2016

DISCLOSING THE FACTS:

TRANSPARENCY AND RISK IN HYDRAULIC FRACTURING

A COLLABORATIVE PROJECT OF:

AS YOU SOW®

BOSTON COMMON ASSET MANAGEMENT

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HEALTHY PEOPLE...HEALTHY BUSINESS

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THE INVESTOR ENVIRONMENTAL HEALTH NETWORK (IEHN) is a collaborative partnership of investment managers and advisors concerned about the impact of corporate practices on environmental health.

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EXECUTIVE SUMMARY

Disclosing the Facts 2016 is the fifth in a series of investor reports intended to promote improved operating practices among oil and gas companies engaged in horizontal drilling and hydraulic fracturing. Hydraulic fracturing is performed to release oil and gas from what is currently known as "unconventional resources"—shale and other geological formations from which oil and gas are difficult to retrieve without fracturing. From a production perspective, these formations are anything but unconventional; the U.S. Energy Information Administration reports that in 2015 "unconventional resources" yielded approximately two-thirds of the natural gas and roughly half of the oil produced in the United States.

These operations often use toxic chemicals and high volumes of water, release significant levels of greenhouse gases and other pollutants, and have the potential to adversely impact local communities when not properly managed. These issues, in turn, can translate into financial risk to companies and shareholders in the form of fines, regulations, lawsuits, and threats to companies' social license to operate.

Following the maxim of "what gets measured, gets managed", this report encourages oil and gas companies to increase disclosure about their use of current best practices to minimize the environmental risks and community impacts of their "fracking" activities. Review of disclosed management practices and associated key performance indicators is the primary means by which investors gauge how companies are managing the business risks associated with their environmental and community impacts.

This 2016 scorecard benchmarks the public disclosures of 28 companies on 43 key performance indicators. It distinguishes companies disclosing more information about practices and impacts from those disclosing less. The scorecard assesses five areas of environmental, social, and governance metrics, emphasizing, on a play-by-play basis, quantitative disclosures in: (1) toxic chemicals; (2) water and waste management; (3) air emissions; (4) community impacts; and (5) management accountability.[1] The scorecard relies solely on publicly available information that companies provide on their websites, in corporate SEC postings, or in other reports linked from their websites.

The report focuses on "play-by-play" disclosure, as distinct from reporting at an aggregate level such as company- or country-wide. "Play-by-play" is shorthand for localized reporting, which is appropriate since health and environmental impacts and social license controversies are usually localized. However, in addition to facilitating understanding of local stakeholder relations, localized reporting is important because it offers insight into how company systems for managing risks and impacts are functioning in practice.

This year, the report card has been compiled amidst a continuing dramatic contraction of well drilling and completion activities and enormous financial write-offs. As reported by Baker Hughes, the number of drilling rigs dropped to 476 in March 2016 from a peak of 1,931 in late 2014. Nearly 100,000 jobs linked to the oil and gas sector have been lost in the United States, bankruptcies have multiplied, and companies are now focusing on their most profitable areas rather than expanding into new frontiers.

Despite the sharp downturn from the pell-mell growth of the prior ten years, a core group of companies within the industry has maintained and enhanced disclosures of their practices for managing the environmental risks and community impacts of their operations. While the number of leading scorers has grown, the majority of the oil and gas sector is still leaving investors in the dark about their risk management practices.

KEY FINDINGS

1. **Many companies have substantially increased their disclosures on issues of core concern to both investors and local communities.** Tremendous media attention has been paid for many years to the adverse environmental and community impacts of hydraulic fracturing operations, including high-profile reports of spills, explosions, water contamination, and impacts on community health. Investors have too often had too little information about the concrete measures companies are taking to reduce and manage these risks. Pressed increasingly by investors for greater disclosure—via this and other investor scorecards, investor

dialogues, and shareholder resolutions, companies are responding. For example:

a. Companies are increasingly assessing and reducing the toxicity of the chemicals used for hydraulic fracturing, reducing the numbers of and amount of toxic chemicals used, and lowering the number of chemicals hidden from public disclosure by trade secrecy claims. Although quantitative disclosures are still made by only a few leading companies, a larger number of companies have increased narrative reporting on their progress. Lack of transparency around chemical issues has been a serious challenge for companies seeking to secure their "social license to operate" and has translated into investor uncertainty about company attention to chemical risks.

b. Companies are developing systems to better track community concerns and complaints, which may encompass issues such as traffic safety, noise, light and dust pollution, and road damage. These systems, which also track company responses, promote accountability inside and outside the company, facilitate analysis of these issues at management and board level, and enable reporting to investors and communities on performance.

c. Companies are disclosing numerous operational and technological innovations that reduce their environmental footprint, yield bottom-line benefits, and reduce social conflicts. Companies are sourcing water for hydraulic fracturing operations from treated municipal wastewater, drawing water from deep saline aquifers for which there is no current competition from other users, and treating their own wastewater. Companies are deploying moveable, flexible hoses as substitutes for trucks to move water and wastewater, reducing road hazards, lowering emissions, and saving money. Companies are increasingly using drilling rigs and engines powered by the natural gas they produce, reducing diesel emissions and saving money. Many companies also are taking voluntary actions to reduce emissions beyond regulatory requirements.

SCORECARD

COMPANY	(Out Of 43 Possible Points*) 2016 SCORE	2015 SCORE
BHP Billiton, Ltd. (BHP)	40	32
Noble Energy, Inc. (NBL)	35	19
Apache Corp. (APA)	29	20
Hess Corp. (HES)	27	21
Range Resources Corp. (RRC)	27	11
Southwestern Energy Co. (SWN)	27	16
Carrizo Oil & Gas, Inc. (CRZO)	23	0
CONSOL Energy, Inc. (CNX)	22	19
EQT Corp. (EQT)	21	14
Anadarko Petroleum Corp. (APC)	20	15
Newfield Exploration Co. (NFX)	20	6
ConocoPhillips Corp. (COP)	15	11
Royal Dutch Shell plc (RDS)	15	11
Chesapeake Energy Corp. (CHK)	12	4
Occidental Petroleum Corp. (OXY)	12	10
QEP Resources, Inc. (QEP)	12	15
Encana Corp. (ECA)	10	8
EOG Resources, Inc. (EOG)	8	8
Antero Resources (AR)	7	–
Chevron Corp. (CVX)	7	4
Pioneer Natural Resources (PXD)	7	3
BP plc (BP)	6	8
Exxon Mobil Corp. (XOM)	6	4
Cabot Oil & Gas Corp. (COG)	5	8
WPX Energy, Inc. (WPX)	4	3
Devon Energy Corp. (DVN)	3	7
Continental Resources, Inc. (CLR)	2	2
Whiting Petroleum Corp. (WLL)	2	2

* 2015 had a total of 39 possible points.

2. **Despite these signs of progress, companies are still seriously lagging in taking and disclosing actions to address community and investor concerns.** Three important examples include:

a. *Reducing methane emissions.* Methane, which has more than 84 times the global warming impact of carbon dioxide over a 20-year period, remains a critical environmental challenge. Sound management of these emissions, especially through leak reduction, can yield sizeable business benefits. To lower the climate change hazard from methane emissions, much greater effort is needed to identify methane emission sources in the natural gas value chain (production through distribution). Recent research indicates that a relatively small proportion of sources, labeled "super-emitters", are responsible for the majority of methane

emissions. Companies must do a better job of demonstrating to investors voluntary commitments to measuring and reducing methane emissions beyond regulatory requirements. In particular, much more information should be provided on companies' leak detection and repair (LDAR) programs. Only a very small number of companies report with any detail on this critical issue, have committed to reducing emissions as a percentage of production, or support development of innovative, lower-cost methane detection technologies; more companies should join them.

b. *Addressing Seismicity.* Seismicity has increased dramatically in certain locations, correlated with the location of fracturing or waste injection operations. A significant number of these earthquakes have been of magnitude 3.0 and greater, causing property damage and growing concern. Companies must be vigilant in better understanding this issue, improving their own actions, and assuring oversight and due diligence of contractors.

c. *Addressing health and environmental impacts.* The impact of oil and gas operations on human health and the environment is an enduring, insufficiently researched concern. The potential for significant public health impacts led to New York State's complete ban on hydraulic fracturing and contributes to bans and moratoria around the globe. Scientific studies and incident reports, some more rigorous than others, document adverse health effects associated with oil and gas development; however, little systematic research has been conducted to more firmly establish the likelihood and magnitude of adverse health impacts. Companies should consider contributing to an independent research endeavor co-funded by government and philanthropic foundations concerned about public health (a funding structure likely to reduce arguments over "our science vs. yours") that would enable industry, investors, and communities to better understand the magnitude of health risks and develop precautionary measures to address them.

3. **These disparate trends are reflected in company scores.** This year, *BHP Billiton* retained its #1 position, disclosing on 40 of 43 indicators (93 percent). BHP's comprehensive reporting demonstrates companies' ability to rise to the *Disclosing the Facts* challenge. *Noble Energy*, ranked #2, nearly doubled its score to report on 81 percent of indicators. Other strong and improving performers included *Apache*, which rose to 67 percent, and *Range Resources*, which moved from 28 to 63 percent. *Hess* and *Southwestern Energy* rose to 63 percent. *Southwestern Energy* increased its score despite the company's 40 percent staff reduction announced in early 2016. *Carrizo*, soaring from reporting on 0 to 53 percent of indicators, and *Newfield Resources*, rising from 15 to 47 percent, also were major movers. These scores are a stunning improvement from the inaugural 2013 scorecard, when no company scored above 43 percent. Many of these companies either improved their practices or began reporting on leading practices they previously failed to disclose, or some combination of the two. Nevertheless, 15 of the 28 companies evaluated disclosed on fewer than 33 percent of indicators, preventing investors from gauging how well these companies are addressing environmental and community impact risks. Just as certain companies have made substantial improvements in their disclosures, others have remained intractable in failing to disclose on the majority of indicators. The companies that lag far behind the average include *Whiting* and *Continental*, the lowest scoring companies, which provided information on only 2 indicators each. Devon responded to 3 (notably disclosing on fewer indicators than in 2015 when the company reported on 7 indicators). WPX provided information on 4 indicators and Cabot on 5. Exxon and Chevron still greatly lag their peers; Exxon responded to a mere 6 indicators and Chevron to only 7. Both companies tend to provide worldwide statistics and general practices, for the most part failing to report location-specific practices in all of their U.S. plays, which is critical to understanding localized impacts. Antero and Pioneer also fall in with the bottom scorers by responding to 7 indicators each.

4. **Some companies are mainstreaming *Disclosing the Facts* and developing model disclosure formats.** *Southwestern Energy* and *Apache* have integrated *Disclosing the Facts* indicators into the indices of their corporate sustainability reports. BHP Billiton produces an annual hydraulic fracturing case study that adopts the *Disclosing the Facts* outline. *Noble Energy* produces a stand-alone document addressing hydraulic fracturing indicators that had not been addressed in its prior sustainability reports.

RECOMMENDATIONS

1. **Companies.** All companies that engage in hydraulic fracturing should join in the mainstreaming of risk disclosure. Contamination incidents and community opposition have been associated with companies both large and small. Laggards may be at risk of exclusion from investor portfolios, especially as investors shift resources from increasingly risky fossil fuels to opportunities in renewables and energy efficiency.

2. **Investors.** Investors should continue to press companies, particularly laggards, on disclosure across the five key areas addressed in *Disclosing the Facts 16* to ensure that companies are managing risk and implementing best management practices. Many of the quantitative, locally focused scorecard indicators reflect recommendations made by the International Energy Agency in its 2012 report, *Golden Rules for the Golden Age of Gas*. These indicators are also increasingly being used in investor engagements by a large number of PRI member companies.

3. **Communities.** Officials and concerned citizens at state and local levels should use the leading practice examples highlighted in this and earlier scorecards to query companies seeking to obtain or maintain their social license to operate.

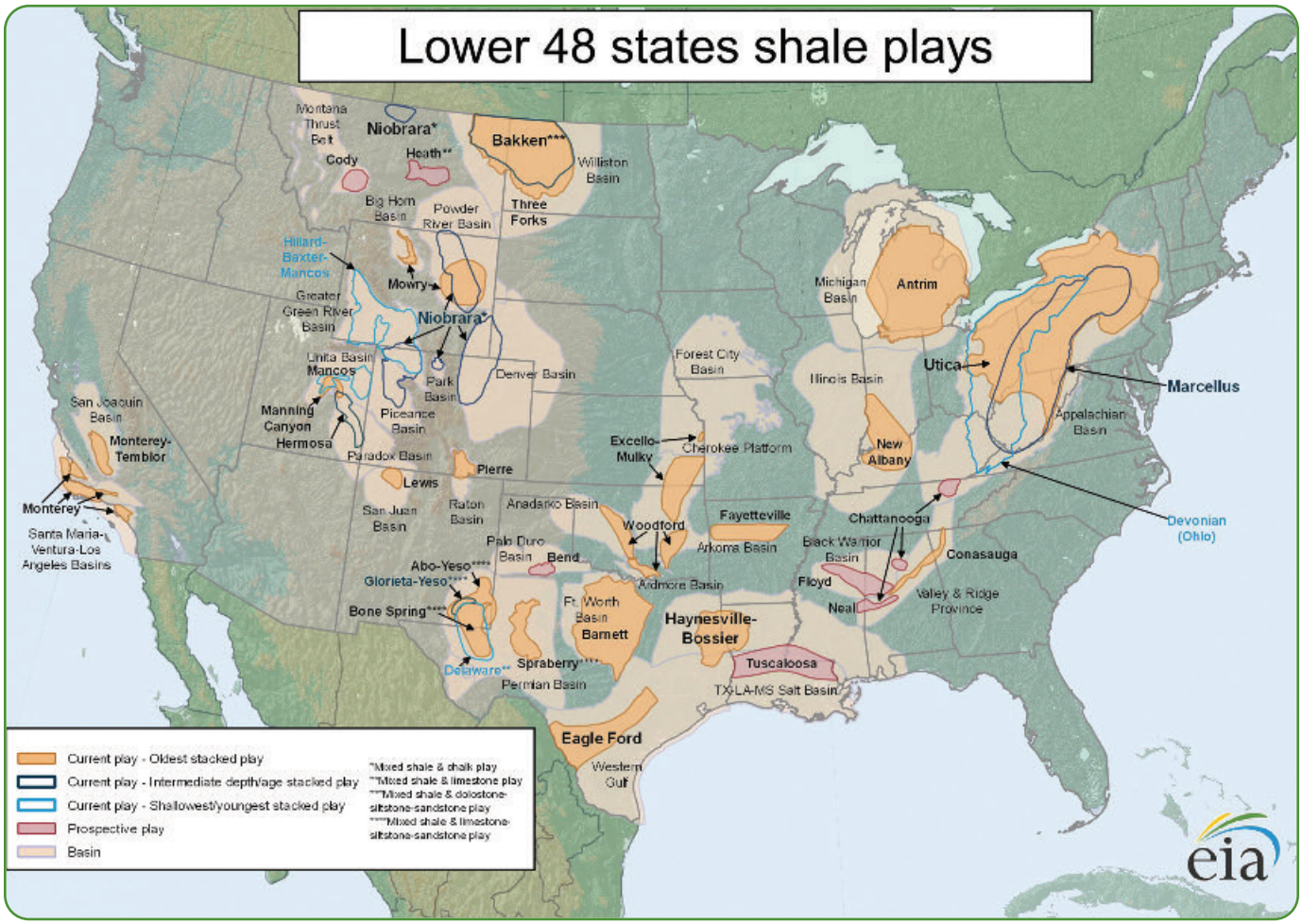

IMAGE: U.S. Energy Information Administration

Source: U.S. Energy Information Administration based on data from various published studies.
Updated: April 13, 2015

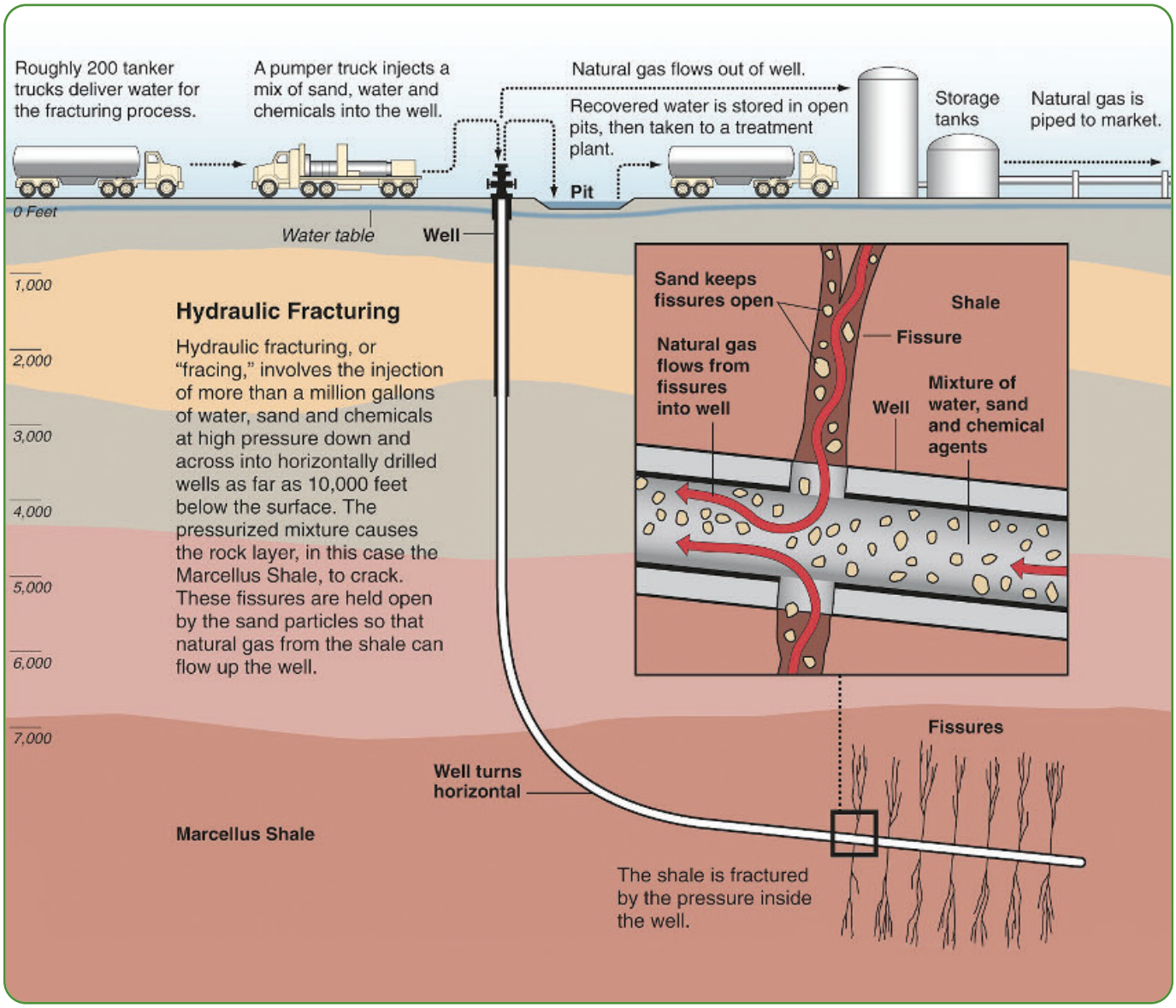

IMAGE: Al Granberg / Propublica.org

INTRODUCTION

Since 2009, coalitions of investors, including public pension funds, banks, and faith-based and socially responsible investors, have been pressing companies—through dialogues and, when necessary, shareholder proposals—to be more transparent about how they manage and mitigate the environmental risks and community impacts inherent in hydraulic fracturing operations. Investors require rigorous, relevant information to make informed investment decisions; hence, this report emphasizes quantitative reporting. Quantitative data also provide assurance to investors that companies have appropriate oversight and accountability practices in place to track—and therefore to mitigate—impacts of their operations. Companies implementing best practices in operations and providing transparent information about these efforts will reduce regulatory and reputational risks, enhance the likelihood of securing and maintaining their social license to operate, and reduce liabilities associated with poor performance, spills, contamination, and lawsuits.

