important within the American energy policy environment. On the other hand, the impacts of surface mining were well understood at the time of the SMCRA's passage,[373] and they dwarf those associated with fracking. Yet the differences and similarities between surface mining and shale-gas production are matters of judgment, and the SMCRA remains an example of federal regulation of an essentially local (albeit enormous) environmental problem, likely not plagued by significant race-to-the-bottom problems. However, the fact that Congress has exercised federal regulatory authority in past situations that are not explained by the traditional rationales for federal regulation does not constitute a strong case for regulating shale-gas production today.

Conclusion: The Case for Narrow Federal Regulation Only

It is certainly conceivable that the case for greater regulation of shale-gas production may turn out to be strong. Indeed, to many it appears that such regulation has lagged behind the industry's growth, which has triggered controversy and public opposition to fracking in some places and a process of adaptation by regulators. Controversy over fracking will be resolved politically, by actors whose concerns for principles of federalism will probably be dwarfed by their desires to promote or restrict fracking for policy reasons. Opponents and proponents of shale-gas production mobilize their supporters and advance their arguments for and against regulation at all levels of government. Local ordinances, state laws, and federal laws ***507** addressing fracking (by permitting, prohibiting, or regulating it) are the products of this political conflict: opponents of fracking may prevail in one setting, proponents of fracking in another. The product of these political processes is a seemingly messy regulatory environment, characterized by fragmentation and fluidity.

A single federal regulatory regime for shale-gas production would certainly be a much neater solution, at least conceptually. A federal licensing regime could both preempt unnecessarily restrictive local laws and establish uniform minimum standards applicable across the country. Such an approach would relieve producers from having to worry about multiple state regulatory regimes, and a system of well-drawn rules might provide a minimum level of environmental protection in the event states or localities fail to regulate adequately.

But however conceptually easy that solution sounds, it is problematic for at least two reasons. First, it assumes that federal government actors (Congress or the EPA) can better regulate and balance the costs and benefits of fracking than can state and local government officials whose constituents are directly experiencing most of those costs and benefits. Whatever the potential imperfections of the local policymaking process, such as susceptibility to capture or a race to the bottom, the most important impacts of shale-gas production--changes in local character of the community, potential contamination of groundwater, and water supply issues--are matters of local concern.

Moreover, despite regulatory lags in some places, state and local governments appear to be adjusting to new information about the local risks associated with fracking and shale gas production. Local governments are amending their ordinances and states are updating their regulatory regimes to respond to newly--or better--understood risks. For instance, both Texas and Pennsylvania have recently strengthened their regulations governing fracking, and New York will soon establish a new regulatory regime for fracking. These actions are typical of states where fracking occurs. There is no evidence to suggest that the states' varying approaches to these questions reflect industry capture; an equally likely explanation is that each state is balancing the costs and benefits of development differently. For these reasons, the enactment of a comprehensive licensing program or broad federal regulation focused on shale-gas production seems, at the very least, premature at this time.

For now, the better option is for the federal government to restrict its regulation of fracking to those aspects of the industry that produce interstate effects or implicate established national interests. For example, fracking ***508** can entail air pollution that poses a threat to established national air pollution standards and greenhouse gas emissions reduction goals, and the EPA is well equipped to address those risks under the CAA. In particular, the EPA is studying the problem of fugitive methane emissions from natural gas production operations--a problem afflicting all natural gas production, not simply fracturing operations. Nevertheless, the explosive growth in natural gas production means that fugitive emissions have grown accordingly. Given the agency's interest in reducing greenhouse gas emissions, we can expect the EPA to propose additional limits on fugitive emissions in the future, perhaps as a byproduct of its study on the risks of fracking. Likewise, the EPA can use the CWA and SDWA's regulatory regimes to address risks associated with the disposal of fracking wastewater into surface waters, sewage treatment facilities, and underground injection wells. The EPA has the power to propose new effluent standards governing the issuance of NPDES permits for the disposal of wastewater from fracking operations and pretreatment standards for the disposal of that wastewater to municipal sewage treatment plants. Both problems are within the domain of its ongoing study of fracking, and we might anticipate new rules addressing those risks as well.

Continuing regulatory adjustment by states (and by the EPA using existing federal authority), then, is an appropriate response to rapid change, and is to be expected. The use of fracking to produce natural gas from shale formations is, despite its explosive growth, still a relatively young industry. Its growth has caught regulators by surprise, and they are responding in myriad ways. We are still learning about the impacts of this form of natural gas production, and as we learn, we can adapt. Based upon the application of the principles of federalism to this regulatory issue, federal regulators ought to let that process of learning and adaptation play out mostly in the states, intervening only to address risks of national concern.

Footnotes

d1 Professor of Law, Politics & Regulation, University of Texas at Austin. Professor Spence wishes to thank participants in the Northwestern University Law School's Searle Center 2012 Conference on Federalism and Energy in the United States for their insightful comments on an earlier draft of this Article and Andrew Dittmar for his research assistance during the preparation of this Article.

1 Bloomberg reported recently that "[t]he U.S. is the closest it has been in almost 20 years to achieving energy self-sufficiency" and that it could become the world's top energy producer in less than ten years. Rich Miller et al., Americans Gaining Energy Independence with U.S. as Top Producer, Bloomberg (Feb. 6, 2012), http://www.bloomberg.com/news/2012-02-07/americans-gaining-energy-independence-with-u-s-as-top-producer.html.

2 For a description of this production technique, see infra Section I.A.

3 See Howard Rogers, Shale Gas--The Unfolding Story, 27 Oxford Rev. Econ. Pol'y 117, 118 (2011) ("In North America, in 2001 domestic production began a pronounced decline and large-scale liquefied natural gas (LNG) imports appeared inevitable by 2010.").

4 The U.S. Energy Information Administration's (EIA) most recent estimate of the United States' unproved technically recoverable shale gas reserves is 482 trillion cubic feet (Tcf), which represents a significant increase in total reserves. U.S. Energy Info. Admin., Annual Energy Outlook 2012: Early Release Overview 9 (2012), available at http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2012).pdf; see also infra note 32 and accompanying text.

5 One way to predict natural gas prices is to look at "forward curves" produced by the New York Mercantile Exchange (NYMEX). These curves are based upon prices of futures contracts--contracts for the sale of natural gas at various points in the future. For a fuller explanation of natural gas forward curves, see Mark Bolinger et al., Accounting for Fuel Price Risk: Using Forward Natural Gas Prices Instead of Gas Price Forecasts to Compare Renewable to Natural Gas-Fired Generation, 34 Energy Pol'y 706 (2006).
As of September 2012, the NYMEX forward curve for natural gas projects that prices will remain at or below five dollars per million British thermal units (MMBtu) over the next five years. Gas Futures Trading: Forward Price Curve, FERC, http://www.ferc.gov/market-oversight/mkt-gas/trading/ngas-tr-fwd-pr.pdf (last updated Sept. 4, 2012). This compares with natural gas spot prices that varied between $1.74 and $18.48 per MMBtu in the first decade of the twenty-first century. See Henry Hub Gulf Coast Natural Gas Spot Price, U.S. Energy Info. Admin., http://www.eia.gov/dnav/ng/hist/rngwhhdd.htm (last updated Oct. 1, 2012). A British thermal unit is roughly the amount of energy required to raise the temperature of one pound of water one degree, from thirty-nine to forty degrees Fahrenheit.

6 See Roberto F. Aguilera & Roberto Aguilera, World Natural Gas Endowment as a Bridge Towards Zero Carbon Emissions, 79 Technological Forecasting & Soc. Change 579, 579 (2012) ("As the world economy continues to expand over the long term, natural gas has the potential to play a significant role in satisfying energy demand and acting as a bridge towards renewables."); Joe Nocera, How to Frack Responsibly, N.Y. Times, Feb. 28, 2012, at A25 (noting Environmental Defense Fund President Fred Krupp's support for the notion of natural gas as a bridge fuel).

7 See Guy Chazan, Shale Gas Boom Helps Slash US Emissions, Fin. Times (May 23, 2012), http://www.ft.com/intl/cms/s/0/3aa19200-a4eb-11e1-b421-00144feabdc0.html (quoting IEA chief economist Fatih Birol supporting this conclusion). Indeed, in April 2012, coal-fired power's share of American electricity generation fell to virtually equal to that of natural gas for the first time. See Monthly Coal- and Natural Gas-Fired Generation Equal for First Time in April 2012, U.S. Energy Info. Admin. (July 6, 2012), (July 6, 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=6990.

8 Office of Fossil Energy, U.S. Dep't of Energy, Modern Shale Gas Development in the United States: A Primer, at ES-1 (2009) [hereinafter OFE, Shale Gas Primer], available at http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf.

9 The term "externality" refers to costs of production that are not borne by the firm, but rather are shifted to society. Externalities can be either negative or positive. For a discussion of the economics of negative externalities, see Tom Tietenberg, Environmental and Natural Resource Economics 51-54 (3d ed. 1992). For a discussion of the externalities of shale gas production, see infra Section I.B.

10 For a discussion of public attitudes toward shale gas production, see infra Section I.B.

11 Hannah Wiseman has referred to this process as "regulatory adaptation." See Hannah Wiseman, Regulatory Adaptation in Fractured Appalachia, 21 Vill. Envtl. L.J. 229, 252-82 (2010) (arguing that while states have adapted with some success in the face of tremendous information asymmetries, there remain regulatory gaps to be filled).

12 See infra Section II.B.

13 See, e.g., infra notes 117-119 and accompanying text (describing the ban on fracking in New York).

14 See infra Section II.B.

15 See infra note 36 and accompanying text.

16 The EPA has outlined the goals and design of the study in Office of Research & Dev., EPA, EPA/600/R-11/1212, Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources 1-8, 20-22 (2011), available at

http://www.epa.gov/hfstudy/HF_Study__Plan_110211_FINAL_508.pdf.

17 See United States v. Lopez, 514 U.S. 549, 559-68 (1995) (holding that an activity can be regulated by Congress under the Commerce Clause if it "substantially affects" interstate commerce); see also United States v. Morrison, 529 U.S. 598, 611 (2000) (requiring activities that are regulated under the Commerce Clause to be "some sort of economic endeavor"). The Lopez and Morrison decisions involved federal attempts to regulate activities that were essentially not economic in nature. See Morrison, 529 U.S. at 601-02 (reviewing the constitutionality of federal civil remedies for victims of gender-motivated violence); Lopez, 514 U.S. at 551 (reviewing the constitutionality of a federal criminal offense for possession of firearms within a school area). Natural gas production, by contrast, is clearly an economic activity closely connected to interstate commerce, since natural gas markets cross state lines.

18 For a thorough description of the race-to-the-bottom argument, see infra subsection III.A.1.

19 Some scholars offer broader rationales for federal environmental regulation that focus on protecting moral rights or giving effect to the preferences of out-of-state actors even when the costs and benefits of the potentially regulated activity fall entirely within the state. For a discussion of these arguments, see infra note 149 and accompanying text.

20 See Andrew Chow, Vermont Bans Fracking, Citing Injury Concerns, FindLaw (May 23, 2012, 8:43 AM), http://blogs.findlaw.com/injured/2012/05/vermont-bans-fracking-citing-injury-concerns.html; Tara Patel, France to Keep Fracking Ban to Protect Environment, Sarkozy Says, Bloomberg (Oct. 4, 2011), http://www.bloomberg.com/news/2011-10-04/france-to-press-ahead-with-shale-research-after-fracking-ban.html; see also Steve Hargreaves, The Fracking Public Relations Mess, CNNMoney (June 21, 2011), http://money.cnn.com/2011/06/21/news/economy/fracking_public_ relations/index.htm (discussing fracking bans in Maryland, Quebec, Germany, South Africa, and elsewhere). For a fuller explanation of the New York ban, see infra notes 118-21 and accompanying text.

21 See Mireya Navarro, Judge's Ruling Complicates Gas Drilling Issue in New York, N.Y. Times, Feb. 22, 2012, at A23 (discussing litigation in New York regarding state restrictions on fracking); John Kemp, Making Fracking Politically Acceptable, Reuters (Feb. 6, 2012), http:// www.reuters.com/article/2012/02/06/column-fracking-politics-idUSL5E8D62Q920120206 ("Hydraulic fracturing has already unleashed a storm of threatening protest threatening the technology's viability."); Jim Polson, New Yorkers Split on Marcellus Shale Gas Drilling, Survey Finds, Bloomberg (Sept. 21, 2011), http://www.bloomberg.com/news/2011-09-21/new-yorkers-split-on-marcellus-shale-gas-drilling-survey-finds.html (describing results of a survey that indicates comparatively higher opposition to drilling among upstate New York residents who have both more to gain and more to lose from fracking operations).

22 Martin Kramer, Manual of Oil and Gas Terms 64, 676 (10th ed. 1997).

23 Some shale gas formations are even deeper. For an in-depth description of the major shale gas formations in the United States, including data on their respective depths, see OFE, Shale Gas Primer, supra note 8, at 17.

24 For an uncomplicated video intelligibly explaining how fracking works, see MarathonOilCorp, Animation of Hydraulic Fracturing (Fracking), YouTube (Apr. 26, 2012) [hereinafter Animation of Hydraulic Fracturing], http://www.youtube.com/watch?v=VY34PQUiwOQ.

25 Eric Schramm, What Is Flow Back, and How Does it Differ from Produced Water?, Inst. for Energy & Envtl. Research for Northeastern Pa. (Mar. 24, 2011), http://energy.wilkes.edu/pages/205.asp.

26 Id.; see also Animation of Hydraulic Fracturing, supra note 24.

27 See OFE, Shale Gas Primer, supra note 8, at 9-10 (attributing the growth in fracking to technological innovations that made the process "economically viable").

28 The Barnett Shale holds an estimated 84 Tcf of technically recoverable reserves. Press Release, U.S. Geological Survey, USGS Releases New Assessment of Gas Resources in the Marcellus Shale, Appalachian Basin (Aug. 23, 2011), available at http://www.usgs.gov/newsroom/article.asp?ID=2893.

29 The Haynesville Shale is a shale gas formation located in northern Louisiana and eastern Texas. It is estimated to contain approximately 75 Tcf of recoverable reserves. See Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays, U.S. Energy Info. Admin. (July 8, 2011), http:// www.eia.gov/analysis/studies/usshalegas.

30 The Marcellus Shale holds an estimated 43 Tcf of technically recoverable reserves. James L. Coleman et al., U.S. Geological Survey, U.S. Dep't of the Interior, Assessment of Undiscovered Oil and Gas Resources of the Devonian Marcellus Shale of the Appalachian Basin Province, 2011 tbl.1 (2011), available at http://pubs.usgs.gov/fs/2011/3092.

31 U.S. Total Natural Gas Consumption, U.S. Energy Info. Admin., http://www.eia.gov/dnav/ng/hist/n9140us2m.htm (last updated Sept. 28, 2012).

32 Estimates of technically recoverable amounts of gas are frequently revised by the EIA and the U.S. Geological Survey, two of the more widely followed sources of data on this topic. The EIA most recent estimate of technically recoverable reserves is approximately 2200 Tcf. Frequently Asked Questions: How Much Natural Gas Does the United States Have and How Long Will It Last?, U.S. Energy Info. Admin., http://www.eia.gov/tools/faqs/faq.cfm? id=58&t=8 (last updated Aug. 29, 2012). This is a considerable increase from previous estimates, which fluctuated between approximately 350 and 850 Tcf. Technically Recoverable Shale Gas Resources Jump 134 Percent, Inst. for Energy Res. (May 16, 2011), http:// www.instituteforenergyresearch.org/2011/05/16/technically-recoverable-shale-gas-resources-jump-134-percent.

33 U.S. Natural Gas Wellhead Price, U.S. Energy Info. Admin., http:// www.eia.gov/dnav/ng/hist/n9190us3m.htm (last updated Sept. 28, 2012). The EIA data are expressed in dollars per thousand cubic feet (mcf). One thousand cubic feet of natural gas contains approximately one million btu.

34 E.g., Platts: November Asia LNG Prices Climb, LNG World News (Oct. 18, 2012), http://www.lngworldnews.com/platts-asia-lng-november-spot-prices-rise ($13.005 per MMBtu).