Disclosing the Facts 2016 ("DTF 2016") is the fifth in a series of disclosure guidelines and scorecards intended to encourage oil and gas companies engaged in horizontal drilling and hydraulic fracturing to adopt current best practices in risk management and provide quantitative reporting on operational metrics, including specific practices and improvements. These reports serve to inform shareowners and oil and gas production companies about effective risk management practices and implementation of those best practices, while allowing comparison of industry-level performance against key risk management indicators. These reports also facilitate shareowner engagements with companies by clearly establishing investor expectations and providing a framework for investors and companies to work together to meet these expectations.

The scorecards' foundation, *Extracting the Facts: An Investor Guide to Disclosing Risks from Hydraulic Fracturing Operations*[1], offers best practice recommendations to oil and gas companies for reporting and reducing risks and impacts from natural gas operations. Investors in North America, Europe, and Australia managing more than $1.3 trillion in assets have supported the report, which was published in 2011. The report offers a framework for assessing core management goals, best practices, and key performance indicators for reporting progress.

Building on *Extracting the Facts*, the initial scorecard, *Disclosing the Facts: Transparency and Risk in Hydraulic Fracturing Operations*[2] *("DTF 2013")*, benchmarked 24 oil and gas companies on their disclosures against 32 performance indicators across the five areas of environmental, social, and governance metrics. The scorecard focused on the need for quantitative disclosures and region-specific reporting where relevant, with the goal of increasing company and investor attention to localized risk. *DTF 2013* revealed an industry-wide failure to provide investors and the public with the information necessary to evaluate whether companies are effectively managing the risks and impacts associated with hydraulic fracturing operations.

Disclosing the Facts 2014[3] *("DTF 2014")* updated *DTF 2013*, assessing 30 companies on 35 indicators across the five issue areas. *DTF 2014* reflected efforts by companies to improve upon their 2013 scores. BHP Billiton became the first to disclose on more than half the indicators. Its leap from near the bottom to the top supported conjecture in

1. Investor Environmental Health Network and Interfaith Center on Corporate Responsibility, 2011, http://www.iehn.org/documents/frackguidance.pdf. An eighteen-month investor dialogue with oil and gas companies, convened by Boston Common Asset Management and Apache Corporation and supported by members of the Interfaith Center on Corporate Responsibility and Ceres, provided a venue for extended conversations concerning risks, management practices, and disclosures associated with hydraulic fracturing operations and a forum for industry experts to review draft practices and indicators. The dialogue became the foundation for *Extracting the Facts*, which identifies 12 core management goals, best management practices, and key performance indicators on which investors require disclosure to adequately assess risk management practices. *Extracting the Facts* was intended to promote a "race to the top", encouraging companies to be more transparent and strive for and report on best practices. It urges companies to implement best management practices or to explain why such practices cannot be carried out. Furthermore, it emphasizes the importance of going beyond compliance with existing regulations since the current regulatory framework, particularly at the state level, varies in stringency and, as evident from local bans and moratoria, may not be trusted by local communities.

2. As You Sow, Boston Common Asset Management, Green Century Capital Management, and the Investor Environmental Health Network, *Disclosing the Facts: Transparency and Risk in Hydraulic Fracturing Operations*, 2013, available at http://disclosingthefacts.org/report/DisclosingTheFacts_2013.pdf.

3. As You Sow, Boston Common Asset Management, Green Century Capital Management, and the Investor Environmental Health Network, *Disclosing the Facts 2014: Transparency and Risk in Hydraulic Fracturing*, 2014, http://disclosingthefacts.org/2014/#fullreport.

DTF 2013 that some companies might be implementing certain best practices but not disclosing them. Despite these signs of improvement, *DTF 2014* nevertheless concluded that "failure to quantitatively disclose key performance metrics remains the industry-wide standard".

Disclosing the Facts 2015[4] *("DTF 2015")* again scored 30 companies on 39 indicators across the five issue areas. *DTF 2015* reflected substantial improvements by a growing number of companies. Moves by additional companies from near the bottom of the rankings towards the top indicated a greater focus and uptake of best practices. These positive developments notwithstanding, 70 percent of evaluated companies failed to disclose on two-thirds or more of the indicators.

Overall, the scorecards have demonstrated that the oil and gas industry as a whole is still failing to meaningfully address key public concerns as reflected in on-going media attention, an increasing number of studies into health and pollution impacts, continuing calls for bans and moratoria, and uneven but strengthened state regulations. While some companies have begun responding to these growing concerns by providing increased voluntary disclosures, the broad lack of quantitative reporting makes it challenging for investors and other key stakeholders to objectively evaluate operational risks and the integrity and robustness of corporate risk management systems. With consideration to the difficulty of managing that which is not measured, investors and other key stakeholders are concerned with this lack of accountability and will continue to press for more transparent and rigorous reporting from companies engaged in hydraulic fracturing.

SCORECARD

OVERVIEW

Disclosure is critical as it is the primary vehicle by which investors gain insight into the extent to which companies are adopting current best management practices and reducing key risks. Risk management policies are most meaningful to investors when companies disclose data demonstrating their policies' effectiveness. Some companies may, in fact, be implementing current best practices on a broad scale but, absent disclosure, investors are left in the dark about the effectiveness of companies' systems and the relations they have built with local stakeholders.

Disclosing The Facts 2016 scores 28 oil and gas companies[5] on their performance on 43 disclosure indicators. The 43 questions reflect the changing nature of company actions and public concerns. For instance, certain best practices—such as replacing trucks with pipelines to transport water—have been widely adopted across the industry, so investors can now focus their questions on when and how a company employs pipes in place of trucks. Similarly, the changing nature of local and national priorities, such as the focus on a company's community response systems or the now red-hot attention to methane leaks from drilling and production operations, and how companies are responding to these issues, require new or more focused questions.[6]

Each company is scored based solely on documents and information available on, or linked from, its public website. The indicators include practices set forth in cutting-edge regulations recently adopted or proposed in various jurisdictions and are grouped into the five aforementioned areas of risk management.

4. As You Sow, Boston Common Asset Management, Green Century Capital Management, and the Investor Environmental Health Network, *Disclosing the Facts 2015: Transparency and Risk in Hydraulic Fracturing*, 2015, http://disclosingthefacts.org/2015/DisclosingTheFacts_2015.pdf.

5. The number of companies evaluated in each scorecard every year has changed to reflect changes in the industry. We began in 2013 with the 24 largest gas producers in the U.S. and Canada and in 2014 added six companies to include the three largest publicly owned producers in each of the major plays at the time. Further adjustments were made in 2015 and 2016 to reflect acquisitions as well as various changes in activity levels. A core group of 23 companies has been scored continuously since 2013. In 2016, three companies that have declared bankruptcy or indicated they might need to do so were deleted and one company, Antero Resources, which has become a leading well driller in the Marcellus Shale, was added.

6. Appendix A lists the complete set of questions for *DTF 2016*.

The scorecard places special emphasis on the quantitative reporting of activities and impacts on a play-by-play[7] basis due to the often local consequences of hydraulic fracturing operations. While we recognize that companies must have company-wide policies and risk management practices in place to guide operations across all plays, play-by-play reporting is critical as it enables investors to gain confidence that companies are accountable for how they manage risks that manifest on a local level, including water quantity and quality, air quality, waste management, and community impacts such as increased traffic, noise, and strain on infrastructure. The scorecard's focus on play-by-play reporting also reflects the regional and local variations among plays, as well as the reality of diverse regulatory systems where onshore oil and gas exploration and production in the U.S. is largely state-regulated as opposed to federally regulated.

DTF 2016, for the sake of brevity, offers less detailed information and documentation about the five areas of risk management than was provided in earlier versions of the scorecard; however, we provide numerous cross-references to where such details can be found in prior reports. *DTF 2016* continues to provide examples of exemplary corporate disclosures that have surfaced since publication of *DTF 2015*. For prior noteworthy practices, readers should consult previous editions of the *DTF* scorecard.

COMPANY PERFORMANCE ON RISK MANAGEMENT DISCLOSURE INDICATORS

The following five sections describe why the area of risk management is important to investors, provide detailed company scores, and provide examples of notable practices and disclosures.

IMAGE: FracTracker Alliance

Truck Hauling Chemicals to Well Pad

TOXIC CHEMICALS

Issue and Questions

The toxic chemicals used in hydraulic fracturing operations have generated significant public concern and become a flashpoint for public controversy. These chemicals, if released into the environment, can have a range of harmful

7. The U.S. Geological Survey defines a play as a "set of known or postulated oil and/or gas accumulations sharing similar geologic, geographic, and temporal properties". See U.S. Geological Survey, "World Petroleum Assessment 2000", 2000, pp. GL-6, http://certmapper.cr.usgs.gov/data/PubArchives/WEcont/chaps/GL.pdf. Examples include the Barnett, Marcellus, and Fayetteville Shales and the Bakken Formation. Many plays extend across state or provincial boundaries.

impacts based on their toxicity, mobility, solubility, volatility, and persistence.[8,9] Companies reducing the toxicity of their chemicals or eliminating them entirely mitigate associated environmental, legal, and social risks. Companies that disclose their chemical use publicly can enhance credibility if they are clear about when those disclosures are limited by trade secret constraints. In the past, failure to disclose data based on trade secret limitations has been a significant critique of the FracFocus database.[10]

The 2016 scorecard asks, as did prior editions, whether a company provides quantitative reporting regarding its progress in reducing the toxicity of hydraulic fracturing additives, has a practice to not use diesel or BTEX in its fracturing fluids, and clearly states on its website that FracFocus reports may not include specific chemicals due to claims of confidential business information (CBI).[11]

This year's scorecard elaborates on these inquiries in two ways. First, it asks companies to disclose whether they have a practice to use dry (powdered) fracturing chemicals in place of liquid chemicals to reduce risk. Dry forms of chemicals are regarded as easier to clean up in the event of spills; for example, a release of dry chemicals is not as likely to require excavation of massive amounts of contaminated soil as a wet spill would. They also save on energy and transportation expenses because they are lighter and more compact than liquid chemicals.[12] However, some companies may decide against their use based on concern about workers' exposure to dry chemicals during on-site mixing and handling processes. Second, the scorecard asks what steps oil and gas production companies are taking to reduce their own and their contractors' CBI claims. Research conducted in 2015 shows that approximately 18 percent of substances listed in FracFocus have their identities masked by CBI claims.[13]

Scores

Measuring elimination of harmful chemicals. Many oil and gas companies communicate their intention to use "environmentally friendly" fracturing fluids, but few provide specifics that would allow investors or other stakeholders to evaluate the effectiveness of these initiatives. Six (6) companies quantitatively report toxicity reductions; however, these company disclosures vary in their detail.

8. The California Council on Science and Technology, in a report requested by California's state legislature, recommended, "use of chemicals with unknown environmental profiles should be disallowed. The overall number of different chemicals should be reduced, and the use of more hazardous chemicals and chemicals with poor environmental profiles should be reduced, avoided, or disallowed". The council further suggested that operators should apply green chemistry principles (e.g., reducing innate chemical hazard) in formulating hydraulic fracturing fluids. See California Council on Science and Technology, *An independent scientific assessment of well stimulation in California—summary report—an examination of hydraulic fracturing and acid stimulations in the oil and gas industry*, 2015, p. 36, https://ccst.us/publications/2015/2015SB4summary.pdf.

9. In its 2015 draft report on hazards to drinking water from hydraulic fracturing operations, the U.S. Environmental Protection Agency similarly noted sizeable gaps in knowledge about the potential human health impacts posed by chemicals used in hydraulic fracturing. See U.S. Environmental Protection Agency, *Assessment of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources, Executive Summary*, 2015, E.S. p. 12, http://www2.epa.gov/sites/production/files/2015-06/documents/hf_es_erd_jun2015.pdf.

10. FracFocus (www.fracfocus.org) is the principal vehicle by which companies report chemical use on a well-by-well basis. For additional discussion about the evolution and limitations of FracFocus, see *DTF 2014*, p. 13 and *DTF 2013*, note 10.

11. As noted in *DTF 2013*, p. 12, "Two chemical categories of particular concern (among many others, including endocrine disrupters and bio-accumulative chemicals) are diesel fuels and BTEX (benzene, toluene, ethylbenzene, and xylenes). Diesel fuel contains chemicals of concern including BTEX, which is a family of 'poster child' toxic chemicals associated with leukemia, neurological damage, and other health effects". For further background, see *DTF 2014*, p. 10 and p. 24.

12. Apache, "2016 Sustainability Report", p. 4, http://www.apachecorp.com/Resources/Upload/file/sustainability/APACHE-Sustainability_Report_2016.pdf.

13. See K. Konschnik and A. Dayalu, "Hydraulic fracturing chemicals reporting: analysis of available data and recommendations for policymakers", *Energy Policy*, 2016, 88:504-514, doi:10.1016/j.enpol.2015.11.002. The authors looked at data for just over four years beginning in March 2011. They found that when companies and their suppliers used a different reporting approach on FracFocus called a "systems approach"—separating specific chemicals from the products containing them—CBI claims dropped four-fold. FracFocus has been promoting increased use of a "systems approach" to reporting since February 2015. An important but non-related finding of the report is that reporting compliance rates are low where states fail to enforce reporting requirements.

TOXICS COMPANY	Quantitative Toxicity Reduction	Use of Dry Chemicals	No Diesel in Frac Fluids	No BTEX in Frac Fluids	CBI Exclusion Disclaimer	Reducing Contractor CBI Claims	TOTAL
Apache	✓	✓	✓	✓	✓	✓	6
BHP Billiton	✓	✓	✓	✓		✓	5
Anadarko		✓	✓		✓	✓	4
Chesapeake	✓	✓	✓		✓		4
QEP	✓		✓	✓	✓		4
Southwestern Energy	✓		✓	✓	✓		4
Carrizo			✓	✓	✓		3
ConocoPhillips			✓	✓	✓		3
Hess Energy	✓		✓	✓			3
Noble Energy		✓	✓		✓		3
Occidental Petroleum			✓	✓	✓		3
Range Resources		✓	✓	✓			3
BP		✓			✓		2
Cabot			✓	✓			2
Chevron			✓	✓			2
Shell			✓		✓		2
CONSOL			✓				1
Continental Resources					✓		1
Encana			✓				1
ExxonMobil			✓				1
Antero							0
Devon							0
EOG							0
EQT							0
Newfield Resources							0
Pioneer							0
Whting Oil & Gas							0
WPX							0

Eliminating diesel and BTEX chemicals. Eighteen (18) companies report eliminating diesel from their fracturing fluids.[14] Eleven (11) companies report eliminating the suite of benzene, toluene, ethylbenzene, and xylene (BTEX) chemicals. Since diesel use has been reported only several hundred times in a FracFocus database that now holds chemical records for about 110,000 wells, it is likely that most companies now use diesel rarely, if they use it at all.

Dry chemical use. Seven (7) companies report substituting dry chemicals for liquid chemicals. Substituting dry chemicals for chemicals shipped in liquid form can reduce truck trips and associated vehicle emissions and highway risks of spills. It can also lower costs. *Apache* is experimenting with replacing liquid friction reducers and scale inhibitors with powdered materials. These powdered materials will reduce the required friction reducers and scale inhibitors volume by two-thirds and one-sixth, respectively, by reducing the need for carrier solvents and additional chemicals.[15]

Disclosure of toxic chemicals and CBI, and measures to reduce CBI claims. Corporate disclosure of the chemicals used for hydraulic fracturing has increased exponentially, from virtually no disclosure in 2010 to disclosure

14. Diesel use is subject to regulation by the U.S. Environmental Protection Agency, so companies have an incentive to avoid it. As noted in *DTF 2014*, an independent analysis of FracFocus data in 2014 showed that diesel had only been used in several hundred of the thousands of wells reported. See *DTF 2014*, p. 11 and note 8.

15. Though there can be concern by some companies that using dry chemicals could lead to increased worker inhalation exposures on the well pad, these chemicals can be mixed in enclosed systems that minimize worker risk.

IMAGE: FracTracker Alliance

Chemicals being trucked to well sites

of most of the chemicals used in the approximately 110,000 wells completed since 2011. However, companies sometimes do not disclose all the chemicals used because of confidential business information (CBI)[16] or trade secrecy claims in sales contracts with chemical suppliers. To protect their credibility, when companies discuss chemicals use on their websites, they should acknowledge when disclosure is limited by CBI claims. Currently twelve (12) companies provide such acknowledgment. CBI claims are likely to be less of an issue in the future, as FracFocus has been implementing a new 'systems' reporting format that allows reporting of specific chemicals separate from the products containing them.[17] Greater adoption of this type of reporting should reduce the need for companies to claim confidentiality or trade secrecy. Three (3) companies—Anadarko, Apache, and BHP Billiton—report on their steps to reduce CBI claims.

Notable Practices

- *Apache* continues its industry-leading fracturing chemical innovation efforts. It reduced by 60 percent the volume of toxic chemicals it used in North America between 2014 and 2015. The company reports progress in substituting dry chemicals for liquids. Apache "self-sources" its hydraulic fracturing fluids, working with its suppliers to source chemicals without CBI protection claims.[18]
- *Southwestern Energy* reports that it has evaluated, through its Right Products program, 99 percent of its hydraulic fracturing chemicals for environmental and health hazards. The company identified "greener alternatives" for 20 chemicals used, out of 175 total, and has begun evaluating chemical toxicity in other phases of its operations.[19]
- *Anadarko* has developed a Chemical Assessment Rating Evaluator (CARE) tool to evaluate the environmental profile of its fracturing fluids. Anadarko staff are developing a baseline of chemicals used in well completions to assess chemical use reduction since 2009. Anadarko also reports that it encourages its suppliers to use a reporting format that enables disclosure of materials without the need to make CBI claims. The company has also worked with FracFocus to alter the website to provide for greater disclosure.[20]
- *BHP Billiton*, working with its service companies, has developed several dry chemicals that are either now in use or undergoing field trials for testing.[21]

16. "Confidential Business Information" as used in this report denotes trade secrets and all other claims of business confidentiality related to chemical disclosure.
17. In the fall of 2016, FracFocus's joint venture partners, the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission, launched an update to FracFocus that had been announced in February 2015. See http://fracfocus.org/major-improvements-fracfocus-announced. The update includes a format change that should help reduce confidential business information claims, as well as new systems to reduce data errors and increase the ability of the public to search the data.
18. Apache, "2016 Sustainability Report", pp. 25-26, http://www.apachecorp.com/Resources/Upload/file/sustainability/APACHE-Sustainability_Report_2016.pdf.
19. Southwestern Energy, "Corporate Responsibility Report 2015-16", 2016, p. 26, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report.pdf.
20. Anadarko, "Health, Safety, Environment and Sustainability Overview 2015", p. 14, https://www.anadarko.com/content/documents/apc/Responsibility/Governance_Documents/2015_HSE_Overview.pdf.
21. BHP Billiton, "Responsibly managing hydraulic fracturing: Case Study 2016", p. 2, http://www.bhpbilliton.com/~/media/bhp/documents/society/reports/2016/161018_responsiblymanaginghydraulicfracturing.pdf?la=en.

WATER AND WASTE MANAGEMENT

Issue

Due to the toxic chemicals used during hydraulic fracturing and the large volumes of contaminated water produced from wells, risks related to water quality are a significant concern for companies, their investors, and the public. Also, hydraulic fracturing of horizontally drilled wells typically requires millions of gallons of water per well, which can be a significant issue in water-stressed areas.

Well drilling and fracturing present potential for chemicals used in fracturing fluid or methane and other naturally-occurring pollutants to migrate into ground water. One pathway is through wellbore leaks that allow pollutants, including methane from non-targeted methane-bearing formations, to travel along the outside of the well casing into ground water. A second pathway can be created by contaminants moving, via newly created fractures in the production zone, through intersecting neighboring wells, abandoned wells, or existing natural or man-made fractures.[22] In 2015, the U.S. Environmental Protection Agency released a long-awaited review of studies related to water contamination associated with hydraulic fracturing. EPA's draft report noted that there are above- and below-ground mechanisms by which hydraulic fracturing activities have the potential to impact drinking water resources and identified specific instances of impacts on drinking water resources, including contamination of drinking water wells. Although EPA did not find evidence of widespread, systemic impacts on drinking water resources in the U.S. from hydraulic fracturing, it noted that this finding may be due to a rarity of effects on drinking water resources or as a result of other limiting factors including insufficient pre- and post-fracturing data on the quality of drinking water resources; the paucity of long-term systematic studies; the presence of other sources of contamination precluding a definitive link between hydraulic fracturing activities and an impact; and the inaccessibility of some information on hydraulic fracturing activities and potential impacts.[23]

IMAGE: Bill Hughes, OVEC/ohvec.org

Construction of Large Fresh Water Holding Pond

22. For a review of the literature on contamination risks from drilling and fracturing, see *DTF 2014*, note 24, and *DTF 2015*, note 21.

23. See U.S. Environmental Protection Agency, *Assessment of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources, executive summary*, 2015, p. ES-6, http://www2.epa.gov/sites/production/files/2015-06/documents/hf_es_erd_jun2015.pdf. See also Susquehanna River Basin Commission, "SRBC Releases Report for its Remote Water Quality Monitoring Network", 2015, http://www.srbc.net/newsroom/NewsRelease.aspx?NewsReleaseID=144. In comments on the draft EPA report, EPA's Science Advisory Board urged the agency to clarify its statement regarding not finding "widespread, systemic impacts". While four of the panel's 30 members concluded this statement is "clear, concise, and accurate" most panelists did not share that view. Rather, they said the agency's findings "are ambiguous and appear inconsistent with the observations, data, and levels of uncertainty" presented and discussed in the report. Consequently, the statement "has been interpreted by readers and members of the public in many different ways". The Advisory Board further noted that if EPA retains the original statement, it should provide quantitative analysis supporting it. Many of the panel's additional observations underscore the need for further clarification. For example, they noted that local impacts on water quality, when they occur, have the potential to be severe; they urged EPA to say more about findings from high-profile water contamination controversies in Dimock, Pennsylvania; Pavillion, Wyoming; and Parker County, Texas. The panel placed particular emphasis on disclosure of the probabilities and risks of various contributors to potential water contamination. The Panel referred, for example, to "the higher likelihood" of impacts associated with various elements of well construction, well integrity, and well injection. Noting that naturally occurring contaminants and degraded drinking water in wells can occur for reasons not related to hydraulic fracturing, the Panel urged EPA to add greater information on existing conditions that pre-date fracturing operations. See U.S. Environmental Protection Agency, "SAB review of the EPA's draft assessment of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources", 2016, https://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/BB6910FEC10C01A18525800C00647104/$File/EPA-SAB-16-005+Unsigned.pdf.

Other sampling studies have found a range of results.[24]

After the fracturing process is completed, some of the water containing intentionally added chemicals as well as chemicals naturally present in the formation being fractured (including varying levels of salts, heavy metals, BTEX chemicals, and naturally occurring radioactive elements) returns to the surface.[25] This water must be stored, treated, reused, and/or disposed of safely. One of the highest risk pathways for water contamination of surface and ground waters is through surface spills and leaks of this return water, also called produced water.[26] Injection of produced waters into deep wells drilled for the purpose of disposing of liquid wastes from producing wells has been linked to increased seismicity risks.

Water scarcity is another increasingly polarizing concern for many communities when considering hydraulic fracturing activities, especially in drought-stricken or water-stressed areas. Even areas with plentiful water may become stressed if a high proportion of available water is already allocated among regional users. Regional population growth, among a host of other issues such as heavy agricultural or industrial consumption, can increase water stress. Perceived or actual competition for water resources will continue to be an issue as droughts persist or increase in frequency across the nation in line with increasing global temperatures.

24. In 2016, additional studies were published addressing water contamination. For example: U.S. Geological Survey and university researchers collected water samples upstream and downstream from an underground injection site in West Virginia and found elevated concentrations of chemicals known to be in oil and gas wastewater in downstream surface waters and sediments. The researchers concluded that while most of the chemical levels were not high enough to cause immediate and lethal concerns for aquatic life, the observed changes in the microbial community and evidence of endocrine (hormone) disrupting activity "indicate potential adverse health outcomes for organisms living in or near the stream". See U.S. Geological Survey, "Indication of Unconventional Oil and Gas Wastewaters Found in Local Surface Waters", 2016, http://toxics.usgs.gov/highlights/2016-05-09-uog_wastes_in_streams.html.

    Research by academic researchers at the University of Texas, Arlington and elsewhere found various chemicals associated with fractured oil wells in groundwater in the Cline Shale of West Texas. See University of Texas, Arlington, "UTA research demonstrates that groundwater quality changes alongside the expansion of hydraulic fracturing and horizontal drilling", 2016, https://www.uta.edu/news/releases/2016/04/Schug-permian-basin.php. In 2015 the University of Texas, Arlington researchers published a study of the Barnett Shale that found elevated levels of metals and chemicals associated with fracturing operations, and while careful to neither definitively associate nor dismiss their association with the fracturing operations, the study found an association to be "more likely" than not. See "Study finds elevated levels of metals, chemicals in Barnett Shale water samples", *Fort Worth Star-Telegram*, 2015, http://www.star-telegram.com/news/business/barnett-shale/article24830848.html.

    Research from the University of Cincinnati, funded by private foundations (Deer Creek Foundation and David and Sara Weston Foundation), the Ohio Board of Regents, and the National Science Foundation, reported in 2016 that natural gas drilling in Ohio's Utica Shale had no observed effect on water quality based on three years' pre- and post-drilling monitoring data from 23 wells above the Utica Shale. The researchers found that some of the highest observed methane concentrations were associated with subsurface coal beds that underlie much of eastern Ohio. See "Study shows natural gas drilling not contaminating water wells in Carroll County", *New Philadelphia Times Reporter*, 2016, http://www.timesreporter.com/article/20160205/NEWS/160209495 and University of Cincinnati press release, "Tapping a valuable resource or invading the environment? Research examines the start of fracking in Ohio", 2013, http://www.uc.edu/news/NR.aspx?id=18455.

    Researchers at the University of Colorado, Boulder, in a study of 924 wells, found that 593 had dissolved methane, mostly generated by bacteria, likely within shallow coal seams. Forty-two wells were found to have stray gas from gas-producing formations, with inadequate surface casing and leaks in production casing and wellhead seals in older, vertical wells identified as the pathway. The leaking vertical wells were constructed prior to 1993, when Colorado tightened its well construction requirements. See, O. Sherwood, et al., "Groundwater methane in relation to oil and gas development and shallow coal seams in the Denver-Julesburg Basin of Colorado", 2016, *Proceedings of the National Academy of Sciences*, http://www.pnas.org/content/113/30/8391.abstract.

    A team of researchers, including present and former Chesapeake Energy employees, found that almost a quarter of approximately 27,000 pre-drilling samples collected by the company in Pennsylvania and West Virginia contained naturally-occurring methane. See D. Siegel et al., "Dissolved methane in shallow groundwater of the Appalachian Basin: Results from the Chesapeake Energy predrilling geochemical Database", *Environmental Geosciences*, 2016, http://eg.geoscienceworld.org/content/23/1/1.full.pdf+html.

25. See A. Vengosh, "Fracking wastewater is mostly brines, not man-made fracking fluids", Phys.org, 2016, http://phys.org/news/2016-10-fracking-wastewater-brines-man-made-fluids.html.

26. See Resources for the Future study cited in DTF 2013, note 28. In North Dakota, academic researchers (funded by the National Science Foundation and Natural Resources Defense Council) are studying areas that experienced spills from wastewater over several years resulting in soil and surface water in the areas being contaminated with radioactive materials and other toxic chemicals. See "Toxic chemicals from fracking wastewater can persist for years", *Chemical and Engineering News*, 2016, http://cen.acs.org/articles/94/web/2016/05/Toxic-chemicals-fracking-wastewater-spills.html and "Study indicates lingering saltwater contamination in oil patch", *Bismarck Tribune*, 2016, http://bismarcktribune.com/news/state-and-regional/study-indicates-lingering-saltwater-contamination-in-oil-patch/article_d62aaa65-c9ff-5ddb-bb40-8e0983efdde3.html.

WATER AND WASTE ISSUES

COMPANY	Cement Evaluation	Well Integrity	Assesses Offset Wells	Avoids Inducing Seismic Activity	Pre-drill H2O monitor^	Post-drill H2O monitor^	Flowback water reuse %^	Total water use^	Water Source Types^	Non-potable water policy	Water Scarcity Planning	Water intensity^	Wastewater Storage^	Closed loop drilling residuals^	NORMs disclosure	TOTAL
BHP Billiton	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	14
Hess Energy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		14
Noble Energy	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	14
Apache	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	12
Carrizo	✓		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	12
Range Resources	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	12
Southwestern Energy		✓	✓				✓	✓	✓	✓	✓	✓		✓	✓	10
CONSOL			✓		✓	✓	✓	✓	✓	✓			✓	✓		9
Newfield Resources	✓	✓	✓				✓			✓	✓			✓	✓	8
Anadarko	✓			✓				✓	✓	✓	✓			✓		7
Occidental Petroleum	✓						✓	✓	✓	✓	✓			✓		7
EQT							✓			✓		✓	✓	✓	✓	6
Shell				✓	✓	✓				✓	✓					5
ConocoPhillips			✓							✓	✓					3
EOG	✓				✓					✓						3
ExxonMobil				✓						✓	✓					3
QEP	✓		✓							✓						3
Antero													✓	✓		2
BP				✓							✓					2
Chesapeake										✓					✓	2
Devon										✓					✓	2
Pioneer				✓						✓						2
WPX	✓				✓											2
Cabot	✓															1
Chevron										✓						1
Encana										✓						1
Continental																0
Whiting Oil & Gas																0

Management of water risks at each stage of drilling, completion, and production must be a core priority for companies. In evaluating corporate disclosures on water management practices, play-by-play reporting is critical because water concerns are primarily local in nature. Accountability at this level serves as an important indicator to investors of a company's ability to effectively manage local operating challenges. In some cases, water risk can vary even within plays, where the plays are several hundred square miles across and cut across diverse hydrologic systems. In other cases, geologic plays are stacked on top of one another, so it may be most appropriate to aggregate reporting for such plays. While localized reporting is critical to understanding water risk, selection of the most appropriate reporting scale remains a challenge.

Questions

Due to the large number of questions regarding water and waste management, questions, scores, and notable practices are presented in subsections below.[27]

27. Many of the well integrity, water, waste, and seismicity practices discussed in this section are increasingly being addressed in state regulations governing hydraulic fracturing operations. For example, California's regulations (SB 4-Well Stimulation Treatment Regulations) call for identification of nearby offset wells (Sec. 1784(a)(2)) and nearby faults (Sec 1784(a)(3)); running a cement evaluation log (Sec. 1784.2); seismicity monitoring (Sec. 1785.1); storage of waste fluids in containers instead of pits (Sec. 1786(a)(4)); and identification of water sources for fracturing fluids (Sec. 1788(a)(12). See ftp://ftp.consrv.ca.gov/pub/oil/laws/Final%20Text%20of%20SB%204%20WST%20Regulations.pdf.

DTF 2016 adds two additional indicators to those addressed in *DTF 2015*. One asks companies to report the percentage of well integrity failures that result in releases to the environment and the second asks companies to specifically disclose whether they operate in "water-scarce areas" and their practices for reducing fresh water use in such areas.

CEMENT INTEGRITY: Proper well construction—an essential element of well integrity—is widely viewed by experts as a key factor in reducing risk to ground water from hydraulic fracturing operations. The methods for constructing wells and monitoring integrity have been improving continually.[28] States have been tightening regulations governing well integrity since the early 2000s; however, regulations still vary in their stringency.[29]

The scorecard focuses in particular on whether companies disclose cement evaluation practices such as cement evaluation logs or temperature, acoustic, or ultrasonic measures that can provide an extra level of assurance about cement integrity.[30]

Scores: Thirteen (13) companies reference the use of cement evaluation practices.

IMAGE: Bill Hughes, OVEC/ohvec.org

Cementing Casing on Drill pad in Wetzel County, WV

WELL INTEGRITY FAILURES THAT RESULT IN A RELEASE TO THE ENVIRONMENT: Most companies describe many measures they take to construct wells to keep them from leaking contaminants into the environment. Yet contamination episodes occur. This new indicator for 2016 asks about the ultimate outcome of the multiple protective systems they use: does a component failure result in a release to the environment? While many companies routinely report the number and volume of spills they experience, which can be the result of equipment failures, human errors, and other factors on the surface, this question asks more specifically about the results of companies'

28. The published literature contains diverse estimates of the frequency of problems with well construction. Wells are constructed with multiple pipe and cement barriers, so if one barrier fails, the well may still not pose a risk to the environment. However, poor cementing jobs in regions where methane exists close to the surface may allow methane to move upward through the outermost portion of the wellbore into drinking water aquifers or may allow it to escape to the atmosphere. It is generally believed that risks increase as wells age and that even when constructed properly, earlier generations of wells are riskier than newer wells due to the continual improvement of cementing practices over time. See sources cited in *DTF 2014*, note 25, and *DTF 2013*, notes 24 and 28. Academic researchers studying methane contamination of wells in the Denver-Julesburg basin (see note 24 above) estimated wellbore failure to be from 0.06 percent of the 54,000 oil and gas wells in the basin to 0.15 percent of the 20,700 wells in the area where stray gas contamination occurred. The failure rate has remained steady at about two cases per year since 2001, although hydraulic fracturing and horizontal drilling were not introduced until 2010. The researchers based their conclusions on archived water quality data from 1988 to 2014. However, it is not clear that all newer wells are necessarily safer than older wells. Recent comparative analysis finds that newer wells in certain locations experienced greater numbers of violations than wells drilled in an earlier period; explanations may include greater regulatory scrutiny, greater length of new wells, greater intensity of fracturing pressures, greater volumes of water used, and generally increased complexity due to these factors. See, for example, R. Jackson, "The integrity of oil and gas wells", *Proceedings of the National Academy of Sciences*, 2014, 111(30): 10902–10903, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121783/. Although practices are improving, well construction issues can still occur, as evidenced by fines levied by Pennsylvania's Department of Environmental Protection in 2015 for incidents stemming from casing and cementing issues at a Chesapeake Energy well in 2012 and at an XTO (Exxon Mobil) well in 2011. See Pennsylvania Department of Environmental Protection, "DEP reaches penalty agreements with three natural gas exploration companies in the Northern Tier", 2015, http://www.ahs.dep.pa.gov/NewsRoomPublic/SearchResults.aspx?id=20820&typeid=1.

29. For example, a review of regulations in 27 states by the multi-state Groundwater Protection Council found that all states require cementing outer surface casing from top to bottom, but other provisions for well integrity vary substantially among the states. See Groundwater Protection Council, *State oil & gas regulations designed to protect water resources*, 2014, Appendix 3, pp. 71-74, http://www.gwpc.org/sites/default/files/Oil%20and%20Gas%20Regulation%20Report%20Hyperlinked%20Version%20Final-rfs.pdf.
In 2016, the Ground Water Protection Council published a compilation of 136 "regulatory elements" for regulators to consider when improving the permitting process governing construction, operation, and plugging of oil and gas wells. See Ground Water Protection Council, *Well integrity regulatory elements for consideration*, 2016, http://www.gwpc.org/sites/default/files/Well%20Integrity%20-%20Full%20Publication%202016.pdf. The council drew upon a model regulatory framework developed by a collaboration of the Environmental Defense Fund and Southwestern Energy, which Texas and other states had drawn on previously in updating their regulations.

30. *DTF 2015*, note 25, provides an extensive review of pertinent state regulations and American Petroleum Institute standards and guidelines.

efforts to protect well integrity. *Hess* was the first company to report such data, reporting in 2015 that it experienced no such failures in North Dakota, where it had been drilling 200 wells annually for several years; this indicator invites other companies to provide similar information.[31]

Scores: Four (4) companies report their well integrity failures that are known to have resulted in a release to the environment. These include *BHP Billiton*, *Hess*, *Newfield Exploration*, and *Southwestern Energy*.

Notable Practices

- *Southwestern Energy* reports that it drilled 385 unconventional wells during 2015 and a total of about 5,335 such wells from 2005 through the end of 2015. Since 2005, the company has recorded 195 instances (representing approximately 3.7 percent of wells drilled) in which individuals have questioned whether Southwestern's operations may have affected their privately owned groundwater wells. Southwestern reports play-by-play data regarding the outcomes of its investigations into these complaints, concluding that in the majority of cases either there was no identified water quality problem or the problem was the result of naturally occurring bacteria; in one case the company concluded that its operations were a contributor.[32]
- *Newfield Exploration* reports "no well integrity events have occurred on Newfield operated wells since 2011".[33]

RISKS FROM NEARBY WELLS AND EXISTING FAULTS AND FRACTURES: The scorecard asks if companies disclose the steps they take to identify and avoid the risk of hydraulic fracturing fluids, water, gas, and other pollutants intersecting nearby oil and gas wells and existing faults and fractures from past drilling. Nearby wells and fractures can allow fracturing fluids, water, and other pollutants to move out through them.[34] This problem has been especially visible in the Province of Alberta, Canada, where 21 such incidents were reported between 2010 and 2012, some leading to spills and others leading to nearby well damage. These incidents led to Alberta regulators directing companies to better assess and reduce risks related to nearby wells.[35, 36]

In the U.S., state regulations addressing existing wells are uneven.[37] Model drilling regulations developed by Southwestern Energy and the Environmental Defense Fund (EDF) call for states to establish databases of existing and abandoned wells and for drilling permit applicants to identify them during the permit process.[38]

Scores: Eleven (11) companies describe their actions to reduce risks from offset wells.