35 See, e.g., James Inhofe, Federal Interference in Energy Development Regulation a Bad Idea, Hill (July 19, 2011), http://thehill.com/special-reports/energy-july-2011/172393-federal-interference-in-regulation-of-energy-development-a-bad-idea ("Since the first use of hydraulic fracking ... producers have completed more than 1.5 million fracturing jobs without one confirmed case of groundwater contamination ...."); Hydraulic Fracking Overview, Empire Energy F. (Jan. 10, 2011), http:// www.empireenergyforum.com/article/hydraulic-fracturing-overview (responding to New York citizens' concerns about hydraulic fracturing and asserting that no U.S. government study has found evidence that fracking leads to water contamination).

36 See, e.g., Sean Savett, Inhofe Is Wrong: Five Famous Times Fracking Contaminated Our Water, ThinkProgress (July 21, 2011, 10:04 AM), http:// thinkprogress.org/climate/2011/07/21/274064/inhofe-is-wrong-five-famous-times-fracking-contaminated-our-water.

37 For a discussion of these studies, see infra notes 45-51 and accompanying text.

38 See Paul R. Epstein et al., Full Cost Accounting for the Life Cycle of Coal, 1219 Ann. N.Y. Acad. of Sci., Feb. 2011, at 73, 82-83 (assessing the negative externalities associated with coal production, including premature deaths). For a summary of other studies estimating the external costs of coal, see External Costs of Coal, SourceWatch, http://www.sourcewatch.org/index.php?title=External_costs_of_coal (last visited Nov. 16, 2011).

39 On the other hand, natural gas (methane) is itself a potent greenhouse gas. To the extent that natural gas production generates increases in fugitive emissions of natural gas from production facilities and pipelines, a move from coal- to natural gas-fired generation might not yield much in the way of greenhouse gas emissions benefits. See, e.g., Ramón A. Alvarez et al., Greater Focus Needed on Methane Leakage from Natural Gas Infrastructure, 109 Proc. Nat'l Acad. Sci. 6435, 6438 (2012) (concluding that reductions in methane leakage are needed to maximize the environmental benefits of natural gas).

40 John D. Podesta & Timothy Wirth, Ctr. for Am. Progress, Natural Gas: A Bridge Fuel for the 21st Century 3 (2009), available at http:// www.americanprogress.org/issues/2009/08/pdf/naturalgasmemo.pdf; Joel Kirkland, Natural Gas Could Serve as "Bridge Fuel" to a Low-Carbon Future, Sci. Am. (June 25, 2010), http://www.scientificamerican.com/article.cfm?id=natural-gas-could-serve-as-bridge-fuel-to-low-carbon-future (discussing the efforts of environmental advocates to promote the use of natural gas as a short-term option for cutting emissions caused by coal-fired power plants).

41 U.S. Energy Info. Admin., U.S. Dep't of Energy, DOE/EIA-0560(98), Natural Gas 1998: Issues and Trends 53 fig.22 (1999), available at http:// www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_ issues_trends/pdf/it98.pdf.

42 For a more thorough description of the environmental consequences of fracking and some state efforts to regulate those consequences, see Wiseman, supra note 11, at 253-75.

43 OFE, Shale Gas Primer, supra note 8, at 64. The New York State Department of Environmental Conservation estimates that a typical fracking job would require "2.4 million to 7.8 million gallons of water." N.Y. State Dep't of Envtl. Conserv'n, Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program at 5-93 to -94 (2011), available at http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf.

44 OFE, Shale Gas Primer, supra note 8, at 66. Flowback water contains constituents that were originally in the fracturing fluids, as well as dirt, silt, and other elements or contaminants added to the water during its time underground.

45 There is considerable disagreement about the degree to which fracking exacerbates water supply problems. The Railroad Commission of Texas established a task force to study water supply issues in the Eagle Ford Shale, which concluded in January 2012 that fracking did not threaten local water supplies. Press Release, R.R. Comm'n of Tex., Eagle Ford Task Force Finds South Texas Water Supply Sufficient (Jan. 26, 2012), available at http:// www.rrc.state.tx.us/commissioners/porter/press/012612.php. But cf. Rick Spruill, Water Availability, Not Contamination, Worries Residents Above Eagle Ford Shale, Caller.com (Oct. 15, 2011), http:// www.caller.com/news/2011/oct/15/water-availability-not-contamination-worries (reporting on local water shortages that occurred soon after fracking operations began in Karnes County, Texas); Water Worries Shadow Eagle Ford Development, Am. Water Intelligence (Jan. 2011), available at http:// www.americanwaterintel.com/archive/2/1/general/water-worries-shadow-eagle-ford-development.html (describing experts' uncertainty about the impact of fracking on the water supply in the Eagle Ford region).

46 The components of fracturing fluids have become generally known over the last few years, in part because of efforts by regulatory agencies to compel disclosure, and in part because of voluntary disclosure efforts by natural gas producers and their contractors. For an introduction to the composition of fracturing fluid, see OFE, Shale Gas Primer, supra note 8, at 61-64.

47 For a thorough discussion of the toxicity of the constituents of fracturing fluids used in New York State, see N.Y. State Dep't of Envtl. Conserv'n, supra note 43, at 5-63 to -79.

48 Id. at 5-76 to -77, 5-79.

49 See, e.g., Ken Cohen, "Fracking" Fluid Disclosure: Why It's Important, ExxonMobil Persps. (Aug. 25, 2011), http:// www.exxonmobilperspectives.com/2011/08/25/fracking-fluid-disclosure-why-its-important (identifying several common household products containing the same chemicals found in fracturing fluid mixtures).

50 See New EPA-Aproved [sic] Fracking Fluid 100% Green, Business Wire (Jan. 10, 2012, 11:00 AM), http://

www.businesswire.com/news/home/20120110005568/en/EPA-Aproved-Fracking-Fluid-100-Green (discussing a new eco-friendly biocide recently approved by the EPA and the FDA that will not "harm ground water, area land or jeopardize the health of workers during the fracking process"); see also Emran Hussain, Baker Hughes Launches Green Fracking Fluid Systems, ArabianOilandGas.com (Dec. 9, 2010), http://www.arabianoilandgas.com/article-8157-baker-hughes-launches-green-fracking-fluid-systems (reporting the launch of environmentally friendly fracking fluids and additives). Some natural gas producers have begun to advocate "propane fracking"--a technique for fracturing rock that uses liquid propane instead of conventional fracking fluids. E.g., Safe and Efficient, Gasfrac Energy Services, http://www.gasfrac.com/safer-energy-solutions.html (last visited Nov. 16, 2012); see also Anthony Brino, Waterless Fracking Technique Makes Its Debut in Ohio, Midwest Energy News (May 15, 2012), http:// www.midwestenergynews.com/2012/05/15/waterless-fracking-technique-makes-its-debut-in-ohio (describing the early experimental stage of fracking with liquid propane gas in the Utica Shale).

51 See William J. Kemble, Kingston Won't Accept Fracking Fluids at Sewage Treatment Plant, Daily Freeman (Kingston, N.Y.) (Dec. 19, 2011), http:// www.dailyfreeman.com/articles/2011/12/19/news/doc4eee73521641a869886272.txt (citing concerns by local officials that prompted them to decline treating wastewater from fracturing operations at a local sewage treatment plant). Wastewater can become radioactive because of radioactive elements that enter the water deep underground. For a description of these so-called "naturally-occurring radioactive materials" (NORM), see Oil and Gas Production Wastes, EPA, http://www.epa.gov/radiation/tenorm/oilandgas.html (last updated Aug. 30, 2012).

52 See The Hydraulic Fracturing Water Cycle, EPA, http:// www.epa.gov/hfstudy/hfwatercycle.html (last updated Oct. 19, 2012) (summarizing wastewater disposal options).

53 This method of discharge would require obtaining a National Pollutant Discharge Elimination System (NPDES) permit under the Clean Water Act. See 33 U.S.C. §1342(a) (2006) (providing that the Administrator of the EPA may issue a permit for discharge after holding a public hearing, as long as certain other statutory conditions are met).

54 Sewage treatment facilities maintain their own NPDES permit system under the Clean Water Act. However, the Clean Water Act imposes "pretreatment" standards on parties that would discharge to sewage treatment plants. For example, if a discharge of wastewater to a sewage treatment facility disrupts the treatment process of the facility (e.g., by killing the biological organisms that are used to treat sewage), that discharge would violate the Clean Water Act's pretreatment rules. See 40 C.F.R. §403.5(a)(1) (2011).

55 Underground injection of wastewater from gas production operations may have triggered recent earthquakes in Ohio and Texas. See Pete Spotts, How Fracking Might Have Led to an Ohio Earthquake, Christian Sci. Monitor (Jan. 2, 2012), http://www.csmonitor.com/Science/2012/0102/How-fracking-might-have-led-to-an-Ohio-earthquake (noting that several cities have prohibited new wastewater-injection wells close to existing wells that have been linked to recent seismic activity). But see David J. Hayes, Is the Recent Increase in Felt Earthquakes in the Central US Natural or Manmade?, U.S. Dep't of Interior (Apr. 11, 2012), http://www.doi.gov/news/doinews/Is-the-Recent-Increase-in-Felt-Earthquakes-in-the-Central-US-Natural-or-Manmade.cfm (indicating that, while changes in the seismicity rate are likely manmade, there is no evidence linking fracking to an increased rate of earthquakes).

56 See Don Hopey, Gas Drillers Recycling More Water, Using Fewer Chemicals, Pittsburgh Post-Gazette (Mar. 1, 2011), http://www.post-gazette.com/stories/local/region/gas-drillers-recycling-more-water-using-fewer-chemicals-210363 (describing one company's wastewater-recycling progression used in the Marcellus Shale from 80% of its wastewater in 2009 to 90% in 2010, and its ultimate goal of 100% recycling in 2011). Recycling may be far more common in the Marcellus Shale than elsewhere due to the unavailability of inexpensive disposal methods in other states. Stephen Rassenfoss, From Flowback to Fracturing: Water Recycling Grows in the Marcellus Shale, J. Petroleum Tech., July 2011, at 48, 48, available at http:// www.spe.org/jpt/print/archives/2011/07/12Marcellus.pdf. In order to reuse wastewater in another fracking operation, the water must be treated to remove solids and elements that might otherwise inhibit fracking production. Id. at 50. For a description of one company's proprietary recycling technology, see Marcellus Gas Well Hydrofracture Wastewater Disposal by Recycled Treatment Process, ProChemTech Int'l, Inc., http:// www.prochemtech.com/Literature/TAB/PDF_TAB_Marcellus_Hydrofracture_Disposal_by_ Recycle_1009.pdf (last visited Nov. 16, 2012).

57 See Ian Urbina & Jo Craven McGinty, Learning Too Late of Perils in Gas Well Leases, N.Y. Times, Dec. 2, 2011, at A1

(describing the negative impacts of fracking operations on the property of lessor landowners); see also Vicki Vaughan, Shale Play a Worry for Bexar Ozone, San Antonio Express-News (May 23, 2012), http://www.mysanantonio.com/business/article/Shale-play-a-worry-for-Bexar-ozone-3581077.php (describing the effect of truck traffic in the Eagle Ford Shale in Texas on ozone levels in the region).

58 One widely reported study by Robert Howarth and others estimates that up to 7.9% of the methane produced from natural gas wells escapes into the atmosphere as the result of leaks or venting. See Robert W. Howarth et al., Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations, 106 Climatic Change 679, 687 (2011) (finding that, within a "20-year horizon, the greenhouse gas footprint for shale gas is at least 20% greater than and perhaps more than twice as great as that for coal when expressed per quantity of energy available during combustion"); Gabrielle Pétron et al., Hydrocarbon Emissions Characterization in the Colorado Front Range: A Pilot Study, J. Geophys. Res., Feb. 2012, at 1 (suggesting that existing estimates of fugitive methane emissions from gas operations are conservative); cf. Lawrence M. Cathles, The 8% vs. 2% Debate: Comments on Selected Papers (2012), http://www.geo.cornell.edu/eas/PeoplePlaces/Faculty/cathles/Gas%20Blog%20PDFs/0%20Comments%C20*o*n%C20selected%Päpers.pdf (reporting a leakage rate of between 2% and 4%); Michael Levi, Yellow Flags on a New Methane Study, Council on Foreign Rel. (Feb. 13, 2012), http://blogs.cfr.org/levi/2012/02/13/yellow-flags-on-a-new-methane-study (identifying methodological problems and inaccurate assumptions with the Pétron study).

59 A report from Cambridge Energy Research Associates contends that the Howarth study is plagued by methodological errors that resulted in an overestimate of methane emissions from gas production operations. Mary Lashley Barcella et al., Cambridge Energy Research Assocs., Measuring Methane: Estimating Greenhouse Gas Emissions from Upstream Natural Gas Development 9-10 (2011), available at http://www.ihs.com/info/en/a/mis-measuring-methane-report.aspx (identifying a number of methodological problems, including an assumption that "all flowback methane is vented, when industry practice is to capture and market as much [methane] as possible, flaring much of the rest"); see also David A. Kirchgessner et al., Estimate of Methane Emissions from the U.S. Natural Gas Industry, 35 Chemosphere 1365, 1366 (1997) (noting that most studies on methane emissions measure "unaccounted for gas," which consistently leads to overestimates).

60 See, e.g., Mike Soroghan, Baffled about Fracking? You're Not Alone, N.Y. Times (May 13, 2011), http://www.nytimes.com/gwire/2011/05/13/13greenwire-baffled-about-fracking-youre-not-alone-44383.html (noting a "well-known [water] contamination case" in Dimock, Pennsylvania, where fracking operations caused methane to seep into local wells). For a fuller discussion of government and academic studies of groundwater contamination associated with fracking, see infra subsection IV.A.5.

61 However, in some places (e.g., portions of the Marcellus Shale), shale gas is found at shallower depths. While the industry is able to measure the size and location of fractures produced by fracking operations, it is not always able to predict the degree of fracturing. This uncertainty gives rise to the possibility that a fracturing operation could cause methane or fracturing fluids to seep into groundwater tables.

62 See Soroghan, supra note 60 ("[M]ethane contamination is not caused by injecting chemicals down the well. It is caused by bad well construction during drilling.").

63 See Urbina & McGinty, supra note 57 (describing the effects of fracking operations in which operators merely covered, rather than removed, waste after the projects' completion).

64 Michael Rubinkam, Pa. Regulators Suspend Cabot Oil & Gas Drilling Over Contamination of Wells in Pa., Minn. Star Trib. (Minneapolis-St. Paul) (Apr. 15, 2010), http://www.startribune.com/templates/Print_This_Story? sid=90960344. Similar claims have been brought against Southwest Energy Production Company and Atlas Energy. See Berish v. Sw. Energy Prod. Co., 763 F. Supp. 2d 702, 704 (M.D. Pa. 2011) (discussing allegations that Southwest's water contamination "has not only exposed Plaintiffs to hazardous materials and created the possibility of causing present and future health problems, but it has also lowered the value of [their] properties"); Jon Hurdle, Pennsylvania Lawsuit Says Drilling Polluted Water, Reuters (Nov. 9, 2009), http://www.reuters.com/article/2009/11/09/us-fracking-suit-idUSTRE5A80PP20091109 (discussing the lawsuit of a private citizen against Atlas for allegedly polluting his soil and water).

65 Rubinkam, supra note 64. For an analysis of the factual issues at play in groundwater contamination claims in the Marcellus Shale, see Lynn Kerr McKay et al., Science and the Reasonable Development of Marcellus Shale Natural Gas Resources in Pennsylvania and New York, 32 Energy L.J., 125, 138-43 (2011). Pennsylvania subsequently lifted that ban. Michael Rubinkam, Cabot Allowed to Resume Fracking in Dimock Twp., Times-Leader (Wilkes-Barre, Pa.), Aug. 21, 2012, at 6A.

66 Some Pennsylvania residents have accused the state's environmental agency of turning a blind eye to contamination of drinking-water wells by gas drilling operations. See Pa. Woman: Chemicals in My Water in Drilling Area, Wall St. J. (Feb. 24, 2012), http:// online.wsj.com/article/APe8e13e02557d4e98ad3d2b92eda99448.html (noting that the state's Department of Environmental Protection "failed to do follow-up tests" when it suspected contamination).