Notable Practices

- *Anadarko* reports that in Colorado it evaluates the mechanical integrity of all offset wells, operated and non-operated, active and not active, and does so 500 feet beyond the 1,500-foot radius required by state

31. Hess, "2014 Corporate Sustainability Report", p. 47, http://www.hess.com/docs/default-source/sustainability/2014-sustainability-report.pdf?sfvrsn=2.
32. Southwestern Energy, "Corporate Responsibility Report 2015-16", p. 26, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report.pdf.
33. Newfield Exploration, "Well Construction & Integrity", http://www.newfield.com/corporate-responsibility/safety-environmental/well-construction-integrity.
34. Pennsylvania's Department of Environmental Protection fined Royal Dutch Shell's SWEPI 1 LP for a 2012 contamination incident, initially reported by the company, affecting both private water wells and surface water "caused by communication between an old abandoned gas well and one or more of SWEPI's gas wells". See Pennsylvania Department of Environmental Protection, "DEP reaches penalty agreements with three natural gas exploration companies in the northern tier", 2015, http://www.ahs.dep.pa.gov/NewsRoomPublic/SearchResults.aspx?id=20820&typeid=1.
35. "As 'frack hits' grew in Alberta, regulators stepped in", *EnergyWire*, 2014, http://www.eenews.net/stories/1059992459.
36. See *DTF 2015*, p. 18 and note 29.
37. Alaska regulations on hydraulic fracturing operations, effective in 2015, require companies to identify and report on the condition of nearby wells and to identify faults that could compromise efforts to prevent contamination. See Office of the Lieutenant Governor of Alaska, "Order certifying the changes to regulations of the Alaska Oil and Gas Conservation Commission", 20 AAC 25.283(a)(10) and (11), https://aws.state.ak.us/OnlinePublicNotices/Notices/Attachment.aspx?id=97850.
38. Environmental Defense Fund, "Model Regulatory Framework for Hydraulically Fractured Hydrocarbon Production Wells (2014)", Sections 2.2 and 2.5, https://www.edf.org/sites/default/files/content/Model_Regulatory_Framework_For_Hydraulically_Fractured_Hydrocarbon_Production_Wells_2014.pdf.

regulations. The company further monitors pressures at live wells within 300 feet of the well it is fracturing and it repairs or plugs wells that do not meet current integrity standards. It also conducts an anti-collision analysis when planning wells to ensure that wells do not intersect live or abandoned wells.[39]

- *Range Resources* reports that, in the Marcellus Shale, it identifies and evaluates active, inactive, orphaned, abandoned, and plugged and abandoned wells' surface and bottom hole locations within 1000 feet of proposed new well locations, including the horizontal portions of new wells scheduled for fracturing. To identify wells, Range uses a combination of regulatory agency data, Range's own extensive database, landowner questionnaires, and physical field surveys. Once any such well is located and evaluated, Range develops a well monitoring plan to reduce risks of contamination moving through the well.[40]

MINIMIZING RISK OF INDUCED SEISMICITY: Public and regulatory concern has grown in recent years about seismic events (i.e., earthquakes) induced by activities related to hydraulic fracturing, especially the disposal of wastewater via injection wells. For example, the state of Oklahoma reports that it experienced 109 magnitude 3.0+ earthquakes in 2013, 585 in 2014, and 907 in 2015. In 2016, Oklahoma experienced its most severe earthquake ever recorded (magnitude 5.8) and subsequently experienced a magnitude 5.0 earthquake that reportedly damaged 40 to 50 homes in the vicinity of Cushing, an enormous oil storage hub.[41] The current average rate of earthquakes in Oklahoma is approximately 900 times historical averages. In the United States, the seismic events appear related primarily to the operation of deep injection wells for disposing of hydraulic fracturing wastewater.[42] The U.S. Geological Survey (USGS) notes there are approximately 35,000 active wastewater disposal wells, 80,000 active enhanced oil-recovery wells, and that tens of thousands of wells are hydraulically fractured every year in the United States, but "only a few dozen of these wells are known to have induced felt earthquakes".[43]

IMAGE: Brian Sherrod, USGS

Building Damage from Oklahoma Earthquake

In an updated seismic hazard report released in early 2016 for the central and eastern United States, USGS reports Oklahoma, Kansas, Colorado, New Mexico, Texas, and Arkansas are the highest hazard areas, noting that near some areas of induced earthquakes, hazard is higher by more than a factor of three from the level of natural quakes considered in the 2014 USGS National Seismic Hazard Model (NHSM). It further noted that "the chance of experiencing

39. Anadarko, "Water Management", http://www.anadarko.com/Responsibility/Sustainable-Development/HSE/Water-Management/.

40. Range Resources, "Water Protection", http://rangeresources.com/corp-responsibility/environment-health-and-safety/water-protection.

41. "Oklahoma Earthquake's Magnitude Raised to 5.8", *Wall Street Journal*, 2016, http://www.wsj.com/articles/oklahoma-earthquakes-magnitude-raised-to-5-8-1473288994 and "Oklahoma 5.0 earthquake damages 40-50 buildings", *Las Vegas Review-Journal*, 2016, http://www.reviewjournal.com/news/nation-and-world/oklahoma-50-earthquake-damages-40-50-buildings.

42. In some cases, hydraulic fracturing has led directly to earthquakes larger than magnitude 2.0, including at sites in Oklahoma, Ohio, England, and Canada. See Congressional Research Service (CRS), "Human-Induced earthquakes from deep-well injection: a brief overview", 2014, p. 1, https://www.fas.org/sgp/crs/misc/R43836.pdf.

43. J. Rubenstein and A. Mahani, "Myths and facts on wastewater injection, hydraulic fracturing, enhanced oil recovery, and induced seismicity", *Seismological Research Letters*, 86(4), 2015, pp. 1-8, https://profile.usgs.gov/myscience/upload_folder/ci2015Jun1012005755600Induced_EQs_Review.pdf. See also, Ground Water Protection Council and Interstate Oil and Gas Compact Commission, "Potential injection-induced seismicity associated with oil & gas development: A primer on technical and regulatory considerations informing risk management and mitigation", 2015, http://media.wix.com/ugd/d3e01e_7a12408392f240c89943d3f500039004.pdf. See *DTF 2015*, note 36 for additional recent overviews of earthquakes and their links to hydraulic fracturing operations.

a "[magnitude] VI ("6.0") or greater (damaging earthquake shaking) is 5-12 percent per year in north-central Oklahoma and southern Kansas, similar to the chance of damage caused by natural earthquakes in parts of California".[44]

In contrast to experience in the United States, where the focus is on wastewater disposal, induced seismicity from the hydraulic fracturing process used to produce oil and gas is more commonly reported in Canada, although it occurs in only a small proportion of Canadian hydraulic fracturing operations. In an area near the border between Alberta and British Columbia, between 1985 and 2015, researchers found 39 hydraulically fractured wells (representing 0.3 percent of those studied) and 17 wastewater disposal wells (representing 1 percent of those studied) that could be linked to earthquakes of magnitude 3.0 or larger (at which magnitude earthquakes can be felt on the earth's surface). Although the responsible wells were a very small portion of the wells studied, the researchers estimated that more than 60 percent of earthquakes in the area greater than magnitude 3.0 in recent years could be associated with fracturing activities, 30-35 percent to wastewater disposal, and only 5-10 percent to natural origins.[45]

Regulators in Ohio, Arkansas, Colorado, Kansas, Oklahoma, and Texas have tightened requirements relating to permitting and operation of disposal wells and drilling of new oil and gas wells.[46] For example, in early 2016, Oklahoma's Corporation Commission, which regulates oil and gas production in the state, issued restrictions on wastewater disposal in a 5,281 square-mile area of Oklahoma encompassing 245 disposal wells. The plan calls for reducing wastewater disposal by more than 40 percent daily.[47]

Increased earthquake frequency in Oklahoma has raised earthquake insurance costs and prompted litigation. Since 2014, six insurers have raised earthquake insurance premiums for homeowners by as much as 260 percent, three increased deductibles, three more stopped writing new earthquake insurance completely, and some signaled they would sue oil and gas companies if they pay claims for earthquake damage.[48] Oklahoma's Supreme Court has ruled that homeowners can sue companies in state courts for damages from earthquakes; several such lawsuits have been filed, and the Sierra Club has filed a lawsuit in federal court.[49]

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44. M.D. Petersen et al., "2016 one-year seismic hazard forecast for the central and eastern United States from induced and natural earthquakes", U.S. Geological Survey Open-File Report 2016-1035, 2016, http://pubs.usgs.gov/of/2016/1035/ofr20161035ver1_1.pdf.

45. H. Gofrani et al., "Hydraulic fracturing and seismicity in the Western Canada Sedimentary Basin", *Seismological Research Letters* (2016), 87(3), 2016, pp. 1-17, https://scits.stanford.edu/sites/default/files/atkinson_canada_eq_study_clean.pdf.

46. Ibid., pp. 17-20.

47. See Oklahoma Corporation Commission, "Media advisory—regional earthquake response plan for western Oklahoma", 2016, http://www.occeweb.com/News/2016/02-16-16WesternRegionalPlan.pdf. Most of the wells affected are operated by Chesapeake Energy and SandRidge Energy. The commission's action is a request, not a directive, because the commission's legal authority to order such broad reductions is unclear. Nevertheless, the commission stated it would take legal action against any well operator refusing to comply. See "Oklahoma puts limits on oil and gas wells to fight quakes", *New York Times*, 2016, http://www.nytimes.com/2016/03/08/us/oklahoma-earthquakes-oil-gas-wells.html?_r=0. The restrictions were further tightened in September 2016, closing additional wastewater injection wells in a 500-square-mile area, following the occurrence of the most severe earthquake in the state's history. As of mid-2016, quakes in Oklahoma had fallen 25 percent compared with a year earlier, a decline attributed partly to state regulatory action and partly to falling production (and associated wastewater accumulation) associated with declining oil prices. See "Oklahoma Quakes Decline Amid Curbs on Energy Industry's Disposal Wells", *Wall Street Journal*, 2016, http://www.wsj.com/articles/oklahoma-quakes-decline-amid-curbs-on-energy-industrys-disposal-wells-1467323816 and "Number of Oklahoma earthquakes down this year: state geologists", *Platts*, 2016 http://www.platts.com/latest-news/natural-gas/houston/number-of-oklahoma-earthquakes-down-this-year-26485701.

    Similarly, in Kansas, earthquakes greater than magnitude 2.8 have dropped approximately 75 percent since new regulatory restrictions were adopted in 2015. The drop is attributed to a combination of the new restrictions and drops in oil and gas development. See "States' efforts to curb fracking-related earthquakes seem to be working", *Albuquerque Journal*, 2016. Kansas further tightened its restrictions in 2016, placing stricter limits on the volume of wastewater that can be disposed and expanding the area where underground disposal is restricted. See "Kansas panel tightens fracking waste limits in effort to prevent earthquakes", *Wichita Eagle*, 2016, http://www.kansas.com/news/local/article94679727.html.

48. See "Fracking-related quakes have made earthquake insurance almost impossible to buy in Oklahoma', *Reuters*, 2016, http://www.rawstory.com/2016/05/fracking-related-quakes-have-made-earthquake-insurance-almost-impossible-to-buy-in-oklahoma/. Lloyd's of London contends in a legal action that its policies covering a company's site pollution liabilities do not include damages alleged to be caused by the company's fracturing-related activities. The company has been sued for alleged earthquake damages in Oklahoma. See "Fracking earthquakes not covered, insurers say", *Courthouse News Service*, 2016, http://www.courthousenews.com/2016/06/29/fracking-earthquakes-not-covered-insurers-say.htm.

49. "Edmond residents file earthquake lawsuit against 12 oil companies", *The Oklahoman*, 2016, http://newsok.com/article/5471984 and "Days after Oklahoma earthquake, Sierra Club lawsuit targets Chesapeake, Devon, others", *Dallas Morning News*, 2016, http://www.dallasnews.com/business/energy/20160217-earthquake-lawsuit-targets-chesapeake-devon-new-dominion.ece.

IMAGE: FracTracker Alliance

Deep disposal wells for fracking waste have been linked to earthquakes. Warren, OH

The scorecard asks if companies disclose the steps they take, or require of their wastewater disposal contractors, to identify and avoid inducing seismic activity that can be felt on the earth's surface.

Scores: Ten (10) companies disclose their specific approaches to addressing seismicity risk. Other companies, if they discuss seismicity at all, merely note that scientific research is highlighting seismic risks from deep well injection and regulators are working to manage these risks, but are silent about their own precautionary actions. Companies usually do not discuss their practices to assure that wastewater disposal contractors follow procedures to avoid inducing felt seismicity events.

Notable Practices

- *Newfield Exploration*, which operates primarily in Oklahoma, provides extensive detail about its seismicity precautions. It notes the specific Oklahoma regulations with which it must comply, states that it and its third-party disposal contractors do not inject wastes into the seismically sensitive Arbuckle formation, evaluates historical seismic data and geologic formations to identify natural faults, and has installed new monitoring equipment around four of its disposal wells. Newfield is also taking steps to increase recycling of wastewater to reduce demand for subsurface disposal.[50]

PRE- AND POST-DRILLING WATER QUALITY MONITORING: The scorecard asks if companies report their pre- and post-drill monitoring practices on a play-by-play basis.

Pre-drill testing can be useful for providing a baseline of water quality data against which claims of water contamination can be measured.[51] Post-drill monitoring can provide continued evaluation of water quality and help ensure timely action should any problem arise.[52]

Scores: On a play-by-play basis, ten (10) companies surveyed report that they conduct some type of pre-drilling monitoring in all plays, while only eight (8) report that they conduct post-drill monitoring in all plays. If other companies discuss their monitoring, they often discuss it only in very general terms or not for all their plays.

Notable Practices

- *Range Resources* provides considerable detail about its pre- and post-drill monitoring practices. The company notes that because Pennsylvania, where most of its shale development occurs, is one of only two states without private water well construction standards or regulations, the company's tests can provide important information to residents about their water quality that they might not otherwise have. Range also conducts post-drilling monitoring when requested by surface owners, regulatory agencies, or other engaged stakeholders or in fulfillment of the lease agreement requirements.[53]

50. Newfield Exploration, "Seismicity", http://www.newfield.com/corporate-responsibility/safety-environmental/seismicity.

51. We note that, while several states have adopted groundwater monitoring requirements, discussions continue regarding the effectiveness of limited sampling.

52. For more detailed information, see *DTF 2014*, pp. 16-17. As noted in FracFocus, the American Petroleum Institute's hydraulic fracturing guidelines recommend baseline testing of private water wells before fracturing operations begin. See FracFocus, "Groundwater Quality Testing", http://fracfocus.org/groundwater-protection/groundwater-quality-testing. North Carolina's 2015 regulations governing fracturing operations call for pre- and post-drilling monitoring. See 15A NCAC §05H.1803, http://ncrules.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2005%20-%20mining%20-%20mineral%20resources/subchapter%20h/15a%20ncac%2005h%20.1803.pdf.

53. Range Resources, "Water Protection", http://www.rangeresources.com/corp-responsibility/environment-health-and-safety/water-protection.

WATER USE AND RECYCLING: Around the globe, fresh water is a scarce and threatened resource in many locations and companies across economic sectors are assessing their water risk and water footprint.[54]

Oil and gas companies can reduce their water footprint and water risk by reducing the intensity of their water use in the first instance, sourcing non-potable water where possible, and increasing their recycling of wastewater.[55]

While moving wastewater for recycling and reuse, companies must responsibly manage the associated risks. These can include road hazards associated with increased traffic and leaks associated with pipelines. Companies must have strong spill prevention and control plans in place. Recycling also increases the amount of concentrated residual wastes requiring management and disposal.[56]

IMAGE: Bill Hughes, OVEC/ohvec.org

Storage Tanks on Well Pad

54. The U.S. Geological Survey reports that water use for fracturing individual wells can vary dramatically both among and within shale plays. The national average in 2014 was 4 million gallons per oil well and 5.1 million gallons per gas well. See Press Release, "Water used for hydraulic fracturing varies widely across United States", 2015, https://news.agu.org/press-release/water-used-for-hydraulic-fracturing-varies-widely-across-united-states/. This press release describes findings in Gallegos, T. J., B. A. Varela, S. S. Haines, and M. A. Engle, 2015, "Hydraulic fracturing water use variability in the United States and potential environmental implications", *Water Resour. Res.*, 51, pp. 5839-5845, http://onlinelibrary.wiley.com/doi/10.1002/2015WR017278/full.

    Researchers have noted that water scarcity can be an issue, especially in arid shale plays of the western U.S. For example, in its 2016 update to its 2014 report on hydraulic fracturing and water stress, Ceres notes that 57 percent of the nearly 110,000 wells fractured between January 2011 and January 2016 were located in regions with high or extremely high water stress, including basins in Texas, Colorado, Oklahoma and California and nine of the top 10 companies it analyzed operated 70 percent or more of their wells in regions with medium or higher water stress. Ceres reports average water use by play, and by combination of company and play in the 2016 update to its 2014 water stress report. See "An Investor guide to hydraulic fracturing and water stress", https://www.ceres.org/issues/water/shale-energy/investor-guide-to-fracking-water-risk/investor-guide-to-hydraulic-fracturing-water-stress. Ceres notes in a footnote to its analysis, "It was not possible to differentiate whether the source of the water was fresh, recycled, saline or wastewater." This may mean that Ceres' current assessments of water use, and accompanying water stress, may not fully account for companies' use of deep saline aquifers and for use of recycled and other alternative sources which reduces the volume of freshwater needed by hydraulic fracturing companies. At the current time there is little competing demand for water in deep saline aquifers but, at some point in the future competition even for these waters may increase if existing sources of fresh water become depleted. Deep saline and confined aquifers are generally not a renewable resource and once mined do not replenish. (Complementing *Disclosing the Facts 2016*, Ceres also has published a guide signaling questions investors should ask companies about their water management policies and practices. See "Investor guide on fracking water use and disposal issues", 2016, https://www.ceres.org/issues/water/shale-energy/investor-guide-to-fracking-water-risk/investor-engagement-guide-on-fracking-water-use-and-disposal.).

    Other key findings based on researchers' analysis of data in both public and proprietary data bases indicate the amount of water used on a well-by-well basis tends to be less for shale oil wells than for shale gas wells. Amounts per well can further vary depending on, for example, the lengths of the horizontal "laterals" being fractured, the number of frac "stages" (the intervals of laterals that are isolated and fractured sequentially), and the frac fluid types ("slickwater" fracs use more water than "gelled" fracs) selected to most effectively produce oil and gas from different types of rock formations. The amounts of water returning to the surface following well completions and during production also vary dramatically among plays, influencing the extent to which companies may find recycling and reuse of wastewater practical. See, e.g., B. R. Scanlon et al, 2016 "Managing the increasing water footprint of hydraulic fracturing in the Bakken play, United States", 2016, *Environ. Sci. Technol* http://pubs.acs.org/doi/pdf/10.1021/acs.est.6b01375; B.R. Scanlon, *et al*, 2014 "Will water scarcity in semiarid regions limit hydraulic fracturing of shale plays?" *Environ. Res. Lett.* 9, 124011, http://iopscience.iop.org/article/10.1088/1748-9326/9/12/124011/pdf; and A. Kondash and A. Vengosh, 2015 "Water footprint of hydraulic fracturing", *Environ. Sci. Technol. Lett.* 2, 276-280, http://pubs.acs.org/doi/pdf/10.1021/acs.estlett.5b00211.

55. Recycling will make economic and operational sense only above certain levels of well drilling and completion activity. Below such activity levels, the amounts of water generated or needed may not justify investment in recycling operations.

56. See D. Mueller, "Recycling wastewater from oil and gas wells poses challenges", EDF Energy Exchange Blog, 2015, http://blogs.edf.org/energyexchange/2015/11/11/recycling-wastewater-from-oil-and-gas-wells-poses-challenges-2/.

    In 2016 EPA published a rule banning disposal of fracturing wastewater at municipal sewage treatment plants. See "EPA bans disposal of fracking wastewater at public treatment plants", *State Impact Pennsylvania*, 2016, https://stateimpact.npr.org/pennsylvania/2016/06/14/epa-bans-disposal-of-fracking-waste-water-at-public-treatment-plants/ and U.S. Environmental Protection Agency, "Pretreatment standards for the oil and gas extraction point source category", 2016, https://www.epa.gov/sites/production/files/2016-06/documents/uog-final-rule_fact-sheet_06-14-2016.pdf.

Forward-looking companies are increasingly recognizing water and wastewater as marketable products, creating subsidiary water management units that provide water supply and wastewater management services to both themselves and other companies. While acknowledging the potential benefits of creative reuse, certain reuses pose concerns—even where permitted and regulated—such as the use of highly saline wastewater as brine on roads or the use of wastewater for agricultural irrigation.[57]

The scorecard asks whether companies disclose the percentage of wastewater[58] managed and reused, the aggregate quantity of water used, the sources of water used in operations (e.g., ground and surface water), and the intensity of water use (i.e., the amount of water used to produce a unit of energy).[59] The scorecard also asks companies to describe their practices for when and how they use non-potable water. The 2016 scorecard adds a new indicator, asking companies to explicitly disclose if they are operating in "water-scarce areas" and if so, the practices they use for limiting water use in such areas.

Scores

For each shale play:

- Ten (10) companies disclose the aggregate quantity of water used for hydraulic fracturing.
- Ten (10) companies report the types of water used.
- Eleven (11) companies report the percentage of flowback water reused.
- Seven (7) companies report the intensity of their water use.

In addition, twenty-two (22) companies report on their practices regarding how and when they use non-potable water in their operations. Thirteen (13) companies report explicitly on whether they are operating in water-scarce areas.

Notable Practices

- *Southwestern Energy* set a goal of being "freshwater neutral" by the end of 2016. For every gallon of fresh water it uses, the company aims to offset or replenish that gallon through water-quality improvement projects or treatment technologies that return fresh water to the environment. The company met that goal in the Fayetteville shale play in 2015 and expects to meet it company-wide in 2016.[60]
- *Range Resources* reports reusing nearly 99 percent of its own wastewater and reusing wastewater supplied by other operators. In its Southern Marcellus Division, nearly 24 percent of the water it sources comes from

57. Amish in Pennsylvania experiencing adverse health effects have posted "no brine" signs. See "Amish Wade Into Fracking Wastewater Fight", *Oil and Gas Online*, 2016, http://www.oilandgasonline.com/doc/amish-wade-into-fracking-wastewater-fight-0001. For a discussion of using wastewater for irrigating food crops in California, see "Farms using oilfield wastewater under review for food safety", *KQED*, 2016, https://ww2.kqed.org/science/2016/01/13/farms-using-oilfield-wastewater-under-review-for-food-safety/.
New Mexico issued regulations in early 2015 to encourage reuse of produced water for fracturing operations. See "New rule clears way for NM oil producers to reuse water", *Albuquerque Journal*, 2015, http://www.abqjournal.com/557662/biz/biz-most-recent/new-rule-clears-way-for-nm-oil-producers-to-reuse-water.html.

58. Wastewater is often separated into categories. *Flowback* water is the water that flows back to the surface immediately after a well is fractured and includes both injected materials, including chemicals used in frac fluids, and water already present in the formation. See Argonne National Laboratory, "Hydraulic Fracturing and Shale Gas Production: Technology, Impacts, and Regulations", pp. vii-viii, http://www.afdc.energy.gov/uploads/publication/anl_hydraulic_fracturing.pdf. *Produced water* refers to the water in the formation that subsequently flows back in smaller quantities over the life of the well. This water has high levels of total dissolved solids and leaches out minerals from the shale including barium, calcium, iron, and magnesium. It also contains dissolved hydrocarbons such as methane, ethane, and propane along with naturally occurring radioactive materials (NORMs) such as radium isotopes. See The Institute for Energy & Environmental Research for Northeastern Pennsylvania, "What is flowback, and how does it differ from produced water?", http://energy.wilkes.edu/pages/205.asp. The scorecard question refers to "produced water", a term that can be used generically to encompass both immediate flowback and longer-term produced water. Plays vary in the proportions of injected fluids that return to the surface and the chemical characteristics of formation waters. See *DTF 2014*, notes 40 and 41.

59. Apache notes that in 2013 FracFocus was upgraded to permit all reporting companies to post water volumes by source type, such as fresh water, brackish groundwater, or recycled produced water on a well-by-well basis. See Apache, "2016 Sustainability Report", p. 26, http://www.apachecorp.com/Resources/Upload/file/sustainability/APACHE-Sustainability_Report_2016.pdf. Like other companies, Apache notes that reliance on saline ground water reduces its competition for water sources used for drinking and agricultural purposes.

60. Southwestern Energy, "Corporate Responsibility Report 2015-16", p.21, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report.pdf.

its own flowback and produced water, as does almost 19 percent of its water sourced from other operators. In its Northern Marcellus Shale Division, these figures are nearly 24 and 39 percent.[61]

- *Anadarko* has partnered with Texas A&M and others in a first-of-its-kind study in Texas of use of recycled produced water for irrigating cotton.[62]
- *Pioneer Natural Resources* developed an innovative pipeline for pumping water to its projects in Colorado's Raton Basin, implementing comprehensive real-time pressure monitoring across more than 800 miles of its water gathering pipeline network. This monitoring allows automated shutdown of wells when possible incidents are detected. Pioneer reduced pipeline water spills in the first year of the project by more than 40 percent compared to its average rate over the prior three years.[63] Pioneer has launched multiple creative, ambitious water management projects, including creation of a separate company, Pioneer Water Management LLC in 2014.[64]
- *CONSOL* created CNX Water Assets LLC to develop water-related services. It states, "our water assets provide the company with significant operational benefits and business opportunities". The company is reducing disposal volumes, use of fresh water and, through careful logistical planning, truck traffic on local roadways.[65]
- *Antero Resources* has constructed nearly 300 miles of freshwater pipelines to serve its wells in the Marcellus and Utica Shale plays and has partnered with Veolia to construct the largest advanced wastewater treatment complex in Appalachia, with a capacity to process 60,000 barrels of wastewater daily. The complex is expected to save the company $150,000 per well in completion costs.[66]
- *Chesapeake Energy* launched a pilot program in 2011 in its Mississippi Lime play with the goal of creating a water recycling process that costs the same or less than using fresh water. It has since completed more than 200 wells in the play with 100 percent recycled water, declaring that its recycled water use is "so much that we use minimal freshwater in our core Mississippi Lime operations".[67]

SURFACE WATER PROTECTION AND TREATMENT AND DISPOSAL OF WASTE WATER: Water contamination can result from the chemicals used in drilling a well and those used in fracturing fluids or from naturally occurring contaminants in formation waters that are brought back to the surface. Open surface pits for storing waste materials have been identified as a relatively high water contamination risk if not appropriately designed, constructed, and maintained, as well as an air quality concern where wastewaters contain sizeable amounts of volatile chemicals and steps are not taken to separate out these chemicals before wastewaters are stored.[68] Aboveground storage

61. Range Resources, "Water Sourcing", http://www.rangeresources.com/corp-responsibility/environment-health-and-safety/water-sourcing.
62. See Anadarko, "Water Management", http://www.anadarko.com/Responsibility/Sustainable-Development/HSE/Water-Management/. Texas is the United States' largest cotton producer. See Texas Farm Bureau, "Cotton", http://www.beagsmart.org/a-look-at-texas-ag/crops/cotton.
63. Pioneer Natural Resources, "Water", http://www.pxd.com/values/sustainability/water.
64. DTF 2015, p. 23; Pioneer Natural Resources, "Operations", http://www.pxd.com/operations/water-management/operations; and Pioneer Natural Resources, "Water Management", http://www.pxd.com/operations/water-management.
65. CNX Water Assets LLC provides turnkey water sourcing, distribution treatment, and disposal systems. See CONSOL, "2015 Corporate Responsibility Report", p. 22 and p. 43, http://2015crr.consolenergy.com/.
66. Savings are based on comparisons of anticipated costs to historical recycling and disposal costs. See Antero Resources, "Antero Announces 60,000 Barrel per Day Advanced Wastewater Treatment Complex", 2015, http://investors.anteroresources.com/investors-relations/press-releases/press-release-details/2015/Antero-Announces-60000-Barrel-per-Day-Advanced-Wastewater-Treatment-Complex/default.aspx and Antero Resources, "Company Overview", 2016, p. 41, http://s1.q4cdn.com/057781830/files/doc_presentations/2016/Company-Website-Presentation-(A)-June-2016.pdf.
67. Chesapeake, "Corporate Responsibility Report 2014", p. 22, http://www.chk.com/Documents/media/publications/responsibility-report-2014.pdf.
68. "Small study may have big answers on health risks of fracking's open waste ponds", InsideClimate News, 2014, http://insideclimatenews.org/news/20141010/small-study-may-have-big-answers-health-risks-frackings-open-waste-ponds.

IMAGE: Bill Hughes, OVEC/ohvec.org

Drill Cuttings on Well Pad Going to Landfill

tanks equipped with vapor controls, while not entirely risk-free, can lower various risks, especially from volatile emissions, compared to surface pits.[69] Risk mitigation requires good maintenance and operational practices, including use of leak detection equipment, installation of protective barriers to minimize damage from leaks that do occur, and precautionary measures to minimize human operational errors.[70]

The scorecard asks whether companies report, on a play-by-play basis, their practices for storing wastewater and whether they similarly report on the use of closed-loop systems[71] for managing drilling wastes.[72]

Scores

- Seven (7) companies disclose their practices, by play, for storing produced water in closed tanks.
- Eleven (11) companies disclose, by play, their practices for using closed-loop systems for managing drilling residuals.

Notable Practices

- *Noble* provides the most detailed discussion on a play-by-play basis of its wastewater storage practices in tanks and open impoundments, describing the precautionary measures it takes to reduce emissions, detect and prevent leaks, and protect wildlife.[73]

69. For an assessment of risks from pits and tanks, based on 14 years of data from New Mexico, see Resources for the Future, "Pits versus tanks: comparing storage methods for fluids used in fracking", *Resources* 189, 2015, http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-Resources-189_Infographic.pdf. The RFF study found that spills from pits occurred twice as often as spills from tanks, while also losing over ten times as much fluid. In 2015, the Groundwater Protection Council published a non-quantitative comparison of risk factors from pits and tanks that, while not including air pollution, noted that some risks were higher for pits than tanks and some were lower. See Groundwater Protection Council, "State oil & gas regulations designed to protect water resources", 2014, Appendix 15, pp. 106-109, http://www.gwpc.org/sites/default/files/Oil%20and%20Gas%20Regulation%20Report%20Hyperlinked%20Version%20Final-rfs.pdf.

70. See, for example, "Denbury deals with 11th saltwater spill in 2015", *Bismarck Tribune*, 2016, http://bismarcktribune.com/news/state-and-regional/denbury-deals-with-th-saltwater-spill-in/article_884c56c2-4351-537b-96db-8d740242cbfc.html. The article cites a North Dakota Department of Health representative maintaining that Denbury's record is no worse than that of other companies and that the department recorded 1,600 spills in 2015. A June 2016 spill of approximately 9,000 gallons of wastewater from a connection leak at another company's tank facility was largely contained within a protective tank berm. See North Dakota Department of Health, "Produced water spill in Renville County", 2016, https://health.nd.gov/media/1379/2016-06-16-produced-water-renville_final.pdf.

    The Environmental Defense Fund has noted that regulators often lack sufficiently detailed databases identifying spills and their causes, limiting regulators' ability to design the most effective spill reduction regulations. EDF cites North Dakota's improved specificity in its reporting requirements, whose data prompted state regulators to tighten their regulations for containing spills around new and existing well sites. See H. Pearen, "Want to know the leading cause of oil & gas spills? So do we.", 2016, http://blogs.edf.org/energyexchange/2016/08/31/want-to-know-the-leading-cause-of-oil-gas-spills-so-do-we/. Texas reportedly does not require companies to report spills of wastewater but some companies, especially larger ones, report these as a matter of corporate policy. See "In Texas, wastewater spills get less scrutiny", *EnergyWire*, 2016, http://www.eenews.net/stories/1060041056.

71. In a closed-loop system, open reserve pits for capturing drilling muds are replaced by a series of storage tanks. Solids and liquids are separated, minimizing the amount of drilling waste muds and cuttings that require disposal and maximizing the amount of drilling fluid recycled and reused in the drilling process. See Earthworks, https://www.earthworksaction.org/issues/detail/alternatives_to_pits#CLOSEDLOOP.

72. In May 2016 a coalition of environmental and community organizations concerned about disposal of both drilling wastes and wastewater sued the U.S. Environmental Protection Agency for failure to update federal regulations governing management of oil and gas wastes. Seismic events from underground injection and contamination from spreading of wastewater onto roads and fields were among the risks cited by the filers. See "Environmental groups sue EPA, seek stricter rules over fracking waste linked to earthquakes", *Washington Post*, 2016, https://www.washingtonpost.com/news/energy-environment/wp/2016/05/04/environmental-groups-sue-epa-seek-stricter-rules-over-fracking-waste-linked-to-earthquakes/.

73. Noble Energy, http://responsibility.nobleenergyinc.com/wp-content/uploads/2016/10/IEHN-Disclosing-the-Facts.pdf.

- *Carrizo* reports that it stores all its wastewater in closed tanks or pipes it directly to disposal wells to minimize the potential for leaks or spills. The company describes the several containment systems it deploys to catch leaks or spills, including those exceeding regulatory requirements.[74]
- *Chesapeake Energy*. Chesapeake conducts an "integrity management program" that focuses on "proactively identifying and correcting corrosion" of its equipment. The company notes that weather and salt water can corrode steel equipment, potentially causing leakage or malfunction. Company staff are trained on corrosion identification for their field equipment inspections. The company also has a standard that all new and replacement storage tanks must be coated to resist corrosion, and it encourages installation of metal components that will provide early warnings of tank failure.[75]
- *Anadarko* conducts an "Ultrasonic Thickness Testing Program" in its Greater Natural Buttes operations in Utah as part of a precautionary program to assess corrosion in the parts of storage tanks most susceptible to corrosion that can lead to leaks. *Anadarko* reports that, as a result of this program, more than 60 tanks were removed from service before failure occurred, preventing potential spills.[76]

IDENTIFYING AND MANAGING NORMS: Naturally occurring radioactive materials (NORMs) associated with wastewater have drawn considerable attention in the Marcellus Shale region and in North Dakota, raising community concern about waste management and disposal practices.[77] NORMs may be present in wastewater brought to the surface and can coat equipment with which they come in extended contact.[78] Materials above specified hazard thresholds require careful tracking to assure they are disposed of only in landfills specially designated for their disposal. Any materials used or produced during the exploration and production process that exceed local, state, or federal thresholds for radioactive materials must be handled and disposed of at facilities specifically designated for their disposal. This effort includes both field assessments to monitor for radioactive material and analytical testing of the solid wastes that can be associated with wastewater treatment. Wastewaters containing NORMs can also be a hazard if disposed of at treatment plants not able to remove them or otherwise discharged or spilled into local waterways.

IMAGE: Kathiann M. Kowalski

Landfill radiation monitoring for trucks dumping shale drill cuttings and other waste. Pennsylvania.

The scorecard asks whether companies report practices for identifying and managing hazards associated with NORMs.

Scores

Ten (10) companies address, in some form, their practices for identifying and managing hazards associated with NORMs.

Notable Practices

- *Newfield Exploration* reports that produced water radiation levels in its three plays—North Dakota, Oklahoma and Utah—are at background or marginal levels. Newfield states that it concentrates on managing NORM-contaminated equipment, describing its training practices.[79]

74. Carrizo, "Environment", http://www.carrizo.com/sustainability/environment.
75. Chesapeake Energy, "Preventing Spills", http://www.chk.com/responsibility/environment/spill-prevention.
76. Anadarko, "Health, Safety, Environment and Sustainability Overview 2015", 2015, p. 28, https://www.anadarko.com/content/documents/apc/Responsibility/Governance_Documents/2015_HSE_Overview.pdf.
77. See *DTF 2015*, note 67 and *DTF 2014*, p. 21 and associated notes, for discussion of pertinent assessments of issues related to NORMs.
78. U.S. Geological Survey, "Naturally Occurring Radioactive Materials (NORM) in Produced Water and Oil-Field Equipment—An Issue for the Energy Industry", USGS Fact Sheet FS-142-99, 1999, http://pubs.usgs.gov/fs/fs-0142-99/fs-0142-99.pdf.
79. Newfield Exploration, "Waste Management", http://newfield.com/corporate-responsibility/safety-environmental/waste-management.

- *BHP Billiton* describes its company procedures for addressing NORMs and describes on a play-by-play basis whether NORMs have been detected.[80]

Progress and Prospects

Companies have begun to respond to water quantity concerns, reducing demand for fresh water by increasingly sourcing water from deep, non-potable aquifers, municipal sewage treatment plant effluent, and even acid mine drainage. Development of a new generation of fracturing chemicals that can work cost-effectively with non-potable water has accompanied this increased sourcing of non-potable water. In tandem with this technological innovation, companies have been scaling up waste treatment operations and increasing collaboration with other companies on waste treatment.

Increasing on-site wastewater recycling has lowered demand for fresh water withdrawals while reducing air emissions, road damage, and community disruption from water trucks, particularly when recycling is done on multi-well pads. Wastewater recycling has the salutary effect of lowering the need for deep wastewater wells, which is particularly significant as wastewater injection has increased dramatically in recent years, resulting in induced seismicity.[81] However, as noted previously, it is important for companies to assure they take appropriate precautionary measures, including spill prevention and control programs, to lower risks associated with storage and moving wastewater among sites via truck or pipeline.

Companies' disclosures on their websites attest to the increasing uptake of cost-effective innovations to decrease use of fresh water and to handle waste more effectively.[82] Such disclosures provide investors with insight into the quality of corporate management, particularly regarding the extent to which companies have developed data on and planning processes enabling adoption of improved measures. While certain companies have improved corporate disclosures, the industry as a whole has a long way to go to present a complete picture of the effectiveness of management practices to decrease water and waste impacts. Currently, a significant portion of the industry is leaving investors substantially in the dark in this regard.