67 See Office of Research & Dev., EPA, 600/R-00-/000, Draft: Investigation of Groundwater Contamination Near Pavillion, Wyoming 33 (2011) (finding evidence of wellwater contamination resulting from fracking operations through the use of both shallow and deep monitoring wells).

68 Indep. Petrol. Ass'n of Am., Six--Actually, Seven--Questions for EPA on Pavillion, Energy in Depth, http://www.energyindepth.org/six-questions-for-EPA-on-pavillion (last updated May 21, 2012).

69 In April 2011, Chesapeake Energy, a major shale gas producer in Pennsylvania, suffered a blowout of one of its wells, causing spills of drilling fluids. Edward McAllister, Chesapeake Stems Flow from Blown Pennsylvania Gas Well, Reuters (Apr. 22, 2011), http:// www.reuters.com/article/2011/04/22/us-chesapeake-blowout-idUSTRE73K5OH20110422.

70 See Office of Research & Dev., supra note 16.

71 Id. at 7.

72 For a comprehensive description of these cycles in the U.S. prior to World War II, see generally Daniel Yergin, The Prize: The Epic Quest for Oil, Money and Power chs. 1-17 (1991); James Stafford, The Real Reason Behind Oil Price Rises--An Interview with James Hamilton, Oilprice.com (Aug. 28, 2012), http://oilprice.com/Interviews/The-Real-Reason-Behind-Oil-Price-Rises-An-Interview-with-James-Hamilton.html.

73 Specifically, the "rule of capture" specifies that no single owner of a portion of the field may prevent an adjoining landowner from producing oil and gas from the field, even if that production pulls minerals out from under adjoining lots. For an illustration of the rule of capture at work, see Barnard v. Monongahela Natural Gas Co., 65 A. 801, 801-03 (Pa. 1907). For an analysis of the modern rule of capture and its effects, see Bruce M. Kramer & Owen L. Anderson, The Rule of Capture: An Oil and Gas Perspective, 35 Envtl. L. 899, 925-33 (2005).

74 Production by multiple owners of a single field constitutes a classic prisoner's dilemma. While the parties might wish to cooperate in order to maximize production from a single field, there is a temptation for individual owners to defect from any cooperative arrangement, and garner more revenue for themselves. However, if all parties to the agreement defect, the market for oil is glutted, and prices fall.

75 Yergin, supra note 72, at 231-37.

76 The process of managing the rights of multiple owners of a single oilfield involves prorating production and sharing revenues. State commissions, like the Railroad Commission of Texas and the Oklahoma Corporation Commission, oversee these processes. For a brief history of the early proration orders issued by the Texas and Oklahoma commissions, see Stephen L. MacDonald, Petroleum Conservation in the United States: An Economic Analysis 36-37 (1971).

77 For examples of these rules, see infra Section II.B.

78 Some commentators have referred to this period of intense growth in federal environmental regulation as "the environmental decade." Political scientist Lettie Wenner may have been the first to coin this phrase. See Lettie M. Wenner, The Environmental Decade in Court (1982).

79 Clean Air Act Extension of 1970, Pub. L. No. 91-604, 84 Stat. 1676 (codified as amended at 42 U.S.C. §§7401-7671q (2006)).

80 Federal Water Pollution Control Amendments of 1972, Pub. L. No. 92-500, 86 Stat. 816 (codified as amended at 33 U.S.C. §§1251-1387).

81 Pub. L. No. 94-580, 90 Stat. 2795 (1976) (codified as amended at 42 U.S.C. §§6901-6992k). The RCRA authorizes the EPA to promulgate "cradle to grave" regulations of hazardous waste generation, transport, treatment, storage, and disposal. 42 U.S.C. §6922(a)(4).

82 Pub. L. No. 93-523, 88 Stat. 1660 (1974) (codified as amended at 42 U.S.C. §§300f-300j-26).

83 Pub. L. No. 91-596, 84 Stat. 1590 (1970) (codified as amended at 29 U.S.C. §§651-700).

84 For extensive surveys of federal and state regulations of fracking operations, see Charles P. Groat & Thomas W. Grimshaw, Univ. of Tex. at Austin Energy Institute, Fact-Based Regulation for Environmental Protection in Shale Gas Development 33-55 (2012), and Hannah Wiseman, Untested Waters: The Rise of Hydraulic Fracturing in Oil and Gas Production and the Need to Revisit Regulation, 20 Fordham Envtl. L. Rev. 115, 142-67 (2009).

85 42 U.S.C. §300h(b)(1).

86 See id. §300h(b)(1)(A) ("Such regulations shall require that a State program ... shall prohibit ... any underground injection in such State which is not authorized by a permit issued by the State (except that the regulations may permit a State to authorize underground injection by rule) ...."); id. §300h-4(a) (providing that underground injection operations are permitted if the State demonstrates that "such portion of the State program meets the requirements of subparagraphs (A) through (D) of section 300h(b)(1) ... and represents an effective program (including adequate recordkeeping and reporting) to prevent underground injection which endangers drinking water sources").

87 Id. §300h(d)(1)(B)(ii).

88 See Brief of Respondent at 13, Legal Envtl. Assistance Found., Inc. v. EPA, 118 F.3d 1467 (11th Cir. 1997) (No. 95-6501), 1995 WL 17057927 ("EPA has ... never interpreted 'well injection' to include hydraulic fracturing operations related to methane production. Rather, EPA has focused the [underground injection control] program on regulation of wells at which the 'principal function' is underground emplacement of fluids, not wells at which any 'emplacement' is wholly incidental to production." (citation omitted)).

89 Coalbed methane is natural gas (methane) that is found in coal seams. See Kramer, supra note 22, at 160-61.

90 Office of Ground Water & Drinking Water, EPA, 816-R-04-003, Evaluation of Impacts to Underground Sources of Drinking Water by Fracking of Coalbed Methane Reserves 7-5 (2004), available at http://www.epa.gov/ogwdw/uic/pdfs/cbmstudy_attach_uic_ch07_conclusions.pdf.

91 The Bureau of Land Management (BLM) proposed a rule in May 2012 that would require disclosure of fracturing fluid constituents in connection with fracking operations on BLM lands. Oil and Gas; Well Stimulation, Including Hydraulic Fracturing, on Federal and Indian Lands, 77 Fed Reg. 27,691, 27,710 (proposed May 11, 2012) (to be codified at 43 C.F.R. pt. 3160). The proposed rule would also establish certain wellbore construction rules and rules governing the handling and disposal of produced and flow backwater from fracking operations on BLM lands. Id. at 27,710-11.

92 42 U.S.C. §§11001-11050.

93 Id. §11023(a)-(b).

94 See EPA, EPA 260-R-10-001, Toxic Chemical Release Inventory Reporting Forms and Instructions 1 (2011) (listing the industries to which the toxic chemical release form applies, and not listing SIC code 13). Originally, the requirement applied only to owners and operators of facilities that are in SIC codes 20-39, the manufacturing industries. 42 U.S.C. §11023(b)(1)(A). While the EPA has expanded its coverage somewhat, the requirement remains inapplicable to the natural gas-production industry.

95 See U.S. Dep't of Labor, Standard Industrial Classification Manual, Major Group 13: Oil and Gas Extraction, OSHA, http://www.osha.gov/pls/imis/sic_ manual.display?id=8&tab=group (last visited Nov. 16, 2012).

96 The Inventory is the publicly available compendium of information aggregated from all the submitted toxic chemical release forms. To access the inventory, see Toxic Release Inventory, EPA, http://www.epa.gov/tri/ (last updated Oct. 16, 2012).

97 42 U.S.C. §11021.

98 See FracFocus Chemical Disclosure Registry, http://fracfocus.org/ (last visited Nov. 16, 2012).

99 49 U.S.C. §§ 5101--5127; see also id. § 5110 (shipping papers and disclosure); 49 C.F.R. §171.15 (incident disclosure rules).

100 The bill was called the Fracturing Responsibility and Awareness of Chemicals (FRAC) Act. H.R. 2766, 111th Cong. (2009).

101 It was introduced into the 112th Congress, as well, in March of 2011 but never came to a vote. See Thomas, Libr. of Congress, http:// thomas.loc.gov/home/thomas.php (click "Word/ Phrase"; enter "FRAC" in text box; click "Search") (last visited Nov. 16, 2012).

102 See Summary of the Resource Conservation and Recovery Act, EPA, http://www.epa.gov/lawsregs/laws/rcra.html (providing basic information about the implementation, compliance, enforcement, and history of the RCRA).

103 The RCRA mandated that the EPA should "develop and promulgate criteria for identifying the characteristics of hazardous waste, and for listing hazardous waste, ... taking into account toxicity, persistence, and degradability in nature, potential for accumulation in tissue, and other related factors." 42 U.S.C. §6921(a) (1976).

104 Hazardous Waste Guidelines and Regulations, 43 Fed. Reg. 58,946, 58,955-57 (Dec. 18, 1978) (to be codified at 40 C.F.R. pt. 25).

105 Id. at 58,991.

106 Id. at 58,991-92.

107 See 42 U.S.C. §6921(b)(2)(A) (Supp. IV 1981) ("[D]rilling fluids, produced waters, and other wastes associated with the ... production of crude oil or natural gas or geothermal energy shall be subject only to existing State or Federal regulatory programs in lieu of this subchapter until ... after promulgation of [certain] regulations ...."). In 1988, the EPA issued a report explaining the basis for the exemption. Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25,446 (July 6, 1988). The EPA explained that (1) adopting RCRA Subtitle C requirements would result in impractical burdens or "disruption and, in some cases, duplication" of state regimes; (2) compliance with current state and federal requirements for management and disposal would prevent most cases of damage to health and the environment; and (3) the oil and natural gas industry, as well as consumers, would suffer from the prohibitive costs of regulation. Id. at 25,454-56.

108 Presumably, most fracking fluids do not exhibit the characteristics of hazardous waste, as any toxic constituents present comprise a minute fraction of the mixture. However, the RCRA generally treats a mixture as a hazardous waste if any nonexempted ingredient of the mixture is a hazardous waste. 40 C.F.R. §261.3(a)(2)(iv) (2012).

109 See supra notes 80-82 and accompanying text.

110 A thorough review of state regulatory standards is beyond the scope of this Article. For a good description of state regulation of fracking, see Wiseman, supra note 84, at 142-67; and Groat & Grimshaw, supra note 84, at 33-55.

111 See infra Table 2.

112 See id.

113 See Newark, East (Barnett Shale) Drilling Permits Issued (1993 Through June 2012), Railroad Commission Tex., http://www.rrc.state.tx.us/barnettshale/drillingpermitsissued.pdf (showing a peak of 4145 Barnett Shale drilling permits in 2008) (last visited Nov. 16, 2012).

114 Texas Eagle Ford Shale Drilling Permits Issued 2008 Through September 2012, Railroad Commission Tex., http://www.rrc.state.tx.us/eagleford/EagleFordDrillingPermitsIssued.pdf (estimating that 4293 permits will be issued for Eagle Ford Shale drilling through 2012) (last visited Nov. 16, 2012); see also Robert W. Gilmer et al., Oil Boom in Eagle Ford Shale Brings New Wealth to South Texas, Sw. Econ., 2d Quarter 2012, at 3, 3 (calling Eagle Ford "[p]erhaps the largest discovery of new oil reserves in the United States since ... 1968").

115 See infra Table 2.

116 For a description of these regimes, see infra notes 126-139 and accompanying text.

117 In January 2012, the Railroad Commission of Texas promulgated new rules requiring operators to provide additional information about the makeup of fracturing fluids and other information about their operations. 16 Tex. Admin. Code §3.29(c) (2012). Pennsylvania also adopted new rules to regulate fracking in February 2012. See Corbett Signs Shale Well Impact Fee into Law, Pittsburgh Post-Gazette (Feb. 14, 2012), http://www.post-gazette.com/pg/12045/1210009-503.stm ("[T]he measure ... will charge drillers a per-well fee, update state environmental regulations and subject local zoning ordinances to state-crafted standards."). For a more comprehensive description of the regulatory changes that have taken place in Pennsylvania since 2009, see McKay et al., supra note 65, at 132-34.

118 The New York ban, enacted by executive order of the Governor, required further environmental review of high-volume fracking in the Marcellus Shale. Exec. Order No. 41 (N.Y.) (Dec. 13, 2010), available at http://www.governor.ny.gov/archive/paterson/executiveorders/EO41.html (last visited Nov. 16, 2012). It followed the Governor's veto of

state legislation imposing a much broader ban. See Governor David Paterson's Veto Message No. 6837 (Dec. 10, 2010), vetoing S.B. 8129-B, Leg. 233d Sess. (N.Y. 2010). The veto and executive order both followed an announcement by the Delaware River Basin Commission that natural gas producers must apply for commission approval before drilling in shale formations that lie within the Delaware River basin. See Carol R. Collier, Del. River Basin Comm'n, Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations Within the Drainage Area of Special Protection Waters (May 19, 2009), available at http:// www.state.nj.us/drbc/library/documents/EDD5-19-09.pdf (providing official notification of the new approval process to gas extraction project sponsors). For a report detailing various responses to Governor Andrew Cuomo's efforts to lift the moratorium on fracking, see Danny Hakim & Nicolas Confessore, Cuomo Moving to End a Freeze on Gas Drilling, N.Y. Times, July 1, 2011, at A1.

119 The proposed rules were detailed in a Supplemental Generic Environmental Impact Statement published by the New York Department of Environmental Conservation. See N.Y. State Dep't. of Envtl. Conserv'n, supra note 43, at ch. 3.

120 See Danny Hakim, Cuomo Proposal Would Restrict Gas Drilling to Struggling Region, N.Y. Times, June 14, 2012, at A1 (reporting that the ban would be lifted in only a few economically distressed communities in New York's southern tier that have passed resolutions in favor of the drilling process).

121 See Danny Hakim, Shift by Cuomo Clouds Future of Gas Drilling, N.Y. Times, Oct. 1, 2012, at A1.

122 The data in Table 2 come from the U.S. Energy Information Administration and are available for download at Number of Producing Gas Wells, U.S. Energy Info. Admin., http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm (last updated Nov. 2, 2012).

123 See infra notes 126-139 and accompanying text.

124 25 Pa. Code §78.71(a) (2011). Similarly, rather than specify the depth of surface casing, the rules state that the operator must ensure that the casing is of sufficient depth to protect groundwater. Id. §78.73(b).

125 N.Y. Comp. Code R. & Regs. tit. 6, §554.1(d) (2011).

126 The Texas rules require cement casing "from the shoe [the bottom of the surface casing] to a point at least 600 feet above the shoe." 16 Tex. Admin. Code §3.13(b)(3)(A) (2003).

127 See id. §3.13(b)(1)(A) (specifying that "all casing cemented in any well shall be steel casing"); id. §3.13(b)(2)(A)(ii) (requiring that the cement casing be installed by the "pump and plug method"); id. §3.13(b)(2)(C) (detailing the quality of cement to be used).

128 Id. §1.13(b)(1)(A)(requiring the use of hydrostatic pressure testing).

129 16 Tex. Admin. § 3.13(c)(2)(B).

130 For example, the Pennsylvania rules require blowout preventers only under certain conditions, 25 Pa. Code §78.72(a) (2011), while the New York rules stipulate that "[w]ellhead connections adequate to control blowouts will be employed," including blowout preventers, "[i]n areas where the subsurface formations and pressures are unknown or uncertain." N.Y. R. & Regs. §554.3(b) & .4(c).

131 See 16 Tex. Admin. § 3.29(c)(2) (requiring operators of fracking wells to complete the form posted on the fracking chemical registry website).

132 See N.Y. State Dep't of Envtl. Conserv'n, supra note 43, at 8-30; see also N.Y. R. & Regs. §560.3(c) (proposed Sept. 28, 2011) (requiring disclosure of each fracking fluid additive and the proposed volume of each additive with each application for permit).

133 Act of Feb. 14, 2012, P.L. 87, No. 13, § 3222.1(b) (Pa.) (to be codified at 58 Pa. Cons. Stat. Ann. § 3222.1(b) (West 2012)).

134 16 Tex. Admin. §§3.8(d)(4), 3.9(1). The rules governing disposal wells require consultation with the Texas Commission on Environmental Quality and compliance with that agency's rules. Id. §§3.8(J)(1)(B)(i) & 3.9(2).

135 25 Pa. Code §§ 78.56(a)(4)(i), (iii).

136 Id. §78.55-60.

137 N.Y. R. & Regs. § 556.5(a).

138 Id. § 556.4(a).

139 For a complete description of the proposed rule in New York, see N.Y. State Dep't of Envtl. Conserv'n, supra note 43. For a comparison of various state rules, see Groat & Grimshaw, supra note 84, at 6-1 to -31.

140 This argument has become known as the "structure and process" hypothesis, and is associated with Mathew McCubbins, Roger Noll, and Barry Weingast (sometimes known collectively in the literature as "McNollgast"). See Mathew D. McCubbins, Roger G. Noll & Barry R. Weingast, Administrative Procedures as Instruments of Political Control, 3 J.L. Econ. & Org. 243, 253-64 (1987) (exploring the principles of political control of bureaucratic decisions through oversight and administrative procedure); Matthew [sic] D. McCubbins, Roger G. Noll & Barry R. Weingast, Structure and Process, Politics and Policy: Administrative Arrangements and the Political Control of Agencies, 75 Va. L. Rev. 431, 435-45 (1989) [hereinafter McNollgast, Structure and Process] (arguing that where legislative specificity is not possible, elected officials can ensure the achievement of policy goals by carefully structuring the processes of administrative agencies). Similarly, Jonathan Macey has emphasized the ways in which politicians can "hardwire" an agency in support of a particular policy perspective through structural choices, such as defining the agency's mission, establishing its internal organizational structure, and choosing its location within the larger executive branch. See Jonathan R. Macey, Organizational Design and the Political Control of Administrative Agencies, 8 J.L. Econ. & Org. 93, 99-108 (1992). Macey has also argued that using structural design and process to shape the policy outcomes of administrative agencies has important limitations. See Jonathan R. Macey, Separated Powers and Positive Political Theory: The Tug of War over Administrative Agencies, 80 Geo. L.J. 671, 675-702 (1992) [hereinafter Macey, Separated Powers] (noting that the efforts of Congress and the President to influence the policy outcomes of an administrative agency are limited by judicial review and by the power of subsequent Presidents to redirect the orientation of the agency at a later time).

141 See McNollgast, Structure and Process, supra note 140, at 468-81 (describing legislators' use of structure and process to constrain and anticipate agency decisions in the context of environmental regulation); see also Arthur Lupia & Matthew [sic] McCubbins, Designing Bureaucratic Accountability, 57 Law & Contemp. Probs. 91, 106-10 (1994) (discussing ways in which legislatures design agencies to retain effective control and oversight over their policy agendas).

142 See 16 Tex. Admin. Code §3.30 (2012) (spelling out the jurisdictional relationship between the Railroad Commission of Texas and the TCEQ in connection with oil and gas production, and assigning to TCEQ jurisdiction over hazardous waste disposal, stormwater, underground injection wells, and various other externalities of gas production).

143 Data available upon request from the author and from the University of Texas, McCombs School of Business Energy Management and Innovation Center.

144 See Jody Freeman, Op-Ed., The Wise Way to Regulate Gas Drilling, N.Y. Times, July 6, 2012, at A23 (advocating a "cooperative federalism" approach to fracking regulation).

145 See supra note 17.

146 See Jason Scott Johnston, The Tragedy of Centralization: The Political Economics of American Natural Resource Federalism, 74 U. Colo. L. Rev. 487, 616-17 (2003) (arguing that whether an activity has a substantial effect on interstate commerce "says nothing about the general need for federal resource regulation").

147 For some influential examples of this literature, see Matthew D. Adler & Seth F. Kreimer, The New Etiquette of Federalism: New York, Printz and Yeskey, 1998 Sup. Ct. Rev. 71 (1999); Barry Friedman, Valuing Federalism, 82 Minn. L. Rev. 317 (1997); Larry D. Kramer, Putting the Politics Back into the Political Safeguards of Federalism, 100 Colum. L. Rev. 215 (2000); Michael W. McConnell, Federalism: Evaluating the Founders' Design, 54 U. Chi. L. Rev 1484 (1987); Edward L. Rubin & Malcolm Feeley, Federalism: Some Notes on a National Neurosis, 41 UCLA L. Rev. 903 (1994); and Herbert Wechsler, The Political Safeguards of Federalism: The Role of the States in the Composition and Selection of the National Government, 54 Colum. L. Rev. 543 (1954).

148 This tradition includes economists and rational-choice political scientists who model this problem as one of maximizing social welfare (the aggregated utility of individuals). Under this approach, regulatory authority ought to be exercised by the level of government that is able to translate individual preferences into policy choices most accurately. This tradition arose out of a seminal article in the economics literature by Charles Tiebout. See Charles M. Tiebout, A Pure Theory of Local Expenditures, 64 J. Pol. Econ. 416, 416, 419-20 (1956) (describing a "model [that] yields a solution for the level of expenditures for local public goods which reflects the preferences of the population more adequately than they can be reflected at the national level"). For examples of the application of this rational-choice approach to regulatory federalism questions, see William A. Fischel, Fiscal and Environmental Considerations in the Location of Firms in Suburban Communities, in Fiscal Zoning and Land Use Controls 119, 125-43 (Edwin S. Mills & Wallace E. Oates eds., 1975); James E. Krier, The Irrational National Air Quality Standards: Macro- and Micro-Mistakes, 22 UCLA L. Rev. 323, 323, 335-41 (1974); Richard O. Zerbe, Optimal Environmental Jurisdictions, 4 Ecology L.Q. 193, 209-22 (1974). See also Johnston, supra note 146, at 614 (arguing that centralization may "inefficiently stifle development in order to transfer economic rents across jurisdictions"); infra notes 159-60 and accompanying text. Some argue that rational choice critiques of federal regulation are cover for attacks on regulation generally. See, e.g., Carol M. Browner, Partners in Protecting the Public, Wash. Post, May 30, 1994, at A15 (contending that critics of "federal-state partnership[s]" seek to "undermine federal protection of public health and natural resources"); see also Rubin & Feeley, supra note 147, at 935.

149 Joshua Sarnoff, for example, attacks the rational-choice approach directly by arguing that local decisions that fail to account for the preferences of out-of-state citizens will not be welfare-maximizing decisions. See Joshua D. Sarnoff, The Continuing Imperative (But Only from a National Perspective) for Federal Environmental Protection, 7 Duke Envtl. L. & Pol'y F. 225, 244 (1996) ("When states refuse to provide political recognition to the interests of out-of-state citizens ... they may reduce social welfare by preventing reciprocal bargaining to establish 'efficient' prices for legal entitlements."). Sarnoff has argued that when Congress acts to address a problem the costs and benefits of which are felt locally, its action is legitimate because it reflects the preferences of out-of-state voters who care about the problem. Id. at 243-48. This argument makes the boundaries of federal power coterminous with the boundaries of the proper exercise of federal power. One rejoinder to this view is offered by environmental economists, who have found that people who may never use or visit an environmental resource tend to overstate the true value they attach to its existence because expressing a preference is costless. This is a kind of moral hazard problem that is endemic to attempts at valuing environmental resources using stated measures of "existence value." See, e.g., Daniel C. Esty, Revitalizing Environmental Federalism, 95 Mich. L. Rev. 570, 595 n.73 (1996) ("[W]ithout a 'willingness to pay' mechanism to check the reality and depth of such harms, there exists a moral hazard problem of potentially significant proportions because those claiming [psychological] injury have little reason to report accurately on their welfare losses and much reason to exaggerate."). Sarnoff also argues that environmental regulation aimed at protecting basic rights renders the rational-choice analysis irrelevant, noting that "if federal regulation codifies moral rights, the argument that federal regulation reduces social welfare may simply be irrelevant." Sarnoff, supra, at 232-33. This view is a descendant of earlier morality-based views of environmental protection, such as that espoused by the ecologist Aldo Leopold. See Aldo Leopold, A Sand County Almanac 165-77 (1960) (rejecting the view of nature as an economic good rather than an aesthetic one); see also Steven Kelman, Cost-Benefit Analysis and Environmental, Safety and Health Regulation: Ethical and Philosophical Considerations, in Cost-Benefit Analysis and Environmental Regulations: Politics, Ethics, and Methods 137, 138-43 (Daniel Swartzman et al. eds., 1982) (questioning whether a cost-beneficial policy is necessarily the right

policy); Steven Kelman, Economists and the Environmental Muddle, Pub. Int., Summer 1981, at 106, 109 (surveying individuals involved in environmental policy in Washington, D.C., and finding that few cite efficiency as an argument for pollution-charging policies); Christopher H. Schroeder, Cool Analysis Versus Moral Outrage in the Development of Federal Environmental Criminal Law, 35 Wm. & Mary L. Rev. 251, 255-58 (1993) (emphasizing that environmental criminal law conceives of environmental regulation as establishing moral obligations, as opposed to merely economic or administrative obligations). Finally, some advocate a "dynamic federalism" in which regulatory responses are multi-layered and adaptive to changing circumstances. See, e.g., David E. Adelman & Kirsten H. Engel, Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority, 92 Minn. L. Rev. 1796 (2008); Hari M. Osofsky & Hannah J. Wiseman, Dynamic Energy Federalism, 72 Md. L. Rev. (forthcoming 2013) (manuscript at 55), available at http:// ssrn.com/abstract=2138127 (arguing that dynamic federalism can account for situations in which regulatory capture is a risk).

150 We typically justify national government regulation (as opposed to state government regulation) using one or more of these rationales. Rationales for federal regulation are to be distinguished from rationales for regulation generally. Rationales for regulation, such as the need to force firms to internalize externalities and the need to protect consumers in the presence of information asymmetries, do not necessarily militate in favor of federal government regulation, if state regulation will suffice.

151 This list of four rationales is adapted from Peter S. Menell & Richard B. Stewart, Environmental Law & Policy 246-47 (1994); and William N. Eskridge, Jr. & John Ferejohn, The Elastic Commerce Clause: A Political Theory of American Federalism, 47 Vand. L. Rev. 1355, 1363-64 (1994).

152 See, e.g., Wallace E. Oates, Thinking About Environmental Federalism, Resources, Winter 1998, at 14, 14 ("The central idea emerging from the literature in public economics is that the responsibility for providing a particular public service should be assigned to the smallest jurisdiction whose geographical scope encompasses the relevant benefits and costs associated with the provision of the service.").

153 See, e.g., Menell & Stewart, supra note 151, at 246 ("One possible justification [for national regulation] is the existence of substantial environmental spillovers from one state to another.")

154 42 U.S.C. §7426(b) (2006) (providing that "[a]ny State or political subdivision may petition the Administrator for a finding that any major source or group of stationary sources emits or would emit" pollution in violation of certain federal laws). Indeed, the Clean Air Act's acid rain program (added to the statute by the Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 104 Stat. 2468) and its embattled program for regulating transport of nitrogen oxides in the eastern United States address this spillover problem directly. See id. §7651 ("The Congress finds that ... the problem of acid deposition is of national and international significance ....").

155 For a good discussion of the argument for decentralizing environmental regulation, as well as a discussion of "worthy" environmental policy innovations pioneered by the states, see Barry G. Rabe, Power to the States: the Promise and Pitfalls of Decentralization, in Environmental Policy in the 1990s 31, 34-46 (Norman J. Vig & Michael E. Kraft eds., 3d ed. 1997).

156 See, e.g., Gary C. Bryner, Blue Skies, Green Politics: The Clean Air Act of 1990 and Its Implementation 24-25 (2d ed. 1995) ("[S]tate legislatures may fail to delegate sufficient authority to regulatory bodies for them to effectively implement environmental laws and may fail to provide adequate staffing of state regulatory agencies."); see also Paul R. Portney, Air Pollution Policy, in Public Policies for Environmental Protection 27-31 (Paul R. Portney ed., 1990) (detailing the failure of state focused efforts to control air pollution prior to the passage of the Clean Air Act of 1970). But see Rabe, supra note 155, at 32-34 (explaining the expanded state capacity for and state commitment to environmental policy over the first twenty years after Earth Day).

157 See Kirsten H. Engel, State Environmental Standard-Setting: Is There a "Race" and Is It "To the Bottom"?, 48 Hastings L.J. 271, 315-67 (1997) (marshaling empirical evidence to support the race-to-the-bottom theory); Richard B. Stewart, Pyramids of Sacrifice? Problems of Federalism in Mandating State Implementation of National Environmental Policy, 86 Yale L.J. 1196, 1212 (1977) (arguing that the mobility of industry poses a risk for "any individual state or community [that decides] unilaterally to adopt high environmental standards," and communities may reasonably "fear that the resulting environmental gains will be more than offset by movement of capital to other areas with lower standards"); see also Menell & Stewart, supra note 151, at 246 ("[S]tates might seek to attract industry by adopting less stringent and therefore less costly environmental regulation," such that federal

regulation "might be justified in order to secure for states the environmental quality that they prefer.").

158 See Menell & Stewart, supra note 151, at 246; see also Johnston, supra note 146, at 498-530 (arguing that as natural resources grow increasingly scarce, locals capture the benefit of development but externalize many of the costs, providing an incentive for overdevelopment and justifying centralized federal regulation).

159 Perhaps the most prominent critic is Richard Revesz, who argues that states may relax environmental standards not because they are caught in a prisoner's dilemma, but rather because they are making a conscious choice to balance economic development against environmental protection. In other words, some states may place a higher value on the underlying polluting activity than others, and that choice ought to be respected. See Richard L. Revesz, Rehabilitating Interstate Competition: Rethinking the "Race-to-the-Bottom" Rationale for Federal Environmental Regulation, 67 N.Y.U. L. Rev. 1210, 1233-44 (1992); see also David Schoenbrod, Time for the Federal Environmental Aristocracy to Give Up 5-6 (1998) (echoing Revesz); Henry N. Butler & Jonathan R. Macey, Externalities and the Matching Principle: The Case for Reallocating Environmental Regulatory Authority, 14 Yale L. & Pol'y Rev. 23, 31 (1996) (same).

160 There also exist robust criticisms of Revesz's arguments. See, e.g., Sarnoff, supra note 149, at 278-85, 318 (arguing that "it defies credulity to believe [states] will achieve the goals on their own" given states' inability to achieve environmental goals both before and after the passage of major federal environmental laws); see also Engel, supra note 157, at 315-57, 375 (using industry location studies and empirical observation to conclude that "the preponderance of the evidence indicates that states engaged in interstate competition for industry are also engaged in a race-to-the-bottom in environmental standard-setting"). But see Richard L. Revesz, The Race to the Bottom and Federal Environmental Regulation: A Response to Critics, 82 Minn. L. Rev. 535, 546-63 (1997) (reasserting his claim that state competition in a market for mobile investment can be welfare-enhancing). For a middle ground, see Esty, supra note 149, at 648-52.

161 See Menell & Stewart, supra note 151, at 247 ("[L]egitimate but conflicting state product requirements could create a regulatory crazy-quilt.").

162 See 42 U.S.C. §7521(a) (2006).

163 See id. §6312.

164 See Pub. L. No. 74-333, 49 Stat. 842 (directing the Federal Power Commission (now FERC) to issue hydroelectric licenses on the condition that the applicant's plan is "best adapted to develop, conserve, and utilize in the public interest the water resources of the region") (codified as amended at 16 U.S.C. §803(a)(1)).

165 See Pub. L. No. 83-703, §1(a), 68 Stat. 919, 921 ("It is therefore declared to be the policy of the United States that... the development, use, and control of atomic energy shall be directed so as to make the maximum contribution to the general welfare....") (codified as amended at 42 U.S.C. §2011(a)).

166 That is, interest group pluralism treats the policy process as a tug of war between organized groups. Because groups undertake direct lobbying on behalf of their members, only those interests represented by groups will be heard (or at least, influential) in the policy process. Interest group pluralism was the dominant theory of American policymaking in political science in the 1950s and '60s. For a relatively recent summary and literature review, see generally G. David Garson, Group Theories of Politics (1978). See also Jack L. Walker, Jr., Mobilizing Interest Groups in America: Patrons, Professions, and Social Movements 19-55 (1991) (exploring the dynamics of interest group formation and pressure).