Well integrity remains a core issue. There have been a number of high-profile incidents of water contamination associated with faulty well construction. Companies must assure investors and other concerned stakeholders that they have adopted current best practices for well integrity and, more importantly, that those practices have been effectively implemented. Well integrity requires not only the sound construction of production wells, but also taking into account nearby wells in fracturing operations, the siting and operation of disposal wells to minimize induced seismicity, and effective monitoring of wells to ensure integrity. Effective pre- and post- drilling water testing can provide a means by which well integrity can be monitored.

AIR EMISSIONS

Issue and Questions

Air contaminants are emitted during multiple stages of oil and gas development. (*See Figure*, "Air Emissions from Oil & Gas Development in the Eagle Ford"). Volatile organic compounds (VOCs) and nitrogen oxides (NOx) are particularly concerning due to their contributions to regional smog.[83] From a global perspective, emissions of the

80. BHP Billiton, "Case Study 2016: Responsibly managing hydraulic fracturing", p. 4, http://www.bhpbilliton.com/~/media/bhp/documents/society/reports/2016/161018_responsiblymanaginghydraulicfracturing.pdf?la=en.

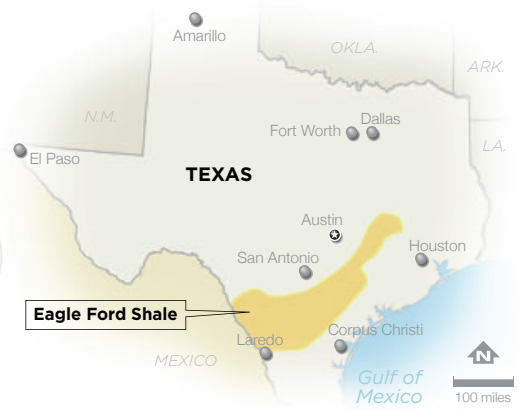
81. The protracted downturn in oil and natural gas prices in recent years and the associated drop in drilling activity has in some instances weakened the economic incentive for companies to recycle and reuse their wastewater rather than dispose of it in waste injection wells. Reduced completion activity lowers both generation of wastewater and demand for recycled wastewater. The most inexpensive route for companies, during a challenging financial period when companies are working to squeeze excess costs from their operations, may be deep well disposal of their wastewater. Such an increase in deep well disposal in the face of declining drilling has been reported in Ohio. See "injections of wastewater rise in Ohio despite lull in fracking", *Columbus Dispatch*, 2016, http://www.dispatch.com/content/stories/local/2016/03/07/injections-of-wastewater-rise-in-ohio-despite-lull-in-fracking.html.

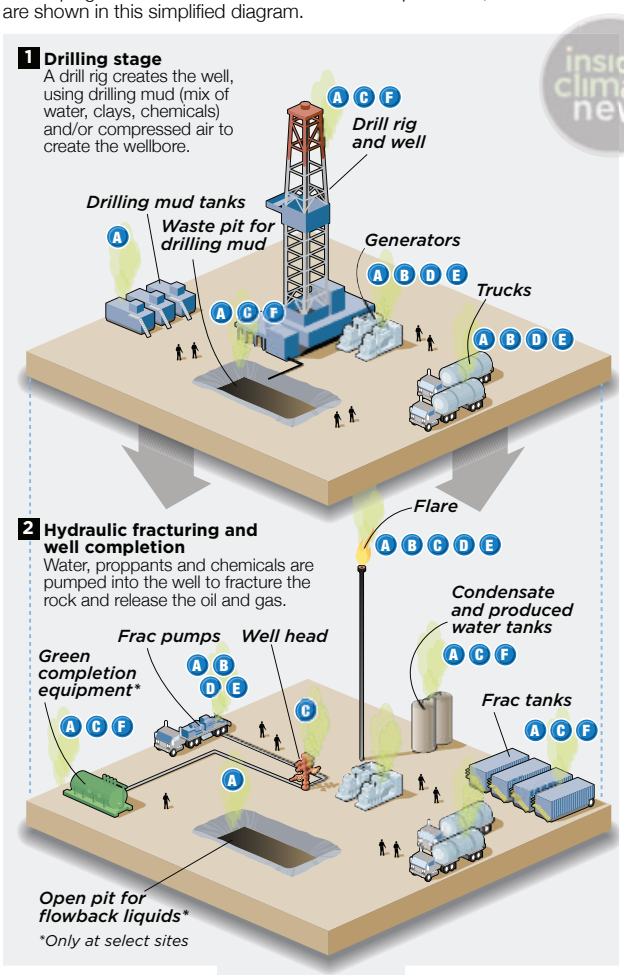
82. *DTF 2014*, p. 19 and notes 44 and 46.

83. *DTF 2014*, p. 23 and notes 65-67.

Air Emissions from Oil and Gas Development in the Eagle Ford

There are more than 7,000 oil and gas wells in the Eagle Ford Shale, and Texas regulators have approved another 5,500. Most of them, like the one shown here, are oil wells that also produce condensate and natural gas. Developing these resources releases various air pollutants, some of which are shown in this simplified diagram.





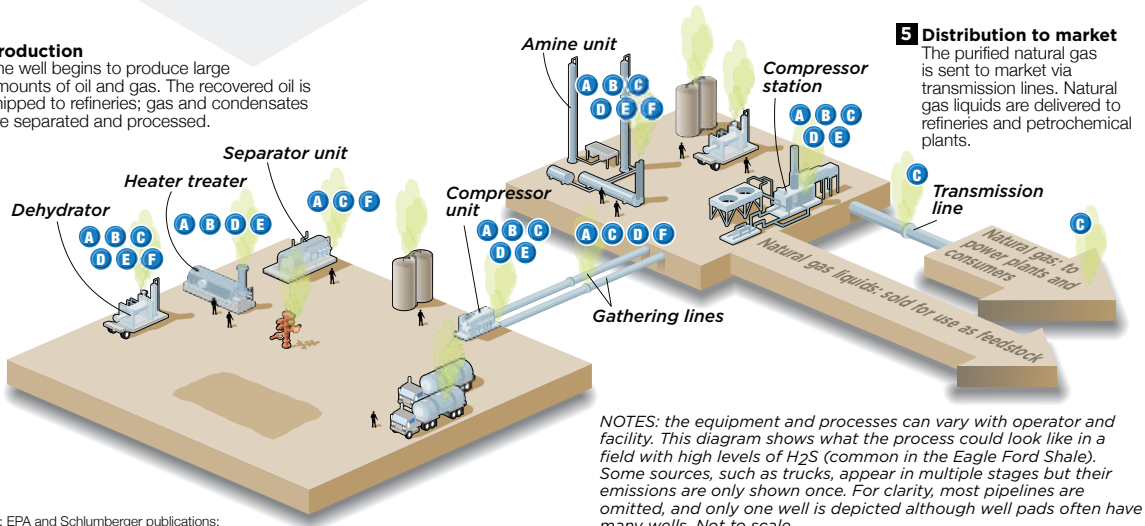
Emission Sources

The pollutants come from a number of sources, including the diesel- or natural gas-fueled equipment, the oil and gas itself, and leaks from storage devices. The emissions' actual and relative amounts vary widely based on operator practices and local geology. The emissions occur regularly in some cases, but are intermittent in others.

CHEMICAL	WHAT IT IS	WHAT IT DOES
A VOCs	Volatile organic compounds including benzene, formaldehyde	There are dozens of VOCs that make people sick. Some can cause cancer. VOCs react with NOx to form ozone, a respiratory irritant and greenhouse gas.
B PM	Particulate matter	Affects the heart and lungs.
C CH_4	Methane	Main component of natural gas. Much more powerful than CO_2 as a greenhouse gas.
D CO_2	Carbon dioxide	Major greenhouse gas.
E NOx	Nitrogen oxides	Reacts with VOCs to create ozone.
F H_2S	Hydrogen sulfide	Toxic gas found in some gas fields. Causes illness and death at certain concentrations.

Fugitive emissions: pipelines, valves, pneumatic devices etc. leak methane, VOCs, H_2S and CO_2 throughout the entire process.

4 Dehydration, treatment and processing
Water, condensate, H_2S and other impurities are taken out of the raw natural gas. This can occur on or near the well pad or at a centralized processing facility. Additional equipment used to purify and process natural gas liquids is not shown here.



NOTES: the equipment and processes can vary with operator and facility. This diagram shows what the process could look like in a field with high levels of H_2S (common in the Eagle Ford Shale). Some sources, such as trucks, appear in multiple stages but their emissions are only shown once. For clarity, most pipelines are omitted, and only one well is depicted although well pads often have many wells. Not to scale.

SOURCES: EPA and Schlumberger publications; experts consulted for various aspects of the diagram include Ramón Alvarez (EDF), Richard Haut and Jay Olaguer (HARC), Alisa Rich (UNT), Jim Tarr (Stone Lions Env. Corp), engineers from industry and Cardno Entrix.

Research by LISA SONG / InsideClimate News Graphic by PAUL HORN / InsideClimate News

IMAGE: Paul Horn / Inside Climate News

greenhouse gases methane and carbon dioxide are also a key concern. Natural gas extracted from the earth, when burned to generate electric power, produces less carbon dioxide than coal and has negligible emissions of sulfur dioxide and mercury. However, these benefits can be offset by leakage of methane into the atmosphere in the natural gas production, transmission, and distribution life cycle.[84] Methane emissions are significant because methane is a tremendously potent greenhouse gas, having a "global warming potential" at least 84 times that of carbon dioxide over a 20-year time frame. Burning ("flaring") is better than venting pure methane. Nevertheless, substantial quantities of carbon dioxide can be generated by flaring methane gas associated with oil production, which may be done for temporary safety reasons or where no infrastructure has been built to capture and bring to market or otherwise make productive use of the associated gas.[85] Federal regulations adopted in 2012 require "green completions" at newly completed gas wells to maximize capture of natural gas and

IMAGE: Bill Hughes, OVEC/ohvec.org

Fracturing Pumps at Work

84. For details on methane emission measurements and estimates, see *DTF 2014*, note 68. There continues to be considerable discussion among technical experts about the amount of methane released from shale gas and oil operations. For many years, EPA's inventory of such emissions was based on engineering estimates developed in the 1990s. There have been continual changes in estimation methods since that time, with the latest estimates published in early 2016. See U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014", 2016, https://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Main-Text.pdf. Technical experts are continually developing data and estimates of emissions through a variety of "top-down" (satellites, airplanes, helicopters) and "bottom-up" (on-the-ground equipment) methods. Using more precise bottom-up measurements is important for multiple reasons, including to improve EPA's emission estimates; to help companies set equipment replacement, monitoring, and repair priorities; and to promote smarter, focused regulation.

    Recent bottom-up measurements have helped highlight the problem of "super-emitters"—a small number of the many components of production operations with significant leaks that produce a disproportionately large portion of emissions. A 2016 review of 15,000 measurements from 18 prior studies concluded that 5 percent of leaks contributed to 50 percent of leakage volume and that 90 percent of all emissions came from leaks significantly above existing regulatory thresholds for addressing leaks. The researchers also concluded that super-sensitive leak detectors might not be required because detecting these larger leaks may be accomplished through use of "less-sensitive but cheaper detection technologies [that] still find the majority of problem leaks". See "'Super emitters' responsible for most US methane emissions", Phys.org, 2016, http://phys.org/news/2016-10-super-emitters-responsible-methane-emissions.html. See also, A. Brandt et al., "Methane leaks from natural gas systems follow extreme distributions", *Environmental Science & Technology*, 2016, http://pubs.acs.org/doi/abs/10.1021/acs.est.6b04303.

    A study of the Barnett Shale published in late 2015 found that 2 percent of oil and gas facilities accounted for about half of the emissions, with 10 percent responsible for 90 percent of emissions. The researchers further found that the super-emitters can change over time and from place to place, indicating emissions may stem from malfunctions rather than permanent design flaws. They concluded that "to reduce these emissions requires operators to quickly find and fix problems", from which the need for strong leak detection and repair programs can be inferred. The study further concluded that methane emissions are 90 percent larger than estimates based on EPA's Greenhouse Gas Inventory (an inventory subsequently updated in 2016), corresponding to 1.5 percent of natural gas production. See D. Zavala-Araiza et al., "Reconciling divergent estimates of oil and gas methane emissions", *Proceedings of the National Academy of Sciences*, 2015, pp. 15597-15602, http://www.pnas.org/content/112/51/15597.full.pdf.

    Conclusions similar to those for the Barnett Shale have been reached by researchers studying the Four Corners region in the Southwestern United States which includes the San Juan Basin, a natural gas production area. Researchers, using airplane-based measurement technology, concluded that the top 10 percent of emitters (including gas processing facilities, storage tanks, pipeline leaks, well pads, and a coal mine venting shaft) explain about half of the observed point source contributions and roughly 25 percent of total basin emissions. (Naturally-occurring seeps from coal beds also contribute to the regional methane "hot spot" that researchers have identified.) See C. Frankenberg, et al., "Airborne methane remote measurements reveal heavy-tail flux distribution in Four Corners Region", 2016, *Proceedings of the National Academy of Sciences*, pp. 9734-9739, http://www.pnas.org/content/113/35/9734.full.

85. In June 2014, the widespread flaring of gas from in North Dakota's Bakken Formation, visible from outer space, prompted North Dakota regulators to require companies to meet flaring reduction targets or cut back production. See *DTF 2014*, pp. 25-26. These regulations were adjusted in 2015 because of delays industry encountered in developing infrastructure for moving and processing gas; an interim deadline for reductions was extended by one year, but the ultimate 2020 goal of capturing 90 percent of emitted gas was tightened to between 7% and 9%. See "North Dakota extends gas flaring deadline", *Salt Lake Tribune*, 2015, http://www.sltrib.com/csp/mediapool/sites/sltrib/pages/printfriendly.csp?id=2988445.

avoid flaring or venting.[86] In May 2016, the U.S. Environmental Protection Agency extended green completion requirements to new oil wells.[87] EPA is also considering extending such requirements to existing sources. In September 2016 the agency issued a request for information pertinent to such potential extension.[88] In October 2016, the agency also issued guidelines for controlling existing sources in areas not meeting national smog standards.[89]

Technical experts generally agree that cost-effective emission reduction measures are currently available to substantially reduce methane and other air emissions.[90] A collaboration of eight oil and gas companies and the Environmental Defense Fund (EDF) is encouraging development of inexpensive leak detection and control technologies. The companies are pilot testing leading technologies in 2016.[91] This move continues a pattern of initiatives by certain companies to voluntarily assess and implement emission control technologies; companies' long-running partnership with EPA in the EPA Natural Gas Star program for more than a decade has reduced emissions and provided technical data for strengthening federal regulations applicable to the entire industry.[92]

Several states have enacted regulations requiring companies to establish leak detection and repair (LDAR) programs.[93] In 2016, EPA published nationally applicable regulations requiring companies to develop LDAR programs for new and modified natural gas well sites.[94]

86. Federal and state regulations governing green completions allow exemptions for gas wells where green completions are not feasible for technical reasons. EPA's 2012 regulations also addressed VOC emissions from storage tanks, compressors, and other sources, and had the co-benefit of reducing methane.

87. U.S. Environmental Protection Agency, "Summary of requirements for processes and equipment at oil-well sites", 2016, https://www.epa.gov/sites/production/files/2016-10/documents/nsps-oil-well-fs.pdf.

88. U.S. Environmental Protection Agency, "Oil and gas industry information requests", 2016, https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/oil-and-gas-industry-information-requests.

89. U.S. Environmental Protection Agency, "2016 control techniques guidelines for the oil and natural gas industry", 2016, https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-industry/2016-control-techniques-guidelines-oil-and.

90. See, for example, ICF International, "Economic analysis of methane emission reduction opportunities in the U.S. oil and natural gas industries", prepared for the Environmental Defense Fund, 2014, https://www.edf.org/sites/default/files/methane_cost_curve_report.pdf. The report estimates that the natural gas industry, from upstream production to downstream distribution, could cut methane emissions by 40 percent below projected 2018 levels, at an average annual cost of less than one cent per thousand cubic feet of produced natural gas, by adopting available emissions-control technologies and operating practices. The most cost-effective reduction opportunities would create over $164 million in net savings for operators. In 2016, ICF International released a second report, funded by industry's ONE Future Coalition, which concluded that achieving these reductions would be more expensive. The second report, among other changes, used lower gas sales prices as a baseline, lowering the savings calculated in the first report, and relied on higher emission control costs based on industry experience. See ICF International, "Economic analysis of methane emission reduction potential from natural gas systems", prepared for ONE Future Inc., 2016, http://www.onefuture.us/wp-content/uploads/2016/06/ONE-Future-MAC-Final-6-1.pdf. For EDF's reaction to the revised estimates, see M. Brownstein, "Industry study applies own numbers to EDF study, strengthens our case for regulation", 2016, http://blogs.edf.org/energyexchange/2016/06/03/industry-study-applies-own-numbers-to-edf-study-and-makes-a-strong-case-for-regulation/. ONE Future's eight corporate members have committed to setting a goal of reducing methane leakage within the natural gas value chain to 1 percent by 2025 and have voluntarily agreed with EPA to set an interim goal by 2020. Within these goals, targets are being set for different segments of the value chain (e.g., exploration and production, storage, transmission, and distribution). See http://www.onefuture.us/. Another ICF report focusing on emissions from federal and tribal land found that 65 billion cubic feet of natural gas—with an estimated value of $360 million—was released into the atmosphere in 2013 alone. See ICF International, "Onshore Petroleum and Natural Gas Operations on Federal and Tribal Lands in the United States: Analysis of Emissions and Abatement Opportunities", 2015, https://www.edf.org/sites/default/files/content/federal_and_tribal_land_analysis_presentation_091615.pdf. It has been widely observed that emission controls to reduce methane also reduce VOCs, and vice versa.

91. See Environmental Defense Fund, "Methane Detectors Challenge", https://www.edf.org/energy/natural-gas-policy/methane-detectors-challenge. Similar work is being conducted by the Advanced Research Projects Agency-Energy (ARPA-E), a U.S. government program that advances high-potential, high-impact energy technologies that are too early for private-sector investment. See ARPA-E's MONITOR program, https://arpa-e.energy.gov/?q=arpa-e-programs/monitor.

92. EPA reported that companies participating in the Natural Gas Star program had reduced emissions by 1.3 trillion cubic feet since 2004. EPA also reported that green completions yielded 32 percent of the emission reductions within the industry's production operations and replacement of high-bleed pneumatic controllers yielded an additional 8 percent reduction in emissions. See U.S. Environmental Protection Agency, "Natural Gas STAR Program", https://www.epa.gov/natural-gas-star-program/natural-gas-star-program#domestic.

93. See *DTF 2015*, note 75 and *DTF 2014*, p. 25 and notes 69-71 and 90. In Colorado, companies must report to regulators annually on their implementation of LDAR programs, including inspection methods and numbers and component leaks identified and repaired. See, for example, Anadarko, "LDAR Annual Report 2014", https://www.colorado.gov/pacific/sites/default/files/Anadarko_Reg_7_LDAR_Annual_Report_2014_rec_5-28-15.pdf.

94. See U.S. Environmental Protection Agency, "Summary of requirements for processes and equipment at natural gas well sites", 2016, https://www.epa.gov/sites/production/files/2016-10/documents/nsps-gas-well-fs.pdf.