167 Here, I use the term "public choice" to describe work that both (1) draws on the methodology and perspective of economics to study political and policy phenomena and (2) ascribes selfish, "rent seeking" motives to actors in the policy process. That is not necessarily the only definition of "public choice," and as I have argued elsewhere, legal scholarship has conflated rational choice methods with normative skepticism about the ability of politics and policy to produce decisions that represent majority preferences. See, e.g., David B. Spence, A Public Choice Progressivism, Continued, 87 Cornell L. Rev. 397, 413-18 (2002) (exploring the

distinction between these two ideas, and the effect of these literatures on administrative law scholarship).

168 Certain strains of public-choice scholarship also deny the existence of any measurable "public interest." Arrow's Theorem, and the literature it spawned, debated this question. See generally Kenneth J. Arrow, Social Choice and Individual Values (1951). Specifically, Arrow's Theorem demonstrated the logical impossibility of devising collective choice mechanisms capable of satisfying simultaneously several desirable characteristics commonly thought to be essential attributes of democracy. Id. at 22-33. Arrow's Theorem produced an enormous scholarly reaction, including a great deal of work attempting to demonstrate ways in which constitutions and legislatures modify some of Arrow's conditions to make meaningful social choice possible. For a summary of that scholarship, see William H. Riker, Liberalism Against Populism: A Confrontation Between the Theory of Democracy and the Theory of Social Choice 65-113 (1982). However, one need not take sides on this issue to address the question of whether federal or state regulation is more desirable in any given instance.

169 For the leading work on this topic, see Mancur Olson, The Logic of Collective Active: Public Goods and the Theory of Groups (1971).

170 Olson's argument is essentially that for mass interests, the decision whether to join a group is represented by the prisoner's dilemma game. For an in-depth treatment of the game-theory aspects of this group-formation problem, see Todd Sandler, Collective Action: Theory and Applications 5-6, 19-20 (1992).

171 Capture theory predates public choice scholarship. For some non-public choice versions of capture theory, analyzing how businesses use their resource advantages to influence, see Charles E. Lindblom, Politics and Markets: The World's Political-Economic Systems 5 (1977). See also Theodore J. Lowi, The End of Liberalism: Ideology, Policy and the Crisis of Public Authority 68-85 (1969) (discussing the rise of "interest-group liberalism"). The canon of the capture theory literature includes William A. Niskanen, Jr., Bureaucracy and Representative Government 29-30 (1971). See also Sam Peltzman, Toward a More General Theory of Regulation, 19 J.L. & Econ. 211, 217 (1976) (portraying regulation as a private rent-seeking activity); George J. Stigler, The Theory of Economic Regulation, 2 Bell J. Econ. & Mgmt. Sci. 3, 5 (1971) (theorizing regulation as an instrument that industries use to their own economic advantage); cf. Sarnoff, supra note 149, at 240 n.54 ("It should ... be obvious: (1) that the ability to spend wealth to influence policy does not provide an objective measure of value; and (2) that policies adopted in response to campaign contributions do not necessarily increase social welfare." (emphasis in original)).

172 See, e.g., Douglas Cater, Power in Washington 26-48 (1964) (arguing that Congress's military-industry alliance created a powerful subgovernment, which could lead to consequences in the organization of political power); John Leiper Freeman, The Political Process: Executive Bureau-Legislative Committee Relations 27 (rev. ed. 1965) (noting that interest groups "do not usually seek to control the whole machinery of policy-making, but rather to prevent policies ... which would injure their special interests and to secure other policies favorable to their interests"); Thomas L. Gais et al., Interest Groups, Iron Triangles, and Representative Institutions, in Mobilizing Interest Groups in America, supra note 166, at 125-39 (investigating the "programmatic goals of different types of groups [in the 1970s and '80s], the implications of their contrasting strategies for seeking to influence the government in pursuit of their goals"); Stigler, supra note 171, at 3 (positing that "regulation is acquired by the industry and is designed and operated primarily for its benefit").

173 See, e.g., Marver H. Bernstein, Regulating Business by Independent Commission 169 (1955) ("On the whole, commissions have not acted in an unfair or arbitrary manner toward private parties. Charges of bias tend to reflect not unsatisfactory procedures or arbitrary action by commissions but rather the opposition of regulated groups to regulatory policy."); Gabriel Kolko, Railroads and Regulation, 1877-1916, at 3-6 (1965); John A. Ferejohn, The Structure of Agency Decision Processes, in Congress: Structure and Policy 441, 442-45 (Mathew D. McCubbins & Terry Sullivan eds., 1987) (illustrating the struggle between case-by-case adjudication and more openness in the agencies' decisionmaking choices); see also David B. Spence, Managing Delegation Ex Ante: Using Law to Steer Administrative Agencies, 28 J. Legal Stud. 413, 417-18 n.19 (1999) (summarizing the literature of agency capture).

174 The idea of "republican moments" comes from James Gray Pope, Republican Moments: The Role of Direct Popular Power in the American Constitutional Order, 139 U. Pa. L. Rev. 287 (1990). For an adaptation of the theory of "republican moments" to the context of environmental politics, explaining how environmental regulation can be enacted in the face of free-rider problems, see Anthony Downs, Politics and Procedure in Environmental Law, 8 J.L. Econ. & Org. 59, 68 (1992). See also Anthony Downs, Up and Down with Ecology--The "Issue-Attention Cycle", 28 Pub. Int., Summer 1972, at 38 (describing the process leading up to a

republican moment, and explaining what kinds of policy issues are most likely to experience such a moment). For a discussion of republican moments in the history of environmental law, see Spence, supra note 167, at 435-36.

175 See, e.g., Evan H. Caminker, State Sovereignty and Subordinacy: May Congress Commandeer State Officers to Implement Federal Law?, 95 Colum. L. Rev. 1001, 1013 n.44 (arguing that state decisionmaking is particularly likely to diverge from majority preferences because of collective action problems); Warren L. Ratliff, The De-Evolution of Environmental Organization, 17 J. Land Resources & Envtl. L. 45, 51-73 (1997) (discussing the difficulties of starting environmental groups at the state level, as opposed to the national level); Stewart, supra note 157, at 1213 (arguing that federal agencies are less susceptible to capture than are local and state agencies); Matthew D. Zinn, Policing Environmental Regulatory Enforcement: Cooperation, Capture, and Citizen Suits, 21 Stan. Envtl. L.J. 81, 131-41 (2002) (arguing that citizen involvement is crucial to policing the relationship between regulators and industry). But see Wendy Wagner et al., Rulemaking in the Shade: An Empirical Study of EPA's Air Toxic Emission Standards, 63 Admin. L. Rev. 99, 123 (2011) (finding evidence of industry's disproportionate participation in EPA rulemakings).

176 See Spence, supra note 167, at 436 (arguing that groundswells of public concern, organized by "political entrepreneurs" in Congress, produced these laws).

177 See 42 U.S.C. §§7602(J), 7661a (2006); 40 C.F.R. §70.2 (2012) (stating the basic permit provisions of the Clean Air Act).

178 See 33 U.S.C. §1342 (stating the basic permit provisions of the Clean Water Act).

179 Some commentators argue that only a minority of Clean Air Act provisions are aimed at interstate pollution problems. See, e.g., Revesz, supra note 159, at 1224-25 ("The Clean Air Act contains several provisions directed primarily at interstate externalities .... By far the bulk of [its] provisions ... however, are wholly unrelated to the control of interstate externalities."). However, this conclusion is too narrowly focused on statutory provisions expressly addressing interstate externalities. In fact, the entire regulatory scheme is built on the premise that air pollution mixes freely in the ambient air, and that emissions in one location will affect the ability of downwind locations to comply with clean air standards.

180 Of course, carbon dioxide and other greenhouse gas emissions present a global problem because they exacerbate global warming. Long-regulated conventional pollutants, such as sulfur dioxide, nitrogen oxides, and particulate matter, present similar environmental problems because they can also travel great distances. The Clean Air Act's National Ambient Air Quality Standards recognize that pollutants mix freely in the ambient air irrespective of state boundaries, as do its provisions regarding interstate transport. For a description of the operation of section 126 of the CAA, governing interstate pollution problems, as well as various cross-state pollution programs, see supra note 154.

181 See, e.g., Solid Waste Agency of N. Cook Cnty. v. U.S. Army Corps of Eng'rs, 531 U.S. 159, 171-73 (2001) (discussing the limitation of Clean Water Act jurisdiction to navigable waters and associated wetlands); Cory Brader, Comment, Toward a Constitutional Chevron: Lessons from Rapanos, 160 U. Pa. L. Rev. 1479, 1489-92 (2012) (analyzing the Supreme Court's restrictive interpretations of the "waters of the United States" language found in the CWA).

182 See 29 U.S.C. §§651-678 (vesting OSHA with the power to protect employees from hazardous work environments).

183 See 42 U.S.C. §§6921-6939 (defining federal standards for disposal of solid and hazardous waste).

184 Some contend that the race-to-the-bottom argument is weak because the relative stringency of state environmental regulatory standards may play a small role in firm location decisions. See Revesz, supra note 159, at 1235.

185 See Robert L. Fischman, Cooperative Federalism and Natural Resources Law, 14 N.Y.U. Envtl. L.J. 179, 180 (2005) (defining "cooperative federalism" as "an arrangement under which a national government induces coordination from subordinate

jurisdictions"); Robert L. Fischman & Angela M. King, Savings Clauses and Trends in Natural Resources Federalism, 32 Wm. & Mary Envtl. L. & Pol'y Rev. 129, 131-41 (2007) (providing the National Elk Refuge as an example of cooperative federalism between a state (in this case, Wyoming) and the federal government).

186 Some commentators justify this kind of cooperative federalism approach as essential to promoting a national interest in minimum standards, while offering states some flexibility on the implementation of those standards. Cf. Sarnoff, supra note 149, at 261-66 (discussing both the flexibility and some of the costs inherent in the regulatory apparatuses that often follow from cooperative federalism).

187 The CAA and CWA each provide that the EPA may delegate enforcement administration functions to the states. The RCRA is similarly structured. See Sierra Club v. EPA, 315 F.3d 1295, 1300 (11th Cir. 2002) (describing the "division of labor" between states and the EPA as "inherent in the regime of cooperative federalism created by the CAA"); Michigan v. EPA, 268 F.3d 1075, 1083 (D.C. Cir. 2001) (describing the CAA as "an experiment in cooperative federalism"); Envtl. Def. Fund, Inc. v. EPA, 82 F.3d 451, 468-69 (D.C. Cir. 1996) (discussing the CAA's focus on federal and state cooperation and planning). The OSH Act authorizes OSHA to delegate authority to administer the regulatory program to so-called "plan states"--states whose safety and health regulatory regimes meet OSHA specifications according to the approved state regulatory plan. 29 U.S.C. § 667.

188 The Environmental Council of the States (ECOS) tracks the EPA's delegation of permitting authority under several major environmental statutes, including the Clean Air Act and the Clean Water Act. For a summary of this data, see Delegation By Environmental Act, Envtl. Council States, http:// www.ecos.org/section/states/enviro_actlist (last updated Nov. 2010). The EPA has clashed with states over how to enforce regulatory standards. See David B. Spence, The Shadow of the Rational Polluter: Rethinking the Role of Rational Actor Models in Environmental Law, 89 Calif. L. Rev. 917, 938-39 (2001) (describing the EPA's conflict with the Missouri Department of Natural Resources in the 1980s).

189 For example, the RCRA savings clause reads, in pertinent part: "[N] o state or political subdivision may impose any requirements less stringent than those authorized under this subchapter ....Nothing in this chapter shall be construed to prohibit any state or political subdivision thereof from imposing any requirements ... which are more stringent than those imposed by such regulations." 42 U.S.C. § 6929.

190 The leading decision affirming this principle in the context of the EPA's establishment of National Ambient Air Quality Standards under the CAA is Whitman v. American Trucking Ass'ns, 531 U.S. 457, 486 (2001). See also Lead Indus. Ass'n v. EPA, 647 F.2d 1130, 1148 (D.C. Cir. 1980) ("[T]he [CAA] and its legislative history made clear that economic considerations play no part in the promulgation of ambient air quality standards ...."). For the leading decision affirming a slightly modified version of this principle in OSHA workplace standards, which notes that the OSH Act "intended to require the elimination, as far as feasible, of significant risks of harm," see Indus. Union Dep't v. Am. Petrol. Inst. (The Benzene Case), 448 U.S. 607, 641 (1980) (Stevens, J., concurring).

191 William Buzbee has called this the "regulatory commons" problem, likening diffuse regulatory responsibility to the problem of managing a public good over which no one has ownership rights. Buzbee argues that, in the regulatory commons, no one has an incentive to balance overall costs and benefits, creating regulatory "free-riding" that mirrors the kind of free riding that economists have associated with the management of public goods. William W. Buzbee, Recognizing the Regulatory Commons: A Theory of Regulatory Gaps, 89 Iowa L. Rev. 1, 7-14 (2003). For a game-theoretic treatment of the public goods management problem and free riding generally, see Sandler, supra note 170, at 13-18.

192 16 U.S.C. §§791a-828c.

193 42 U.S.C. §§2011-2297h-13.

194 15 U.S.C. §717b(e)(1).

195 33 U.S.C. §§1501, 1503.

196 See 30 U.S.C. §§1202(f), 1211 (including among the purposes of SMCRA the need to assure adequate supply of coal and to balance this interest against environmental and other interests). Absent this purpose, it would be difficult to reconcile SMCRA with the other rationales for federal action described here, since most of the effects of surface mining are felt locally (discharges to navigable waters being one possible exception), and the need to mine coal where one finds it makes the race-to-the-bottom rationale a poor fit. But cf. Hodel v. Va. Surface Min. & Reclamation Ass'n, 452 U.S. 264, 281-82 (1981) (explaining that, without federal regulation, interstate competition to attract coal-industry investment would create a race to the bottom, encouraging states to loosen their environmental standards).

197 43 U.S.C. §§ 1331-1356a.

198 42 U.S.C. § 2133(a).

199 15 U.S.C. § 717b(a).

200 The Constitution's Supremacy Clause states simply that federal law shall be "the supreme Law of the Land." U.S. Const. art. VI, cl. 2. Under modern Supremacy Clause jurisprudence, federal regulation may preempt state regulation explicitly, in the statute, or implicitly, when state and federal regulation conflict or when courts decide that federal regulation is sufficiently comprehensive that it "occupies the field," leaving no room for supplemental state regulation. These principles are outlined in Capital Cities Cable, Inc. v. Crisp, 467 U.S. 691, 698-99 (1984), and English v. General Electric Co., 496 U.S. 72, 78-79 (1990). For a summary of the modern case law, see Stephen A. Gardbaum, The Nature of Preemption, 79 Cornell L. Rev. 767, 774-77 (1994).

201 See California v. FERC, 495 U.S. 490, 506 (1990) (holding that the Federal Power Act preempts California minimum stream flow requirements because they would interfere with FERC's comprehensive authority); First Iowa Hydro-Elec. Coop. v. Fed. Power Comm'n, 328 U.S. 152, 181-82 (1946) (declaring that a federal licensee was not required to comply with Iowa permitting requirements for new dam construction because the federal regulatory scheme "leave[s] no room or need for conflicting state controls").

202 See N. States Power Co. v. Minnesota, 447 F.2d 1143 (8th Cir. 1971) (holding that states may not enact stricter radiation emissions regulations than the federal standards), aff'd mem., 405 U.S. 1035 (1972); United States v. City of New York, 463 F. Supp. 604, 614 (S.D.N.Y. 1978) (concluding that a city ordinance requiring an additional license for nuclear reactors was preempted by the Atomic Energy Act); State v. Jersey Cent. Power & Light Co., 351 A.2d 337, 344 (N.J. 1976) (declaring that New Jersey's environmental protection agency's enforcement of state pollution laws against a nuclear power plant was preempted by federal regulation). But cf. Pac. Gas & Elec. Co. v. State Energy Res. Conserv'n & Dev. Comm'n, 461 U.S. 190, 213-16 (1983) (upholding a California statute regulating waste storage because it was "economic"--not siting--legislation, and therefore was not preempted by the Atomic Energy Act).

203 See, e.g., Weavers Cove Energy, LLC v. R.I. Coastal Res. Mgmt. Council, 589 F.3d 458, 475 (1st Cir. 2009) (stating that the Natural Gas Act's grant of "exclusive authority" to FERC over siting LNG facilities preempts local siting laws).

204 See 43 U.S.C. § 1344(c) (requiring the Department of the Interior to consult with other governmental bodies, including state governors, in making leasing decisions under the OCSLA).

205 See 10 C.F.R. § 50.47 (2012) (requiring the NRC to consider state emergency-response planning during the licensing process for a nuclear reactor).

206 See 16 U.S.C. § 803(a)(2)(B) (requiring FERC to consider recommendations from other federal and state resource agencies in making its licensing decisions); 18 C.F.R. §5.1(d) (requiring license applicants to consult with state, as well as federal and

interstate, agencies before filing hydroelectric facility-licensing applications).

207 33 U.S.C. § 1341(a)(4). The term "navigable waters" attained a specific meaning under the Supreme Court's Commerce Clause jurisprudence before Congress used it in the Clean Water Act. It had come to mean surface waters which were navigable "either in their natural or improved condition." United States v. Appalachian Elec. Power Co., 311 U.S. 377, 407 (1940) (internal quotation marks omitted), superseded by statute, Clean Water Act, Pub. L. No. 92-500, 86 Stat. 816 (1972), as recognized in Rapanos v. United States, 547 U.S. 715 (2006).

208 See e.g., PUD No. 1 v. Wash. Dep't of Ecology, 511 U.S. 700, 715 (1994) (authorizing a state agency to impose so-called minimum-flow requirements as a condition to granting certification to a hydroelectric facility). Recently, the New York State Department of Environmental Conservation denied such certification to Entergy Corporation, which was seeking the Nuclear Regulatory Commission's relicensing of its Indian Point nuclear power plant. See Press Release, Riverkeeper, Riverkeeper Hails New York's Decision to Deny Critical Water Quality Certificate for Indian Point (Apr. 3, 2010), available at http://www.riverkeeper.org/news-events/news/stop-polluters/power-plant-cases/riverkeeper-hails-new-yorks-decision-to-deny-critical-water-quality-certificate-for-indian-point.

209 See 16 U.S.C. §1456(c)(1)(A) (requiring "[e]ach federal agency activity... that affects... the coastal zone [to] be carried out in a manner which is consistent to the maximum extent practicable with the enforceable policies of approved State management programs"); Sec'y of Interior v. California, 464 U.S. 312, 321-30 (1984) (discussing whether the CZMA consistency requirement applied to offshore oil and gas leasing in light of the Act's legislative history, which indicated a concern for potential damage to state coastal zones), superseded by statute on other grounds, 16 U.S.C. §1456(c)(1), as recognized in California v. Norton, 311 F.3d 1162 (9th Cir. 2002); Erica Schroeder, Comment, Turning Offshore Wind On, 98 Calif. L. Rev. 1631, 1663 (2010) (discussing a potential role for the states in the author's proposed amendment of the CZMA to promote offshore wind development).

210 See PUD No. 1, 511 U.S. at 711.

211 See 16 U.S.C. §1456(c)(1) (setting forth the CZMA process for approving federal programs even when they are inconsistent with state programs, without consent from state agencies).

212 National Environmental Policy Act (NEPA) of 1969, Pub. L. No. 91-190, 83 Stat. 852 (codified in scattered sections of 42 U.S.C.). The NEPA requires the preparation of an environmental impact statement for any "major Federal action [including the issuance of permits] significantly affecting the quality of the human environment." 42 U.S.C. §4332(c).

213 The Endangered Species Act (ESA) is located at 16 U.S.C. §1531-1544. For the ESA's firm prohibition on federal agencies from taking any actions, including the issuance of permits, that may "jeopardize the continued existence of any endangered species," see id. §1536(a)(2). The ESA is also notable for prohibiting anyone subjected to the jurisdiction of the United States from "tak[ing]" or harming endangered species. Id. § 1538(a)(1)(B).

214 See, e.g., 26 Cal. Code Regs. tit. 14, §1724.6 (2012) (noting that approval must be obtained from the California Division of Oil, Gas, and Geothermal Resources before any subsurface injection or disposal can begin, and requiring that an operator must provide the pertinent and necessary data for the evaluation of the proposed project). Another California conservation regulation stipulates the filing, notification, operating and testing requirements for underground injection wells and projects. In particular, it states that "[n]otices of intention to drill, redrill, or rework, on current Division forms, shall be completed and submitted to the division for approval whenever a new well is to be drilled for use as an injection well." Id. §1724.10(b).

215 State regulatory requirements vary. For instance, in Texas, section 3.9 of the Standards for Management of Hazardous Oil and Gas Waste governs the permitting, operating, monitoring, and testing of disposal by injection into a porous formation not productive of oil, gas, or geothermal resources. 16 Tex. Admin. Code §3.9(3) (2012). All applications, including those with respect to commercial disposal wells, require permits from the Railroad Commission of Texas. Section 3.98 governs nonexempt, hazardous oil and gas waste. Id. §3.98. Oil and gas waste that is not uniquely associated with exploration and production primary field operations, and hence nonexempt from regulation as hazardous waste under section 3.98(2) of the Texas rules, as well as 40 C.F.R.

§261.4(b), requires a hazardous-waste determination. If determined hazardous, the oil and gas waste is then subject to section 3.98. California has adopted a much narrower exploration and production waste exemption than at the federal level. The exemption applies in California if the waste displays the toxicity characteristic for hazardous waste based solely on the Toxicity Characteristic Leaching Procedure (TCLP). One California regulation provides that all discharges into the ocean shall conform to the requirements of the appropriate Regional Water Quality Control Board. Cal. Regs. § 1748.1. Another regulation states that oil-field wastes shall be disposed of in a manner that does not damage life, health, property, freshwater aquifers, surface waters, natural resources, nor menace public safety. Id. §1775(b). Disposal sites shall conform to State Water Resources Control Board and appropriate Regional Board regulations. Id. Section 1775(b) prohibits the dumping of harmful chemicals "where subsequent meteoric waters might wash significant quantities into freshwaters" and the permanent disposal of drilling mud into open pits. Id.

216 Fracking operations that could "take," or harm, an endangered species will trigger regulation under section 9 of the ESA, which prohibits actions which "take" endangered species. 16 U.S.C. §1538(a)(1)(B). Furthermore, section 7 of the ESA prohibits a federal agency from approving any action that could "jeopardize the continued existence" of a listed endangered species. Id. §1536(a)(2).

217 Fracking operations that will discharge wastewater into nearby surface waters require an NPDES permit under section 402 of the CWA. See 33 U.S.C. §§1311, 1342(a)(1) (providing the process by which applicants can receive permits from the federal government for the discharge of any pollutant or combination of pollutants).

218 If a fracking operation's wastewater is discharged to a municipal sewage treatment plant, it will be subject to CWA pretreatment rules. These rules regulate discharges which "upset" the operation of the plant or cause pollutants to "[p]ass [t]hrough" to surface waters. See 40 C.F.R. § 403.8(a) (2010).

219 For a discussion of the SDWA underground-injection-well-permitting program, see supra notes 85-90 and accompanying text.

220 49 U.S.C. §§ 5101-5128.

221 None of these federal wastewater disposal approvals are required if the wastewater is treated and recycled or disposed of on site without underground injection.

222 See supra note 210 and accompanying text.

223 See supra note 212 and accompanying text.

224 See supra Section II.B.

225 This Section examines the spillover, race-to-the-bottom, and national-interest rationales for federal regulation. The fourth rationale, that manufacturers need uniform federal standards, seems inapplicable to this case. See supra notes 161-63 and accompanying text for a discussion of this rationale. However, fugitive methane emissions are an example of a problem that seems amenable to a technical solution, perhaps one that involves federal manufacturing standards in the gas production, compression, and transmission equipment industries. See infra subsection IV.A.3 for a discussion of methane emissions as a national concern.

226 See supra Section I.B.

227 This subsection addresses fracking's potential impact on adequacy-of-water-supply issues. Water-supply issues are distinguishable from concerns about the protection of the quality of groundwater or drinking water aquifers. For a discussion of groundwater quality issues, see infra subsection IV.A.5.

228 See supra note 181.

229 See 33 U.S.C. § 1251(a)(1) (maintaining that it is the goal of Congress to use the CWA to eliminate the discharge of pollutants into navigable waters).

230 See 16 U.S.C. § 821 (expressing the congressional purpose to leave state laws governing water rights undisturbed by the Act).

231 For the Compact Clause, which reserves this power to Congress, see U.S. Const. art. I, § 10, cl. 3. For an insightful discussion of these water management compacts, see Noah D. Hall, Toward a New Horizontal Federalism: Interstate Water Management in the Great Lakes Region, 77 U. Colo. L. Rev. 405, 409-14 (2006).

232 See, e.g., Robin Kundis Craig, Climate Change, Regulatory Fragmentation, and Water Triage, 79 U. Colo. L. Rev. 825, 831 (2008) (pointing out that the lack of comprehensive regulation has contributed to rivers in the western United States being "sucked dry"); Paul Faeth, U.S Energy Security and Water: The Challenges We Face, Env't Mag., Jan.-Feb. 2012, at 4, 9 (calling water-supply issues fracking's "Achilles' heel"), available at http:// www.environmentmagazine.org/Archives/Back%20Issues/2012/January-February% 202012/US-Energy-Full.html.

233 See George William Sherk, The Management of Interstate Water Conflicts in the Twenty-First Century: Is It Time to Call Uncle?, 12 N.Y.U. Envtl. L.J. 764, 765-66 (2003) ("There are three means by which interstate water conflicts may be resolved: litigation in the U.S. Supreme Court, negotiation of interstate compacts, or federal legislation ....With great consistency, the Supreme Court has advised the states to resolve interstate water disputes among themselves.").

234 The Great Lakes Basin Compact was created by American states bordering the Great Lakes, in part to protect water in the lakes from appropriation by the federal government on behalf of other states. See Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement (2005), available at http://www.cglg.org/projects/water/docs/12-13-05/Great_Lakes-St_Lawrence_River_Basin_Sustainable_Water_Resources_Agreement.pdf (last visited Nov. 16, 2012).

235 For a discussion of drought in the Eagle Ford Shale, see supra note 45 and accompanying text. Some climate science researchers believe that climate change will tend to exacerbate drought in the southwestern United States. See, e.g., Jay Gulledge & Dan Huber, Global Warming Contributing to Texas Drought, Ctr. for Climate & Energy Solutions (Oct. 14, 2011), http:// www.c2es.org/blog/huberd/global-warming-contributing-texas-drought (exploring the question of whether climate change is increasing the risk of drought in Texas).

236 See N.Y. State Energy Research & Dev. Auth., Responding to Climate Change in New York State: A Synthesis Report (2011), available at http:// www.nyserda.ny.gov/~/ media/Files/Publications/Research/Environmental/EMEP/climaid/responding-to-climate-change-synthesis.ashx?sc_database=web (detailing the New York State Energy Research and Development Authority's projected increases in rainfall over the next century in the Marcellus Shale area as a result of climate change).

237 Once the fracturing operation is complete and the well is producing natural gas, its local impact is less significant. While the well pad creates a permanent change on the surface of the land, the noise, truck traffic, and vibrations associated with the fracturing operation itself do not continue into the production phase. See, e.g., N.Y. State Dep't of Envtl. Conserv'n, supra note 43, at 6-304.

238 See Peter Applebome, A New York Village's Debate over Drilling Turns Personal, N.Y. Times, Oct. 30, 2011, at 1 ("The dispute has pitted neighbor against neighbor, and has often set people who live in suburbs or villages against the farmers and landowners who live outside them."); see also Eliza Griswold, Situation Normal All Fracked Up, N.Y. Times Mag., Nov. 20, 2011, at 44, 47 ("In Amwell Township [Pennsylvania], your opinion of fracking tends to correspond with how much money you're making and with how close you live to the gas wells, chemical ponds, pipelines and compressor stations springing up in the area.").

239 Pittsburgh Bans Natural Gas Drilling, CBS News (Dec. 8, 2010), http://www.cbsnews.com/stories/2010/11/16/national/main7060953.shtml.

240 Sabrina Tavernise, As Gas Drilling Spreads, Towns Stand Ground over Control, N.Y. Times, Dec. 14, 2011, at A20 (describing how jurisdictions from Dryden, New York, to Flower Mound, Texas, have all used ordinances to restrict companies' ability to pursue fracking opportunities).

241 For an older discussion of this issue as it has played out in California, see Thomas M. Montgomery, State Pre-emption and Local Legislation, 4 Santa Clara Law. 188, 191-93 (1963).

242 For example, New York's constitution has just such a provision. See N.Y. Const. art. IX, § 2(b)(2) (limiting the power of the state legislature "in relation to the property, affairs or government of any local government").

243 See N.Y. Envtl. Conserv. Law §23-0303(2) (McKinney 2012) ("The provisions of this article shall supersede all local laws or ordinances relating to the regulation of the oil, gas and solutions mining industries ....").

244 Envirogas, Inc. v. Town of Kiantone, 447 N.Y.S.2d 221, 223 (Sup. Ct.), aff'd, 454 N.Y.S.2d 694 (App. Div. 1982). That case did not involve fracking, however.

245 For a good discussion of state preemption of local law in New York and Pennsylvania, see Michelle L. Kennedy, The Exercise of Local Control over Gas Extraction, 22 Fordham Envtl. L. Rev. 375, 380-90 (2011).

246 See Anschutz Exploration Corp. v. Town of Dryden, 940 N.Y.S.2d 458, 471 (Sup. Ct. 2012); Rachel Stern, Judge: Dryden Can Block Gas Drilling in Community, Ithaca J. (N.Y.) (Feb. 21, 2012), http://www.theithacajournal.com/article/20120221/NEWS01/202210394/Judge-Dryden-can-block-gas-drilling-community (noting the judge's reasoning that local regulation of oil and gas development is preempted, but that communities retain their ability to block industrial uses within their borders using zoning laws). For another case upholding a town's right to use zoning laws to ban fracking under New York's home-rule provision, see Cooperstown Holstein Corp. v. Town of Middlefield, 943 N.Y.S.2d 722, 779-80 (Sup. Ct. 2012), and compare Jeffrey v. Ryan, No. 2012-01254, 2012 WL 4513348, at *7 (N.Y. Sup. Ct. Oct. 2, 2012) (striking down an anti-fracking ordinance, but upholding the right of municipalities to use zoning laws to limit or prohibit unwanted land uses).

247 The new law, called "Act 13," gives local governments the power to impose (and share revenue from) fees imposed on fracking, but also gives the Pennsylvania Public Utilities Commission the power to disapprove of local ordinances that would regulate fracking. 58 Pa. Cons. Stat. §§2301-2354 (2012); see also Tavernise, supra note 240, at A20 ("As energy companies move to drill in densely populated areas from Pennsylvania to Texas, battles are breaking out over who will have the final say in managing the shale gas boom."); Act 13 (Impact Fee), Pa. Pub. Utils. Comm'n, http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_13_impact_ fee_.aspx (last visited Nov. 16, 2012) (explaining the new law, including the collection and distribution of the gas well fees). As of this writing, at least one court has held that the Pennsylvania Constitution protects the rights of local communities to use zoning to restrict fracking. See Robinson Township v. Commonwealth, No. 284-2012, 2012 WL 3030277, at *26 (Pa. Commw. Ct. July 26, 2012) (en banc) (upholding Act 13 as a valid exercise of the police power that promotes the health, safety, and welfare of the state by "establishing zoning guidance to local municipalities that ensure the uniform and optimal development of oil and gas resources").

248 This bill has passed the New York State Assembly, and as of this writing is under consideration in the New York State Senate. S.B. 3472, 2011 Leg. Reg. Sess. (N.Y. 2011) (ensuring that state laws are not used to "prevent any local government from ... enacting or enforcing local zoning ordinances or laws which determine permissible uses in zoning districts"). Presumably, any state or local bans enacted after drillers have secured rights to the mineral estate might be vulnerable to regulatory takings claims if the owners could have reasonably expected to drill under prior law. See, e.g., Lucas v. S.C. Coastal Council, 505 U.S. 1003, 1029 (1992) (holding that regulation prohibiting any economically beneficial use of the property interest amounts to a taking). But cf. Keystone Bituminous Coal Ass'n v. DeBenedictis, 480 U.S. 470, 506 (1987) (upholding a state anti-subsidence act against mining companies' taking claims). For a summary of other recent state-legislative developments on this issue, see Pierre Bertrand, State Fracking Laws Expand as Ohio Is Set to Approve its own Bill, Int'l Bus. Times (May 24, 2012), http://www.ibtimes.com/articles/345100/20120524/fracking-ohio-vote-house-chemicals-disclosure.htm.