Investors have been pressing companies to set public goals for reducing methane and greenhouse gas emissions, contending that such goal-setting is a corporate best practice and a critically important tool for adjusting to the regulatory and other challenges of a carbon-constrained world.[95] The scorecard asks, on a non-play-specific basis, for corporate methane emission rates from drilling, completion, and production operations; the percentage or number of high-bleed valves replaced with lower-emission valves; the scope and frequency of leak detection and monitoring programs; and whether a company has established greenhouse gas and methane emission reduction goals.

In addition to methane and greenhouse gas emission reduction, the scorecard asks for play-specific information about use of natural gas or other reduced-emission methods to power well pad operations, voluntary efforts beyond regulation to reduce polluting emissions, and substitution of pipelines for trucks for transporting water or wastewater. It also asks for the percentage of total corporate vehicle fleets converted to lower-emission fuels. Companies can save money and reduce emissions by powering pad operations with natural gas and/or renewable energy such as solar or wind, by using renewable fuels rather than diesel fuel in their vehicle fleets, and by substituting pipelines for trucks when transporting water and waste fluids to and from drilling sites.

IMAGE: Bill Hughes, OVEC/ohvec.org

Drill Rig at Work

Scores

For each shale play:

- Nine (9) companies report on the use of natural gas or other reduced emission methods to power well pad operations.
- Ten (10) companies report on voluntary efforts to reduce polluting emissions.
- Ten (10) companies report on substituting pipelines for trucks to move water and waste.

In addition, on a non-play-specific basis,

- Ten (10) companies report the percentage of their vehicle fleets converted to lower-emission fuels.
- Twelve (12) companies report their methane emission rates from drilling, completion, and production operations.
- Twelve (12) companies report the percentage or number of high-bleed valves replaced with lower emission valves.
- Twelve (12) companies report the scope of their leak detection and repair programs.
- Nine (9) companies report the frequency of monitoring by their leak detection and repair programs.
- Four (4) companies—*Apache*, *BHP Billiton*, *Hess*, *Southwestern Energy*—report having established public methane emission reduction goals.[96]
- Three (3) companies—*BHP Billiton*, *ConocoPhillips*, *Hess*—report having established greenhouse gas emission reduction goals.

95. See, for example, the statement by the Tri-State Coalition for Responsible Investment on their 2015 resolution at ExxonMobil asking the company to set greenhouse gas emission reduction goals: http://www.sec.gov/Archives/edgar/data/34088/000121465915003187/c421150px14a6g.htm.

    For a review of climate goal setting (including in the areas of emission reductions, energy efficiency, and renewable energy) by Fortune 500 companies, see Ceres et al., "Power forward 2.0: How American companies are setting clean energy targets and capturing greater business value", 2014, http://www.ceres.org/resources/reports/power-forward-2.0-how-american-companies-are-setting-clean-energy-targets-and-capturing-greater-business-value/view.

    The International Energy Agency has identified minimizing methane emissions from upstream oil and gas production as one of four key global greenhouse gas mitigation opportunities, noting that reductions in such emissions could account for nearly 15 percent of the total greenhouse gas reductions needed by 2020 to keep the world below a 2°C increase in temperature, a level above which catastrophic global impacts are predicted to occur. See International Energy Agency, "World energy outlook special report 2013: Redrawing the energy climate map", https://www.iea.org/publications/freepublications/publication/WEO_Special_Report_2013_Redrawing_the_Energy_Climate_Map.pdf.

96. Some companies may be reluctant to set time-limited goals because of uncertainty about how their operations may change due to asset acquisition and disposal in the dynamic oil and gas asset-transfer marketplace.

AIR EMISSIONS

COMPANY	Low Emission Pad Ops.	% Low Emission Vehicle Conversion	Addt'l Voluntary Emission Reductions	Pipelines Replace Trucks	Methane Leakage %	Low-bleed Controllers	Leak Detection Practices	Leak Inspection Frequency	Methane Goal	GHG Target	TOTAL
BHP Billiton	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
Noble Energy	✓	✓	✓	✓	✓	✓	✓	✓			8
Southwestern Energy	✓		✓	✓	✓	✓	✓	✓	✓		8
Newfield Resources	✓	✓	✓		✓	✓	✓	✓			7
EQT	✓		✓		✓	✓	✓	✓			6
Carrizo				✓	✓	✓	✓	✓			5
CONSOL	✓		✓			✓	✓	✓			5
Hess		✓			✓	✓			✓	✓	5
Range Resources	✓	✓		✓		✓		✓			5
ANTERO	✓		✓	✓			✓				4
Apache		✓			✓		✓		✓		4
Encana			✓	✓	✓	✓					4
Chesapeake	✓	✓				✓					3
ConocoPhillips					✓	✓				✓	3
Pioneer		✓		✓			✓				3
QEP		✓					✓	✓			3
Anadarko		✓		✓							2
EOG					✓		✓				2
Chevron				✓							1
Occidental Petroleum			✓								1
Shell					✓						1
Whiting Oil & Gas			✓								1
BP											0
Cabot											0
Continental Resources											0
Devon											0
ExxonMobil											0
WPX											0

Notable Practices

Greenhouse Gas Emission Reductions

- *Hess* has set targets for 2020 to reduce flaring intensity by 50 percent and greenhouse gas intensity by 25 percent from a 2014 baseline.[97]
- *Southwestern Energy* reports its annual methane leak/loss rate for 2013-2015, and notes its 2015 rate of 0.18 percent is below the goal of 0.36 percent for the production sector set by the ONE Future coalition (which it co-founded).[98]
- *Noble* reports its annual methane emission reductions for 2013-2015, differentiating among emission reductions attributable to infrared cameras, vapor recovery units, and introducing improved artificial lift systems for increasing production of liquids from its wells.[99]

97. Hess, "Hess Corporation's 2015 Sustainability Report Shows Commitment to Safety and Responsible Business Practices", http://www.hess.com/company/news-article/2016/07/14/hess-corporation-s-2015-sustainability-report-shows-commitment-to-safety-and-responsible-business-practices.

98. Southwestern Energy, "Corporate Responsibility Report 2015-16", pp. 5, 7, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report.pdf.

99. Noble Energy, "2015 Sustainability Report", p. 25, http://responsibility.nobleenergyinc.com/wp-content/uploads/resources/report-archives/NobleEnergy_Sustainability_Report_2015.pdf.

Other Air Quality Actions

- *Newfield Exploration* provides a lengthy play-by-play list of its reduced emission initiatives, including use of cleaner-burning engines and dual-fuel rigs and posts the text of its voluntary operational commitments for the Monument Butte region of Utah. The company also states that it has removed essentially all high-bleed controllers in its operations, and its new well sites located in Oklahoma are constructed with non-pneumatic controls powered by solar energy rather than natural gas.[100]
- *Hess and collaborating partners* at a North Dakota well tested the ElectraTherm Power+ Generator™, which uses natural gas from the well to generate electricity and reduces or eliminates onsite flaring. The system offsets the cost of using electricity from the grid. The pilot system showed average estimated reductions of carbon monoxide (98 percent), nitrogen oxides (48 percent), and VOCs (93 percent), compared to flaring.[101]
- *Pioneer Natural Resources* is supplementing its standard LDAR program with a test in the Permian Basin of continuous emissions monitoring systems. The company views the systems as possibly able to better direct its LDAR program and quickly locate unexpected emissions.[102]

IMAGE: FracTracker Alliance

Post Fracking Flaring

- *CONSOL* reports that, for its Pittsburgh International Airport project, it is using fracturing equipment with the latest ("Tier 4") emission controls in advance of regulatory requirements. This equipment yields emission reductions beyond typical emissions reductions from traditional Tier 3 equipment.[103]
- *CONSOL* has converted its entire drilling rig fleet to dual-fuel capability to be able to substitute field gas for use of diesel fuel. CONSOL was the first driller in its area to use all-electric drilling rigs.[104]
- *Antero Resources* has contracted for two clean completion "fleets" of equipment for its completion operations. These replace the diesel engines used for pressure pumping with electric motors powered by natural gas-fired electric generators. The company identifies benefits as up to an 80 percent reduction in fuel costs (representing $40,000/day) and a 99 percent reduction in NOx and carbon monoxide emissions. They also eliminate 25 diesel truckloads per well and significantly reduce noise pollution from the well site.[105]
- *Hess* began using flexible pipes in North Dakota instead of trucks for transporting fresh water, which helps reduce air pollution from trucks. (The hoses collapse flat when not used.) In 2014 Hess pumped 43 percent of its fresh water in North Dakota this way and in 2015 72 percent, exceeding its goal of 65 percent. This initiative led to a reduction in 2015 of 63,000 truck deliveries, 2.3 million miles driven, and 5,010 tons of greenhouse gas emissions.[106]
- *Chesapeake*, to communicate its broad use of novel methods for powering its operations, provides a graphic of seven plays, indicating which operations use dual-fuel drilling and completions and electric grid production and drilling.[107]

100. Newfield Exploration, "Air Quality & Climate Change", http://newfield.com/corporate-responsibility/safety-environmental/air-quality-climate-change and Newfield Exploration, "Final Environmental Impact Statement: Monument Butte Oil & Gas Development Project", 2016, http://newfield.com/docs/default-source/SERC/feis_2016_monument_extract2.pdf?sfvrsn=2.

101. Hess, P. "2015 Corporate Sustainability Report", p. 49, http://www.hess.com/docs/default-source/sustainability/hess-2015-csr.pdf?sfvrsn=2.

102. Pioneer Natural Resources, "Air", http://www.pxd.com/values/sustainability/air.

103. CONSOL, "2015 Corporate Responsibility Report", p. 24, http://2015crr.consolenergy.com/.

104. CONSOL, "2015 Corporate Responsibility Report", p. 46, http://2015crr.consolenergy.com/.

105. Antero Resources, "Company Overview, June 2016", p. 62, http://s1.q4cdn.com/057781830/files/doc_presentations/2016/Company-Website-Presentation-(A)-June-2016.pdf.

106. Hess, "2015 Corporate Sustainability Report", p. 49, http://www.hess.com/docs/default-source/sustainability/hess-2015-csr.pdf?sfvrsn=2.

107. Chesapeake Energy, "Reducing Greenhouse Gas Emissions", http://www.chk.com/responsibility/environment/greenhouse-gas-management.

Progress and Prospects

As concern over global climate change has deepened in recent years, so too has focus on emissions of greenhouses gases associated with production of natural gas, especially methane released to the environment rather than directed towards a pipeline for future use. In contrast to the realm of water sourcing and wastewater management, where technological innovations have driven performance improvements, substantial reduction of air emissions can be accomplished largely by more widespread, systematic application of existing technologies. The companies likely in the best position to adapt to the emerging federal and state regulations will be the first movers who have already implemented monitoring and control measures. These companies have already garnered bottom-line benefits from reduced loss of saleable methane through early adoption of green completion technologies and are beginning to develop more robust leak detection programs. Innovative technologies such as dual-fuel rigs, solar-powered equipment, and new generations of vehicle engines are also contributing to bottom-line savings and providing greater environmental benefits.

Continuing technological innovations have the potential to dramatically enhance companies' ability to detect and remedy methane losses in their operations. EDF's methane detection technology study, conducted collaboratively with industry, seeks to identify and test relatively inexpensive emerging technologies. Development and deployment of drone technology could also provide for less expensive and more timely and accurate leak detection.[108]

IMAGE: Bill Hughes, OVEC/ohvec.org

Silica dust is one of several air emission issues

Companies' disclosures about their air emission control initiatives could provide investors with insight into the quality of corporate management and the potential for companies to reap the benefits from wider use of existing and emerging technologies. However, too few companies currently provide clear, quantitative disclosures about their air emission reductions, an area that is particularly relevant to communities' concerns about ongoing and potential new operations. Disclosure about effective LDAR programs will be critical moving forward since the Paris climate agreement has now gone into effect. Reducing methane emission leaks is a high-leverage and cost-effective method of reducing greenhouse gas emissions associated with the oil and gas sector.

Complementing *Disclosing the Facts 2016*, EDF and the Principles for Responsible Investment (PRI) Initiative recently released *An Investor's Guide to Methane*, a practical tool to help investors engage on methane risks with operators, including a performance assessment tool and suggested questions to guide constructive dialogue.[109]

COMMUNITY IMPACTS

Issue and Questions

The exponential increase in horizontal drilling and hydraulic fracturing since 2002 has generated enormous public controversy in many locations. Communities have expressed concerns about harm to air, water quality, and human health, as well as about disruptions to community life through increased traffic congestion,[110] road damage, impacts on community facilities and services, shortages of affordable housing, and nuisances such as light, noise, and dust

108. "Could drones detect leaks at oil and gas sites?", 2015, http://michiganradio.org/post/could-drones-detect-leaks-oil-and-gas-sites#stream/0 and "Methane-sniffing drones in fracturing operations", 2015, https://www.asme.org/engineering-topics/articles/energy/methanesniffing-drones-in-fracturing-operations.

109. Environmental Defense Fund, "An Investor's Guide to Methane: Engaging with Oil and Gas Companies to Manage a Rising Risk", 2016, https://www.edf.org/sites/default/files/content/investor_guide_final.pdf.

110. New North Carolina regulations governing hydraulic fracturing applications require companies to submit a road impact plan that includes procedures to restore roads to their pre-drilling condition, identify trucking routes that minimize road surface travel, and set travel hours "that avoid otherwise heavy traffic volume, including avoidance of hours during which school buses will be traveling on the roads". See Subchapter 05H—Oil and Gas Conservation, 15A NCAC 05H.1304(c)(8), http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2005%20-%20mining%20-%20mineral%20resources/subchapter%20h/subchapter%20h%20rules.pdf.

among others.[111] The debate over horizontal drilling and hydraulic fracturing is part of a larger national debate about alternative future energy paths for the United States and the relative roles of fossil, renewable, and nuclear fuels as sources of energy supply, in addition to the employment of energy efficiency to lower demand.[112]

The industry's failure to adequately respond to local concerns has prompted backlash and opposition culminating in state and local bans and moratoria on hydraulic fracturing across the United States.[113] For example, in 2015, citing health concerns, New York State banned hydraulic fracturing.[114] There has also been a continuing tug of war between state and local governments in several states regarding whether local authorities should have the right to determine where and under what conditions horizontal drilling and hydraulic fracturing are allowed.[115] In 2015, Maryland's governor did not veto, and therefore allowed to take effect, a two-year legislative moratorium on fracturing.[116] In Colorado and Ohio, where considerable drilling and hydraulic fracturing is under way, state courts

111. Aside from the negative environmental and social impacts at the root of local controversies, fracturing operations can provide overall positive or negative economic benefits. These will be influenced by the scope and pace of fracturing operations and state and local policies related to tax revenues and their distribution. Duke University researchers examining 21 regions in 16 states from 2013 to 2015 found that the net impact of oil and gas development has been mostly positive for local public finances. In some regions, especially very rural regions experiencing rapid population growth, local governments have faced substantial fiscal challenges. Rising local costs have tended to be associated with road repair, water and sewer service for growing populations, cost of expanded police or emergency services, and increased salary demands because of competition with high-paying jobs in the oil and gas sector. See D. Raimi and R. Newell, "Issue brief: Shale public finance: local government fiscal effects of oil and gas development", 2016, http://reports.oah.state.nc.us/ncac/title%2015a%20-%20environmental%20quality/chapter%2005%20-%20mining%20-%20mineral%20resources/subchapter%20h/subchapter%20h%20rules.pdf.

112. The debate over hydraulic fracturing has also been framed as a human rights issue. See, for example, Sisters of Mercy, *A guide to rights-based advocacy: international human rights law and fracking*", 2015, http://www.mercyworld.org/_uploads/_ckbl/files/2015/Final%20Fracking%20Guide%202015.pdf. See also *DTF 2014*, note 103 and related text, and *Extracting the Facts*, note 73.

113. Developments in the United States are also being watched overseas. In 2015, the Dutch government introduced a five-year moratorium on shale gas exploration, indicating that existing licenses will not be renewed and no new exploration permits will be granted. See "Dutch government bans shale gas drilling for 5 years", *Reuters*, 2015, http://uk.reuters.com/article/2015/07/10/netherlands-energy-shale-idUKL8N0ZQ2S720150710.

In 2016, the government of the Canadian province of New Brunswick declared it would indefinitely extend its moratorium on fracturing operations following release of a report by a government-appointed commission that had been established to review hydraulic fracturing. See "New Brunswick indefinitely extends hydraulic fracturing moratorium", *CBC News*, 2016, http://www.cbc.ca/news/canada/new-brunswick/arseneault-fracking-commission-report-1.3602849.

Also in 2016, Germany banned fracturing operations for five years. See "German government agrees to ban fracking", *Pollution Solutions Online*, 2016, http://www.pollutionsolutions-online.com/news/hazardous-waste/20/breaking_news/german_government_agrees_to_ban_fracking/39559/.

Victoria became the first Australian state to ban fracturing operations, making permanent a moratorium that had been established in 2012, "Victorian unconventional gas exploration ban to end fracking and CSG extraction", *ABC*, 2016, http://www.abc.net.au/news/2016-08-30/victoria-to-ban-csg-fracking-and-unconventional-gas-exploration/7796944. In 2016 Australia's Northern territory government announced a moratorium on fracturing of unconventional gas reservoirs pending the outcome of an independent scientific inquiry. See "Northern Territory halts fracking", *Asian Oil & Gas, 2016*, http://www.aogdigital.com/pipelines/item/6096-northern-territory-halts-fracking.

114. New York State Department of Health, "New York State Department of Health Completes Review of High-volume Hydraulic Fracturing", 2015, https://www.health.ny.gov/press/releases/2014/2014-12-17_fracking_report.htm and New York State Department of Environmental Conservation,"New York State Officially Prohibits High-Volume Hydraulic Fracturing", 2015, http://www.dec.ny.gov/press/102337.html.

115. In September 2016, Pennsylvania's Supreme Court issued the latest in a series of rulings strengthening the hand of local communities to regulate oil and gas industry activities. The decisions stem from an environmental rights provision in Pennsylvania's constitution. For a summary of this litigation prepared by the Pepper Hamilton LLP law firm, see "An update on Pennsylvania's oil and gas law—Act 13—after Supreme Court decisions", 2016, http://www.lexology.com/library/detail.aspx?g=c49d494f-7015-4311-85f6-b68d64ea30a1.

In a report requested by state officials, the University of Michigan provides an instructive review of three types of policies that states can adopt to address the scientific uncertainties surrounding horizontal drilling and hydraulic fracturing. The report labels these as precautionary (which in their strongest form ban activities that could potentially result in severe harm), adaptive (which take some regulatory action and then refine the policy as more information becomes available), or remedial or post-hoc (which permit the activity and rely on containment measures and private and public liability actions to address any harm). See University of Michigan Graham Sustainability Institute, "Executive Summary: Hydraulic fracturing in Michigan integrated assessment final report", 2015, p. 10, http://graham.umich.edu/media/files/HF-IA-Final-Exec-Summary.pdf.