249 See, e.g., Cedar Hill, Tex., Ordinances ch. 13, art. II, §13-19 (limiting the city zones in which companies can extract natural resources), available at http://library.municode.com/HTML/11825/level3/PTIICOOR_CH13NAENRE_ARTIISTFAEXSI.html#PTIICOOR_CH13NAENRE_ARTIISTFAEXSI_S13-19La20 (last visited Nov. 16, 2012); Natural Gas Exploration, City Cedar Hill, Tex., http:// www.cedarhilltx.com/index.aspx?NID=915 (last visited Nov. 16, 2012) (explaining the local ordinances governing natural gas deposits in the Barnett Shale).

250 See infra Section IV.B for a discussion of the effects of politics on these regulatory conflicts.

251 See supra notes 58-59 (discussing the results--and critiques--of studies of methane leakage).

252 Howarth et al., supra note 58, at 685.

253 Id. at 680.

254 See Nocera, supra note 6, at A25 (“Unlike others in the environmental movement, [President Fred Krupp] and his colleagues at the Environmental Defense Fund don’t want to shut down fracking ....”).

255 549 U.S. 497 (2007).

256 See id. at 529 (“Carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons are without a doubt ‘physical [and] chemical ... substance[[s] which [are] emitted into ... the ambient air’ ....”).

257 40 C.F.R. §98.6 (2012) (“Greenhouse gas or GHG means carbon dioxide (CO_2), methane (CH_4) ....”).

258 Id. §§52.21(J)(2), (3).

259 See id. §§98.2(a)-(a)(2) (“The GHG reporting requirements and related monitoring, recordkeeping, and reporting requirements of this part apply to the owners and operators of any facility that is located in the United States [and] ... that emits 25,000 metric tons CO_2e or more per year in combined emissions ....”). Some sources are subject to higher thresholds. See, e.g., id. §52.21(b)(49)(v) (explaining that in July 2011 new and existing stationary sources that will or have potential to emit 100,000 tons per year (tpy) of carbon dioxide equivalent (CO_2e), as well as existing stationary sources that undertake physical or operational changes that result in emission increase of 75,000 tpy CO_2e or more will be subject to regulation).

260 Ashley Pettus, Clean Air Task Force, Methane: Tapping the Untapped Potential 3 (2009), available at http:// www.catf.us/resources/whitepapers/files/Methane-Tapping_the_Untapped_ Potential.pdf.

261 EPA, EPA 430-R-12-001, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010, at 2-1 fig. 2-1 (2012), available at http:// www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Main-Text.pdf.

262 Kelsi Bracmort et al., Cong. Research Serv., R40813, Methane Capture: Options for Greenhouse Gas Emission Reduction 14 (2010).

263 The EPA’s proposed rules governing fugitive emissions from gas production operations estimate that fugitive emissions from hydraulically fractured wells are about 200 times those of conventional gas wells, primarily because of gaseous compounds that

escaped to the atmosphere during the production of flowback water. The EPA estimates emissions of about 23 tons of volatile organic compounds per fracturing operation, which implies that methane emissions ought to be less than 1,000 tons per year. Oil and Natural Gas Sector: New Source Performance Standards and National Emissions Standards for Hazardous Air Pollutants Reviews, 76 Fed. Reg. 52,738, 52,757 (Aug. 23, 2011) (to be codified at 40 C.F.R. pts. 60 & 63).

264 Indeed, one of the challenges to the tailoring rule is that the EPA has set the threshold too high, and that the statute does not authorize the EPA to ignore smaller sources. Petition for Review at 1, Ctr. for Biological Diversity v. EPA, No. 10-1205 (D.C. Cir. Aug. 2, 2010).

265 See 40 C.F.R. §§ 60.630-.636 (2012) (regulating the standards of performance for equipment leaks of VOCs from onshore natural gas processing). Natural gas "processing" includes the activities by which gases are separated from liquids upon production, and various compounds are separated from methane. "Processing" also encompasses the operation that prepares natural gas for introduction into the pipeline system. These rules cover processing operations and explicitly do not cover operations upstream of processing. The EPA also regulates VOC emissions from petroleum refineries. See id. §§ 60.590-.593 (regulating the standards of performance for equipment leaks of VOCs in petroleum refineries).

266 See Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews, 77 Fed. Reg. 49,490 (Aug. 16, 2012) (to be codified at 40 C.F.R. pts. 60 & 63) (creating new source performance standards for onshore natural gas-processing plants and finalizing risk- and technology-review procedures for natural gas production, transmission, and storage).

267 Volatile Organic Compounds (VOCs): Technical Overview, EPA, http:// www.epa.gov/iaq/voc2.html (last updated June 21, 2012).

268 40 C.F.R. §51.100(s).

269 Volatile Organic Compounds Master List, EPA, http:// www.epa.gov/iaq/base/voc_master_list.html (last updated Apr. 3, 2012).

270 Oil and Natural Gas Sector: New Source Performance Standards and National Emissions Standards for Hazardous Air Pollutants Reviews, 76 Fed. Reg. 52,738, 52,746 (Aug. 23, 2011).

271 Well completion refers to the steps immediately preceding production from the well. The process can include inserting and cementing-in well casing as well as fracking to stimulate production. Flowback water may be produced during this phase, and the production of flowback water can entail significant venting of methane and nonmethane VOCs to the atmosphere. See id. at 52,757 ("Wells that are fractured generally have great amounts of emissions because of the extended length of the flowback period required to purge the well of the fluids and sand that are associated with the fracturing operation.").

272 See id. at 52,758 ("[W]e are proposing an operational standard ... that would require a combination of REC [Reduced Emissions Completions] and pit flaring to minimize venting of gas ...."). The EPA estimates that of the 25,000 or so new wells constructed annually, only about 3000-4000 currently use green completion. Id. The agency estimates that, as a result of the rule, 21,000 wells will use green completion. Id.

273 Id. at 52,746. In this respect, the EPA's rules might be justified using the second rationale for federal regulation: the desirability of having uniform equipment standards for manufacturers on efficiency grounds. The EPA need not specify technology standards, but rather could specify performance standards for technology, such as maximum leakage rates for compressors, pipe joints, etc.

274 Id. at 52,792.

275 See Status of State Energy Codes, U.S. Dep't of Energy, http:// www.energycodes.gov/states/ (last updated Aug. 2012) (providing

maps and current statuses for commercial and residential building energy codes operable at state levels). Alternatively, as James Connaughton has suggested, federal agencies could use the National Technology Transfer and Advancement Act of 1995, Pub. L. No. 104-113, § 1, 110 Stat. 775 (1996), to incentivize states to develop and standardize new technologies. James Connaughton, Exec. V.P. of Corp. Affairs, Public, & Envtl. Policy, Constellation Energy, Address at Searle Center Conference on Federalism and Energy in the United States at Northwestern University School of Law (Mar. 1, 2012).

276 See supra notes 53, 217-18 and accompanying text for a discussion of CWA regulation of direct discharges to surface waters and discharges to pretreatment facilities.

277 This radiation is often described as "naturally occurring radioactive material." See supra note 51.

278 See 42 U.S.C. §2021(b) (2006) (establishing a federalism-based approach to regulating certain types of low-level radioactive waste).

279 See Office of Water, EPA, EPA-816-R-02-025, Technical Program Review: Underground Injection Control Regulations 4 (2001), available at http://water.epa.gov/type/groundwater/uic/upload/2004_5_3_uicv_techguide_uic_ tech_overview_uic_regs.pdf ("Due to disparate levels of protection afforded ground water under the State injection well programs at the time, Congress passed the SDWA ....").

280 See Griswold, supra note 238, at 49 ("[A]top a hill, about 1,500 feet from her home and less than 800 feet from that of her neighbor, Beth Voyles, there was an open, five-acre chemical impoundment filled with chemically treated water.").

281 See Urbina & McGinty, supra note 57 (noting that state regulations did not protect landowners from contaminated water caused by gas drilling on their land).

282 For a description of the amendment to the Pennsylvania laws, see supra note 135 and accompanying text, and for the proposed New York rules, see supra note 139 and accompanying text.

283 For a discussion of fracking's seismic impacts, see infra note 290. See also Henry Fountain, Add Quakes to Rumblings over Gas Rush, N.Y. Times, Dec. 13, 2011, at D1 (describing earthquakes in Youngstown, Ohio--a seismically inactive area--associated with disposal of fracking waste).

284 See, e.g., Office of Water, supra note 279, at 3 (observing that, as early as 1967, the U.S. Army Corps of Engineers already had determined that underground waste disposal was causing significant seismic activity near Denver, Colorado).

285 See Fountain, supra note 283.

286 See John Daly, U.S. Government Confirms Link Between Earthquakes and Hydraulic Fracturing, Oilprice.com (Nov. 8, 2011), http:// oilprice.com/Energy/Natural-Gas/U.S.-Government-Confirms-Link-Between-Earthquakes-and-Hydraulic-Fracturing.html (noting that the Oklahoma quakes were near 181 underground injection wells for disposal of wastewater).

287 See Alec Liu & Jeremy A. Kaplan, Earthquakes in Arkansas May Be Man-Made, Experts Warn, Fox News (Mar. 1, 2011), http:// www.foxnews.com/scitech/2011/03/01/fracking-earthquakes-arkansas-man-experts-warn (ascribing Arkansas quakes to underground injection wells).

288 33 C.F.R. § 144 (2012).

289 See 40 C.F.R. § 146 (providing that sites could be closed if they do not comply with maintenance and site care requirements).

290 See Austin A. Holland, Okla. Geological Survey, OF1-2011, Examination of Possibly Induced Seismicity from Hydraulic Fracturing in the Eola Field, Garvin County, Oklahoma 12, 25 (2011), available at http://www.ogs.ou.edu/pubsscanned/openfile/OF1_2011.pdf (documenting a correlation between fracking activity and small earthquakes, and suggesting that the fracking process could be the cause); Garry White, Cuadrilla Admits Drilling Caused Blackpool Earthquakes, Telegraph (U.K.) (Nov. 2, 2011), http://www.telegraph.co.uk/finance/newsbysector/energy/8864669/Cuadrilla-admits-drilling-caused-Blackpool-earthquakes.html (concluding that fracking operations very likely caused small tremors).

291 See Fountain, supra note 283, at D3 ("Scientists say the likelihood of that link is extremely remote, that thousands of fracking and disposal wells operate nationwide without causing earthquakes, and that the relatively shallow depths of these wells mean that any earthquakes that are triggered would be minor."); N.Y. State Dep't of Envtl. Conserv'n, supra note 43, at 6-328 ("[T] here is essentially no increased risk to the public, infrastructure, or natural resources from induced seismicity related to hydraulic fracturing. The microseisms created by hydraulic fracturing are too small to be felt, or to cause damage at the ground surface or to nearby wells.").

292 See supra notes 85-90 and accompanying text.

293 See Ernest J. Moniz et al., The Future of Natural Gas: An Interdisciplinary MIT Study 39 (2011) (noting that "over 20,000 shale wells" have been drilled in the last decade).

294 See Ohio Dep't of Natural Res., Preliminary Report on the Northstar 1 Class II Injection Well and the Seismic Events in the Youngstown, Ohio Area 18 (2012), available at http://media.cleveland.com/business_ impact/other/UICReport.pdf (recommending "a review of existing geologic data for known faulted areas within the state and [decisions to] avoid the locating of new Class II disposal wells within these areas"),.

295 See supra Section I.B.

296 See supra note 181.

297 See supra note 87 and accompanying text.

298 See infra Section IV.B.

299 See Howarth et al., supra note 58, at 682-83 (finding that "fugitive methane emissions at well completion" comprised 0.01% of lifetime production for conventional natural gas wells and 1.9% for shale gas wells).

300 Cf. Michael Levi, Rebutting the Howarth Shale Gas Study, Council on Foreign Rel. Blog (May 20, 2011), http://blogs.cfr.org/levi/2011/05/20/rebutting-the-howarth-shale-gas-study (criticizing the study's methodology more generally).

301 Elizabeth W. Boyer et al., Ctr. for Rural Pa., The Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies 16-18 (2011), available at http://www.rural.palegislature.us/documents/reports/Marcellus_and_drinking_ water_2011_rev.pdf.

302 See Moniz et al., supra note 293, at 39.

303 See Groat & Grimshaw, supra note 84, at 18 ("[T]here is at present little or no evidence of groundwater contamination from hydraulic fracturing of shales at normal depths."). The Texas study, however, has come under attack alleging conflicts of interest on the part of the lead author. See Erik Stokstad, Fracking Report Criticized for Apparent Conflict of Interest, Science (July 24, 2012), http:// news.sciencemag.org/scienceinsider/2012/07/fracking-report-criticized-for-a.html (criticizing the Texas study's author for failing to disclose his financial ties to the fracking industry).

304 See Stephen G. Osborn et al., Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing, 108 Proc. Nat'l Acad. Sci. 8172, 8175 (2011) ("[W]e found no evidence for contamination of the shallow wells near active drilling sites from deep brines and/or fracturing fluids.").

305 See id. at 8174 ("The data do suggest gas-phase transport of methane upward to the shallow groundwater zones sampled for this study ...."). The authors of this study could not say how long ago the thermogenic methane found its way to shallower depths, or whether gas drilling was connected with its presence there. See id. at 8175.

306 Daniel J. Rozell & Sheldon J. Reaven, Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale, 32 Risk Analysis 1382, 1388-91 (2012) (estimating the probabilities of various types of accidents that could result in a spill, and extrapolating from those probabilities to produce projected volumes of fracking wastewater that might find their way into groundwater or surface waters in the Marcellus Shale).

307 Estimates of the number of fracking operations vary widely. The MIT study cites a figure of "over 20,000" in the last decade, while industry sources suggest much higher numbers. Moniz et al., supra note 293, at 39.

308 See, e.g., Tavernise, supra note 240 (reporting that the chairman of the Board of Supervisors of Robinson Township, Pennsylvania, opposed a bill that would limit local government's ability to regulate gas company operations because "[t]he state is not capable of monitoring even the most basic parts of this industry")

309 See Brian Nearing, EPA Questions Fracking Study, Times-Union (Albany, N.Y.) (Jan. 12, 2012), http://www.timesunion.com/local/article/EPA-questions-fracking-study-2499294.php (reporting that Enck "questioned whether DEC, which has been dealing with staff cuts in recent years, is ready to oversee natural gas drilling"); cf. Melissa Troutman, Pennsylvania Marcellus Shale Waste Records Are Incomplete, Erie Wire (June 29, 2011), http:// www.eriewire.org/archives/12066/section/economy ("On May 12, [2011,] the ... [[EPA] sent Pennsylvania [Department of Environmental Protection] Secretary Michael Krancer a letter 'asking Pennsylvania to do a better job ... monitoring and regulating Marcellus Shale wastewater discharges near public drinking water sources."'). If one were to put desired policy outcomes before federalism principles, then one could justify federal regulation whenever a state's regulatory response to a problem seems inadequate. As previously noted in the Introduction, however, this Article puts federalism principles before policy, and so addresses the question of which level of government is best suited to determine the appropriate policy response.

310 See supra Section II.B.

311 See supra notes 118-21 and accompanying text.

312 See supra Table 2.

313 Id.

314 See supra notes 64 & 69 (discussing the spills in Dimock, Pennsylvania, and the blowout at a Chesapeake Energy well elsewhere in Pennsylvania).

315 Groat & Grimshaw, supra note 84, at 48.

316 Id.

317 Id. at 49, 51, 54-55.

318 Absent a race to the bottom, states ought to regulate as they understand the risks of fracking. If state budgets are inadequate to fund a proper regulatory response, regulators can charge permitting and other regulatory fees sufficient to fund the state regulatory apparatus.

319 For accounts of divisions within local communities over the relative benefits of fracking, see supra notes 21 & 238 and accompanying text.

320 The race-to-the-bottom literature explores this problematic mismatch between the distribution of costs and benefits, on the one hand, and the distribution of votes within the decision-making polity, on the other. See Johnston, supra note 146, at 614 (arguing that federal control over public goods maybe be "an instrument of inefficient majoritarian redistribution"); Revesz, supra note 159, at 1228-33 (arguing that voters and businesses will sort themselves into jurisdictions whose regulatory standards match their preferences and, therefore, that social welfare will be maximized by allowing locals to establish regulatory standards that balance environment and development according to their wishes). Daniel Ingberman demonstrates that this mismatch problem exists whenever the distribution of costs and impacts is imperfect, even when all costs and benefits remain within a single jurisdiction. See Daniel Ingberman, Siting Noxious Facilities: Are Markets Efficient?, 29 J. Envtl. Econ. & Mgmt. S-20, S-23, S-25 (1995) (noting that if impacts are concentrated on those closest to the noxious facility, a majority of voters within that boundary will suffer less-than-average impacts); see also Wallace E. Oates & Robert M. Schwab, Economic Competition Among Jurisdictions: Efficiency Enhancing or Distortion Inducing?, 35 J. Pub. Econ. 333, 350-51 (1988) (arguing that state jurisdictional competition may not result in efficiency enhancement if policy decisions deviate from the will of the public or if there are "conflicts of interest within a heterogeneous community").

321 See, e.g., Howard Kunreuther & Doug Easterling, The Role of Compensation in Siting Hazardous Facilities, 15 J. Pol'y Analysis & Mgmt. 601, 608 (1996) (explaining why a compensation scheme might fail in practice despite its theoretical appeal).

322 This idea is part of Revesz's response to critics of his argument against the race-to-the-bottom hypothesis. See Revesz, supra note 160, at 542 ("[G]iven the standard public choice argument for federal environmental regulation, it is not clear why the problems observed at the state level would not be replicated at the federal level.").

323 42 U.S.C. §2011 (2006).

324 See id. (acknowledging the Atomic Energy Act's "paramount objective of making the maximum contribution to the common defense and security," as well as its goal of promoting world peace).

325 The national interest in those cases was an economic development interest. Rural Electrification Act of 1936, Pub. L. No. 74-605, 49 Stat. 1363 (codified as amended in 7 U.S.C. §§901-918c); Federal Power Act of 1935, ch. 687, 49 Stat. 838 (codified as amended in 16 U.S.C. §§791-823(d)); Tennessee Valley Authority Act of 1933, ch. 32, 48 Stat. 58 (codified as amended in 16 U.S.C.§§831-831ee).

326 16 U.S.C. §791 et seq.

327 43 U.S.C. §§1346, 1351. Similarly, Congress sought to stimulate development of LNG imports as an energy security measure by establishing a centralized national licensing regime for LNG terminals. 15 U.S.C. §717b(e)(1).

328 See supra note 302.

329 It is important to make a distinction between "energy security" and "dependence upon imports." Some analysts argue that the United States will always import and export energy as a function of its active participation in world markets, and that it is important not to equate energy security with the absence of dependence upon imports. Nevertheless, it seems almost axiomatic to acknowledge that the increased amounts of domestic resources can enhance energy security, all else being equal.

330 Domestic U.S. natural gas prices were distorted considerably by federal regulation between 1955 and 1985. Between 1955 and 1978, the Federal Power Commission, predecessor to FERC, regulated wellhead prices (at the direction of the Supreme Court), leading to such serious shortages that Congress enacted the Natural Gas Policy Act (NGPA) of 1978, Pub. L. No. 95-621, 92 Stat. 3350, which gradually deregulated wellhead prices over the next several years. For a full chronology of these events, see Richard J. Pierce, Reconsidering the Roles of Regulation and Competition in the Natural Gas Industry, 97 Harv. L. Rev. 345, 356, 371-72 (1983). For a description of the strange and unpredictable trajectory of natural gas prices during the slow deregulation process under the NGPA, see James M. Griffin & Henry B. Steele, Energy, Economics, and Policy 301-03 (2d ed. 1986).

331 An examination of monthly natural gas demand in the United States reflects considerable seasonal variation. See Natural Gas Consumption in the United States, 2007-2012, U.S. Energy Info. Admin., http:// www.eia.gov/naturalgas/monthly/pdf/table_02.pdf (displaying monthly natural gas consumption data) (last updated Sept. 2012).

332 See U.S. Energy Info. Admin., SR-OSAF/2001-06, U.S. Natural Gas Markets: Mid-Term Prospects for Natural Gas Supply (2001) ("Like wellhead natural gas supplies, other sources of natural gas supply were also relatively inelastic. For example, while the volume of weather-sensitive natural gas consumption has grown, the capability of natural gas storage facilities to reduce high prices during periods of high winter demand appears to have diminished.").

333 See U.S. Natural Gas Total Consumption, U.S. Energy Info. Admin., http://www.eia.gov/dnav/ng/hist/n9140us2a.htm (charting total yearly national gas consumption data from 1949 to 2010) (last updated Nov. 2, 2012).

334 See U.S. Natural Gas Imports, U.S. Energy Info. Admin., http:// www.eia.gov/dnav/ng/hist/n9100us2m.htm (last updated Nov. 2, 2012).

335 See Reinout De Bock & José Gijón, Will Natural Gas Prices Decouple from Oil Prices Across the Pond? 19 (Int'l Monetary Fund Working Paper WP/11/143, 2011), available at http:// www.imf.org/external/pubs/ft/wp/2011/wp11143.pdf ("Econometric analysis shows that the tight link between US gas and spot oil prices has weakened. This decoupling coincided with a significant increase in the production of non-conventional gas (especially shale gas) in the US. The additional supply has discontinued plans for sizable LNG imports into the US ...."); see also id. at 7 fig. 4 (comparing natural gas wellhead and Western Texas Intermediate oil prices from 1990 to 2010).

336 It is not that plentiful supplies of domestically produced gas prevent Americans from being dependent upon unstable, faraway regimes; to the contrary, the vast majority of American natural gas imports come from Canada and Mexico (via pipeline). However, imports of LNG were beginning to comprise an increasing percentage of American imports prior to the increased availability of domestic shale gas in the early 2000s. The lion's share of LNG imports in recent years have come from Egypt and Trinidad and Tobago. U.S. Natural Gas Imports by Country, U.S. Energy Info. Admin. (Sept. 28, 2012), http://www.eia.gov/dnav/ng/NG_MOVE_IMPC_S1_M.htm.

337 See Natural Gas Spot Prices Near 10-Year Lows Amid Warm Weather and Robust Supplies, U.S. Energy Info. Admin. (Feb. 1, 2012), http:// www.eia.gov/todayinenergy/detail.cfm?id=4810 ("Average spot natural gas prices for January were $2.68/MMBtu. Spot natural gas prices in January 2012 reached their lowest level in 10 years except for a 4-day period over the Labor Day weekend in 2009.").

338 Estimates of reserves are stated as a function of price, among other things. Thus, the amount of recoverable reserves in any gas formation at price X will be less than the amount recoverable at price 2x. In late 2011, the EIA revised its estimate of recoverable reserves in American shale gas formations downward by about 41%, a revision that was partly attributable to the fall in natural gas prices caused by increased supply. U.S. Energy Info. Admin., DOE/EIA-0383, Annual Energy Outlook 2012: With Prediction to 2035 (2012), available at http://www.eia.gov/forecasts/aeo/pdf/0383%282012%29.pdf.

339 Natural Gas Consumption by End Use, U.S. Energy Info. Admin. (Sept. 28, 2012), http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm.

340 See Electric Power Annual 2011: Summary Statistics for the United States, 1999 Through 2010, U.S. Energy Info. Admin. (Oct. 2012), http:// www.eia.gov/electricity/annual/pdf/tablees1.pdf (displaying electricity generation statistics from 1999 through 2010).

341 Id.

342 Id.

343 See Marcy Rood Werpy et al., Draft White Paper on Natural Gas Vehicles: Status, Barriers, and Opportunities 2 (2009), available at http:// www1.eere.energy.gov/cleancities/pdfs/clean_cities_workshop_natural_gas.pdf ("In general, the NGV [natural gas vehicle] strategy in the United States has been to pursue high-fuel-use, urban fleets capable of central refueling. This market includes fleets of buses, trash haulers, taxis, and shuttle, delivery, port, and airport vehicles.").

344 See Craig Trudell & Alan Ohnsman, Chrysler to Begin Natural-Gas Truck Sales to Fleets in 2012, Bloomberg Businessweek (Jan. 17, 2012), http:// www.businessweek.com/news/2012-01-17/chrysler-to-begin-natural-gas-truck-sales-to-fleets-in-2012.html ("Honda Motor Co. is the only automaker selling cars with compressed natural-gas engines to retail customers in the U.S. with its $26,155 Civic Natural Gas sedan. The model, formerly the Civic GX, has sold mainly in California and a small number of other U.S. states that have fueling facilities.").

345 See Gustavo Collantes & Marc W. Melaina, The Co-Evolution of Alternative Fuel Infrastructure and Vehicles: A Study of the Experience of Argentina with Compressed Natural Gas, 39 Energy Pol'y 664, 664 (2011) ("A common denominator of alternative fuel polices has been the discussion over how to coordinate the development of a refueling infrastructure with the deployment of alternative fuel vehicles .... Despite ... efforts, there have been few U.S. success stories to date (e.g., E85 [Ethanol-85] in Minnesota) among a long list of stalled or failed programs.").

346 Epstein et al., supra note 38, at 73.

347 These institutions included the Harvard Medical School, the Harvard School of Public Health, the Boston University School of Public Health, the Department of Pharmacology at Washington State University, and the Department of Community Medicine at West Virginia University. Id.

348 Id. at 91.

349 Id. at 93.

350 Nicholas Z. Muller et al., Environmental Accounting for Pollution in the United States Economy, 101 Am. Econ. Rev. 1649, 1664 tbl.1 (2011).

351 Id. at 1665 tbl.2. The ratio of environmental damage to value added was higher for oil-fired generation (5.13) and for coal-fired

generation (2.20), and higher still for solid waste combustion and incineration (6.72), than for natural gas-fired generation (0.34). Id. at 1665, 1670.

352 Id. at 1667. The next-largest amount of environmental damage was associated with the crop-production industry, at $15.3 billion. Id. at 1665.

353 Id. at 1669.

354 Id. By way of comparison, electricity prices for continental American households range between 8 and 17 cents/kwh. Table 5A. Residential Average Monthly Bill by Census Divison, and State 2011, U.S. Energy Info. Admin. (Sept. 27, 2012), http://www.eia.gov/electricity/sales_revenue_ price/pdf/table5_a.pdf.

355 Muller et al., supra note 350, at 1672.

356 A 2009 National Academy of Sciences study estimated the annual non-climate related external damages from 406 coal-fired power plants to be $62 billion, or about 3.2 cents/kwh. Press Release, National Academy of Sciences, Report Examines Hidden Health and Environmental Costs of Energy Production and Consumption in U.S. (Oct. 19, 2009), available at http:// www.usclimatenetwork.org/resource-database/NAS%20study%C20*on*%C20costs%C20of% 20energy.pdf. Studies of the effects of coal on the budgets of Kentucky and West Virginia concluded that coal had a net negative impact on both states. See Melissa Fry Konty & Jason Bailey, Mtn. Ass'n for Cmty. Econ. Dev., The Impact of Coal on the Kentucky State Budget (2009), available at http:// www.maced.org/coal/documents/Impact_of_Coal-Exec_Summary.pdf (calculating that the coal industry had about a $115 million net negative impact on Kentucky's budget); Researchers Push for Higher Taxes, Fees, Fines on Coal, Charleston Gazette, Sept. 13, 2010, http://www.wvgazette.com/News/201009130914 (reporting that the coal industry cost the West Virginia government a net of almost $98 million in the 2009 budget year).

357 See National Academy of Sciences, supra note 356 ("Burning natural gas generated far less damage than coal, both overall and per kilowatt-hour of electricity generated.").

358 42 U.S.C. §7401(b)(1) (2006).

359 Emissions of conventional pollutants like sulfur dioxide, particulate matter, and nitrogen oxides from new or modified coal-fired power plants have long been regulated under the CAA. In addition, the acid rain program regulates the emission of acid rain precursors (like sulfur dioxide) from older coal-fired power plants. For a history of these regulatory programs and an early history of the efforts to regulate mercury emissions from coal-fired power plants, see David B. Spence, Coal-Fired Power in a Restructured Electricity Market, 15 Duke Envtl. L. & Pol'y F. 187, 193-99 (2005).

360 See National Emission Standards for Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units, 77 Fed. Reg. 9304 (Feb. 16, 2012) (to be codified at 40 C.F.R. pts. 60 & 63) (regulating mercury emissions from coal-fired power plants as toxic emissions under section 112 of the CAA for the first time). One byproduct of the new mercury rule will be reductions in particulate matter emissions. Id. at 9424. The most serious health costs associated with coal-fired power plants are associated with particulate matter emissions. See Epstein et al., supra note 38, at 85 (listing various serious--and even fatal--ailments that can occur as a result of exposure to particulate matter emissions).

361 See, e.g., Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, 77 Fed. Reg. 22,392 (Apr. 13, 2012) (recommending new standards for carbon dioxide emissions from fossil fuel-fired power plants, given the harm to public health resulting from climate change); see also supra notes 257-64 and accompanying text for a discussion of the EPA's "tailoring rule" for greenhouse gases.

362 See Federal Implementation Plans: Interstate Transport of Fine Particulate Matter and Ozone and Correction of SIP Approvals, 76

Fed. Reg. 48,208 (Aug. 8, 2011).

363 See Spence, supra note 359, at 203-11 (describing the differences between the Clinton and George W. Bush Administrations' approaches to EPA regulation).

364 See, e.g., Matthew L. Wald, New Air Quality Rules for Power Plants in Dispute, N.Y. Times, Dec. 2, 2011, at A24 (detailing opposition from utility companies and Republican Congressmen to some of the EPA's new air pollution regulations for power plants).

365 See supra note 337.

366 See Revesz, supra note 160, at 540 ("[E]nvironmental problems such as the control of drinking water quality [create] virtually no interstate pollution externalities.").

367 Even here, however, the race-to-the-bottom argument seems unpersuasive. Anyone who recklessly or knowingly contaminates a drinking water source faces liability risks irrespective of the SDWA. See, e.g., supra note 64 (discussing liability of Cabot Energy for contamination of drinking water sources in Dimock, Pennsylvania). Rather, the SDWA seems aimed more at pushing states to regulate drinking water sources than at preventing a race to the bottom.

368 42 U.S.C. § 300g-1(b) (2006).

369 See note 196 and accompanying text.

370 See id.; see also Olivier A. Taillieu, Case Note, Agency Action: OSM's Regulations under Strict Scrutiny from the D.C. Circuit, 66 Geo. Wash. L. Rev. 935, 961 (1998) (noting that, prior to the enactment of SMCRA, mining was plagued by undercapitalized firms that caused environmental harm).

371 30 U.S.C. §1211.

372 As with natural gas production, coal mining has some interstate impacts, but most of those can be addressed through existing federal authorities, such as the CWA. See e.g., Proposed Suspension and Modification of Nationwide Permit 21, 74 Fed. Reg. 3411 (July 15, 2009) (revising the permitting program for disposal of fill materials from mining activities under CWA Section 404); see also Ohio Valley Envtl. Coal. v. Bulen, 429 F.3d 493 (4th Cir. 2005) (overturning and remanding district court decision finding nationwide permitting inconsistent with the CWA); Kentuckians for the Commonwealth v. Rivenburgh, 317 F.3d 425 (4th Cir. 2003) (upholding fill activities under a nationwide permit); Ohio Valley Envtl. Coal. v. Hurst, 604 F. Supp. 2d 860 (S.D. W. Va. 2009) (holding that the issuance of a nationwide permit was arbitrary and capricious).

373 For a brief summary of the impacts to land and water from surface mining, see Taillieu, supra note 370, at 961 (noting that, before SMCRA's enactment, "people grossly abuse[d] the land" when mining coal).

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