116. See "Md. fracking moratorium to become law without Hogan's signature", *Washington Post*, 2015, http://www.washingtonpost.com/local/md-politics/md-fracking-moratorium-to-become-law-without-hogans-signature/2015/05/29/e1d10434-062c-11e5-a428-c984eb077d4e_story.html. In anticipation of expiration of the ban in 2017, Maryland regulators proposed new regulations in June 2016 to govern fracturing activities. Both industry and environmental groups have criticized the rules. See "Proposed rules to govern fracking in Maryland draw criticism from environmentalists and energy industry", *Baltimore Sun*, 2016, http://www.baltimoresun.com/news/maryland/bs-md-fracking-rules-20160622-story.html. In July, 2016, Friendsville became the second municipality in Garrett County, Maryland to ban hydraulic fracturing. Garrett County, a popular tourism and recreation area, is the only Maryland county where natural gas is currently produced. See "Friendsville bans fracking within its borders", *Cumberland Times-News*, 2016, http://www.times-news.com/news/local_news/friendsville-bans-fracking-within-its-borders/article_c2f9c618-be9f-5165-b59a-034bb040f06f.html.

have outlawed local control of fracturing activities.[117] In Colorado, this prompted activists to gather signatures for two initiatives on the November 2016 ballot, one to expand required setbacks of company operations from occupied homes and other designated areas, and the other to expand local government authority over operations; however, this effort did not secure sufficient valid signatures to qualify the initiatives for the ballot.[118] In 2015, in response to a local ban on drilling and hydraulic fracturing in Denton, Texas, Texas' state legislature enacted a law strictly limiting local control; Oklahoma's legislature enacted a similar law one week later.[119] In contrast, in Florida, where hydraulic fracturing has yet to occur and where 57 local communities have passed resolutions opposing it, efforts by some state legislators to outlaw local bans have been unsuccessful.[120]

IMAGE: FracTracker Allilance

Brine Truck Spill Barnesville, Ohio

Recognizing that the industry faces a material threat to its social license to operate, and that concerns regarding human health and welfare and the environment are mounting, investors have increasingly pressed companies to implement the most effective mechanisms to record, track, and respond to community concerns and to disclose the outcomes of those processes.

The scorecard asks whether companies disclose major identified community impact concerns and company responses on a play-by-play basis; internal processes for gathering and reporting community concern statistics upward within the company; clearly stated practices to respond to local concerns about light, noise, and odor nuisances and policies to adjust activity schedules to prevent or reduce traffic congestion.[121] Because traffic accidents and road safety can be among the greatest local concerns, a new question in 2016 asks companies to disclose their driver training and vehicle tracking practices to reduce road hazards.[122]

117. See *DTF 2015*, p. 33 and notes 99 and 100; DTF 2014, note 101; "OH supreme court rejects local ballot protest", *WOUB Digital*, 2015, http://woub.org/2015/09/16/oh-supreme-court-rejects-local-ballot-protest/; and "Colorado Supreme Court rules state law trumps local bans on fracking", *Denver Post*, 2016, http://www.denverpost.com/2016/05/02/colorado-supreme-court-rules-state-law-trumps-local-bans-on-fracking/.

118. "Fracking Measures Won't Go Before Colorado Voters in November", *Wall Street Journal*, 2016, http://www.wsj.com/articles/anti-fracking-measures-wont-go-before-colorado-voters-in-november-1472486484.

119. See "Abbott signs law to restrict local fracking regulations", *Dallas Morning News*, 2015, http://www.dallasnews.com/news/politics/state-politics/20150518-abbott-signs-law-to-restrict-local-fracking-regulations.ece. The text of the bill, H.B. 40, is available at http://www.legis.state.tx.us/BillLookup/Text.aspx?LegSess=84R&Bill=HB40. See "Oklahoma outlaws local fracking bans", *Longview News-Journal*, 2015, http://www.news-journal.com/news/2015/may/29/oklahoma-outlaws-local-fracking-bans/. The text of Senate Bill 809 is available at http://www.oklegislature.gov/BillInfo.aspx?Bill=SB809&Session=1500.

120. "Bill banning fracking bans gets shut down in Florida senate", *ThinkProgress*, 2016, http://thinkprogress.org/climate/2016/03/01/3755280/florida-fracking-bill-dies/.

121. A report by a collaboration of foundation-funded public policy research organizations in the Marcellus and Utica Shale plays suggests that local governments themselves designate truck routes, set no-drive times for heavy trucks coordinated with school bus schedules, post weight limits, bond roads, and establish road maintenance agreements with companies. See Multi-State Shale Research Collaborative, "Lessons from gas patch communities: a local government guide for dealing with drilling", 2016, https://org2.salsalabs.com/o/6751/images/2016Shale_Handbook.pdf.

122. Bureau of Labor Statistics data indicate that nearly a third of oil and gas industry fatalities are due to traffic accidents and single-vehicle rollovers. See J.L. Adgate et al., "Potential public health hazards, exposures and health effects from unconventional natural gas development", *Environmental Science and Technology* 48, 2014, pp. 8307-8320, http://pubs.acs.org/doi/abs/10.1021/es404621d. In Pennsylvania, there has been a significant increase in the number of total accidents and accidents involving a heavy truck in counties with a relatively large degree of shale gas development as compared to counties with less or no development. See L.A. Muehlenbachs and A.J. Krupnick, "Shale gas development linked to truck accidents in Pennsylvania", 2013, http://www.rff.org/blog/2013/shale-gas-development-linked-traffic-accidents-pennsylvania.

COMMUNITY IMPACTS

COMPANY	Community Impact Concerns, Company Response	Data Tracking of Local Concerns	Upward Reporting within Company	Traffic Congestion Policies	Driver Training & Tracking	Light, Noise, & Odor Actions	TOTAL
BHP Billiton	✓	✓	✓	✓	✓	✓	6
Noble Energy	✓	✓	✓	✓	✓	✓	6
Range Resources	✓	✓	✓	✓	✓	✓	6
Anadarko		✓	✓	✓	✓	✓	5
Apache		✓	✓	✓	✓	✓	5
EQT	✓	✓	✓	✓	✓		5
ConocoPhillips		✓	✓	✓	✓		4
EOG		✓	✓	✓			3
Hess Energy		✓		✓	✓		3
Shell		✓		✓	✓		3
Southwestern Energy		✓		✓	✓		3
Encana		✓		✓			2
Newfield Resources		✓	✓				2
BP		✓					1
Carrizo				✓			1
Chesapeake					✓		1
Chevron					✓		1
CONSOL				✓			1
Continental Resources					✓		1
ExxonMobil				✓			1
Pioneer					✓		1
WPX					✓		1
Antero							0
Cabot							0
Devon							0
Occidental Petroleum							0
QEP							0
Whting Oil & Gas							0

Scores

- Four (4) companies—*BHP Billiton*, *EQT*, *Noble*, *Range Resources*—report major identified community impact concerns and company responses on a play-by-play basis.
- Fourteen (14) companies report their internal processes for capturing and addressing local concerns.
- Nine (9) companies report internal processes for reporting community concern statistics upward within the companies.
- Fifteen (15) companies disclose clearly stated practices to adjust activity schedules to prevent or reduce traffic congestion from operations.
- Fifteen (15) companies disclose driver training and tracking methods used to reduce road accidents.
- Five (5) companies report clearly stated practices to address local concerns about light, noise, and odor nuisances.

Notable Practices

- *Anadarko* launched a "Colorado Response Line" in 2014 as its primary vehicle for capturing feedback from local communities about its operations. The company responds to inquiries within 24 hours and tries to resolve concerns within ten days or less. Anadarko's "Grievance Management Resolution Mechanism" (GMRM)

database tracks the inquiries and company responses. Of 850 "stakeholder tickets" tracked since the inception of the program, 22 percent concerned noise, 17 percent traffic and road conditions, 8 percent property damage, 7 percent light, 3 percent odor, and 2 percent water quality.[123]

- *Hess* has been piloting its "Stakeholder Management System" in the Bakken play. The company's local grievance mechanism, "Community Connection", establishes a process for reporting, investigating, and resolving issues and concerns raised by those who believe they are impacted by Hess operations. When an issue is raised, the company creates a response team that aims to complete investigation within 14 days and then reports back to the complaining party. The company received a total of 214 grievances during the pilot phase, including feedback related to roads, dust, maintenance, land reclamation, weeds, and environmental, health, and safety (EHS) concerns.[124]
- *Southwestern Energy* is implementing a new internal routing and tracking system for all complaints. The system will document the nature of the complaint, where it was received, and how it was addressed. The system will be in place at all operations by the end of 2016.[125]
- *EQT* publishes a chart of major community issues and how it responds to community concerns. It draws upon an issues tracking system implemented by the company's "Community Advisor Program" in 2013. The issues identified by the company include contractor traffic volume, speed, and noise, noise from drilling and completion activity, and road maintenance. The company also tracks on a quarterly basis the number of complaints per 100 wells drilled. Senior management reviews these reports.[126]

IMAGE: Ed Wade Jr., OVEC/ohvec.org

Sharing the Roads

- *Shell* reports that it has implemented community feedback mechanisms at all major operations and projects to receive, track, and respond to questions and complaints from community members. The company uses data from these feedback mechanisms as performance indicators at both local community and global levels and to identify common issues across the company and share knowledge on how they were resolved.[127]
- *Range Resources* provides one of the more wide-ranging, detailed overviews of its community engagement processes, community concerns, and company responses. For example, the company logs and tracks community concerns, addresses school bus schedules, trains and tracks its drivers, and performs advanced light and sound studies.[128]
- *Noble Energy* provides extensive, play-by-play discussion of how it addresses community concerns regarding traffic, light, noise, and odors.[129]

123. See Anadarko, "Health, Safety, Environment and Sustainability Overview 2015", p. 39, https://www.anadarko.com/content/documents/apc/Responsibility/Governance_Documents/2015_HSE_Overview.pdf. The 850 contacts also included requests for information and positive feedback.

124. Hess, "2015 Corporate Responsibility Report", p. 24 and p. 26, http://www.hess.com/docs/default-source/sustainability/hess-2015-csr.pdf?sfvrsn=2.

125. Southwestern Energy, "Corporate Responsibility Report 2015-16", p. 32, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report.pdf.

126. EQT, "2015 Corporate Social Responsibility Report", p. 32, https://www.eqt.com/~/media/sites/eqt/files/corporatesocialresponsibility/eqt_csr_report_2014-2015.ashx?la=en.

127. Shell, "2015 Sustainability Report", p. 26, http://www.shell.com/sustainability/sustainability-reporting-and-performance-data/sustainability-reports.html.

128. http://www.rangeresources.com/corp-responsibility/community-engagement-and-leadership.

129. http://responsibility.nobleenergyinc.com/wp-content/uploads/2016/10/IEHN-Disclosing-the-Facts.pdf.

- *EQT*, *Chesapeake Energy*, *Anadarko*, *Southwestern Energy*, *ConocoPhillips*, and *Apache* report a variety of methods for protecting community road safety. Through signs posted along active truck routes, *EQT* notifies its drivers and contractors of school bus hours during which the company prohibits truck use. It also imposes speed limits, curfews, and route restrictions and requires contractors to deploy GPS-based systems to monitor vehicle speed and location.[130] *Chesapeake Energy's* drivers participate in six online and classroom-based courses and can use simulators to practice driving on ice and in the snow and rain.[131] *Anadarko's* training activities include defensive driving, blind spot training, and "commentary drives".[132] *ConocoPhillips* similarly conducts defensive driving and commentary drives, tracks vehicles, and shares data with government officials about accident-prone intersections.[133] *Southwestern Energy's* driver training programs include in-person and online programs. Southwestern also pays contractors by the hour rather than by delivery load as much as possible to reduce the incentive to speed.[134] *Apache's* detailed disclosure describes tracking, training, and related efforts.[135]

IMAGE: FracTracker Alliance

Trucks can create dust problems

- *EQT*, *Southwestern Energy*, *Chesapeake Energy*, and *Anadarko* also report their motor vehicle accident rates. *EQT* does so annually for a four-year period while *Southwestern Energy* does so for a three-year period.[136] *Chesapeake Energy* reported a 22 percent drop in motor vehicle accidents in 2015 compared to 2014, while *Anadarko* reported a 13 percent reduction over the same period.[137]
- *The Permian Road Safety Coalition* was created in 2015 by *ten companies* assessed in *Disclosing the Facts 2016*, local officials, and oilfield suppliers to address strategic road safety challenges and to enhance data analysis to craft innovative solutions.[138]
- *Southwestern Energy* provides a detailed description of its efforts to reduce noise nuisances. The company notes that noise levels may be regulated at the state or county level and all its facilities are designed to meet any applicable limits "usually by a comfortable margin". It also responds to community concerns in the absence of regulation. These efforts include siting compressor stations away from residential locations, parks, historic sites, and wetlands. Southwestern uses non-standard exhaust systems with extra sound-reduction and other equipment measures to lower noise nuisances and, if needed, constructs buildings or sound walls around compressors.[139]

130. EQT, "2015 Corporate Social Responsibility Report", p. 16, https://www.eqt.com/~/media/sites/eqt/files/corporatesocialresponsibility/eqt_csr_report_2014-2015.ashx?la=en.
131. http://www.chk.com/responsibility/safety/safety-culture.
132. See Anadarko, "Health, Safety, Environment and Sustainability Overview 2015", p. 13, https://www.anadarko.com/content/documents/apc/Responsibility/Governance_Documents/2015_HSE_Overview.pdf. Commentary drives are sessions in which a driver reports to an observer what (s)he sees on the road.
133. Conoco Phillips, "Engaging with Communities", http://www.conocophillips.com/sustainable-development/people-society/engaging-stakeholders/Pages/engaging-with-communities.aspx.
134. Southwestern Energy, "Corporate Responsibility Report 2015-16", p. 34, https://www.swn.com/responsibility/Documents/SWN_CR_Report_2014-15_MR_FINAL.PDF.
135. Apache, "2016 Sustainability Report", pp. 41-42, http://www.apachecorp.com/Resources/Upload/file/sustainability/APACHE-Sustainability_Report_2016.pdf.
136. EQT, "2015 Corporate Social Responsibility Report", p. 47, https://www.eqt.com/~/media/sites/eqt/files/corporatesocialresponsibility/eqt_csr_report_2014-2015.ashx?la=en and Southwestern Energy, "Corporate Responsibility Report 2015-16", p. 16, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report.pdf.
137. Chesapeake Energy, "Safety Culture", http://www.chk.com/responsibility/safety/safety-culture and Anadarko, "Health, Safety, Environment and Sustainability Overview 2015", p. 13, https://www.anadarko.com/content/documents/apc/Responsibility/Governance_Documents/2015_HSE_Overview.pdf.
138. Permian Road Safety Coalition, http://www.permianroadsafety.org.
139. Southwestern Energy, "Corporate Responsibility Report 2015-16", p. 34, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report.pdf.

- *BHP Billiton* notes that noise is one of the most common complaints it receives. The company routinely deploys 32-foot sound barriers in urban, sensitive areas completely surrounding its drilling operations. These also mitigate spill-over of light, though the company also notes that in urban areas it restricts its operations to daylight hours. The company notes that it has not received complaints about odors. It further observes that a high percentage of both its existing and future operations are in remote locations that have limited impact on others.[140]
- *Southwestern Energy* reports on a play-by-play basis the number of complaints it receives for water quality impairment and the results of its investigations into the causes of water quality concerns. *Southwestern* reports that the majority of the complaints were determined to be due to bacterial problems or did not reflect water quality impairments, with the remaining attributed to drought, mechanical, stray gas, or miscellaneous categories.[141]

Progress and Prospects

Recent development of more sophisticated community concern tracking systems by companies appears to be an area where investor disclosure requests are driving improved corporate behavior. Investor requests to understand what systems are in place to track community concerns and for disclosure of statistics about community concerns and their resolution have driven a more granular disclosure of these issues, but so far only by a small number of leading companies. In an environment where companies face risks related to securing and maintaining a social license to operate, investors want to ensure that companies disclose clear systems to gather, respond to, and track community complaints.

IMAGE: FracTracker Alliance

Sound Barrier to reduce noise

As noted in *DTF 2015*, health impacts are another area where substantial improvement in disclosure is needed. Both companies and investors must pay greater attention to the short- and long-term human health effects associated with air and water pollution. A growing number of scientific studies and incident reports document adverse health effects associated with hydraulic fracturing operations.[142] And regulators are responding. For example, New York State has banned shale development on the basis of health concerns.[143]

A recent review of studies associating shale development with environmental health impacts concludes that many of the studies lack scientific rigor. Nevertheless, the authors note that there is no evidence to rule out association of hydraulic fracturing operations with severe health effects.[144] Another literature review cites major uncertainties such as the paucity of baseline data for making before and after comparisons and the unknown frequency and duration of

140. BHP Billiton "Case Study 2016 Responsibly managing hydraulic fracturing", p. 8, http://www.bhpbilliton.com/~/media/bhp/documents/society/reports/2016/161018_responsiblymanaginghydraulicfracturing.pdf?la=en.

141. Southwestern Energy, "Corporate Responsibility Report 2015-16", p. 7, https://www.swn.com/responsibility/Documents/2015-16_SWN_CR_Report_Appendix.pdf.

142. See, for example, S.L. Stacy et al., "Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania", *PLOS One*, 2015, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0126425. This study, which indicated an association between low birth weights and nearby fracking operations, did not demonstrate a causal link. As noted by the authors, more research into the issue is merited.

143. New York State's Department of Health released a study that provided a health-based rationale for the state ban. It found that the weight of the evidence demonstrated significant uncertainties about the kinds of adverse health outcomes that might be associated with hydraulic fracturing, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of mitigation measures to reduce adverse environmental impacts that could affect public health. The department recommended that hydraulic fracturing not move forward in New York State until sufficient scientific information becomes available to determine the level of risk to public health and whether risks could be adequately managed. See New York State Department of Health, "A public health review of high volume hydraulic fracturing for shale gas development", 2014, http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf.

144. A.K. Werner et al., "Environmental health impacts of unconventional natural gas development: A review of the state of the evidence", *Science of the Total Environment* 505, 2015, pp. 1127-1141, http://www.sciencedirect.com/science/article/pii/S0048969714015290.

human exposure. The authors conclude that research is needed to address these uncertainties "before we can reasonably quantify the likelihood of occurrence or magnitude of adverse health effects associated with [hydraulic fracturing operations] in workers and communities".[145]

The Health Effects Institute (HEI), a respected research organization originally created by the United States government and automotive industry to generate credible scientific research for the purpose of developing automobile-related regulatory standards, has developed a research agenda for closing the data gaps related to human health effects and other impacts of shale development.[146] An HEI-like research institute co-funded by government and the oil and gas industry could execute the research agenda, helping to clarify the health risks associated with fracturing operations and enabling industry, investors, and communities to better understand the magnitude of health risks and develop precautionary measures to address them.

While the industry continues to deny health impacts, this issue will not be resolved until credible studies provide data on these critical issues.

MANAGEMENT AND ACCOUNTABILITY

Issue and Questions

A "meta-analysis" incorporating results from more than 2,000 empirical studies found in 2015 that a large majority of the studies identified a positive impact between corporate financial performance and environmental, social, and governance (ESG) performance.[147] When the *Harvard Business Review* released its annual list of the world's 100 best-performing CEOs in 2015, its rankings, for the first time, allocated a 20 percent weighting to the ESG performance of a CEO's company, complementing an 80 percent weighting to long-term financial performance.[148] Similarly, BlackRock, the world's largest investment management firm, with $4.5 trillion assets under management, has recently stated that ESG "is not just about saving the planet or feeling good. We view ESG excellence as a mark of operational and management quality".[149] BlackRock CEO Larry Fink, in a 2016 letter to the CEOs of S&P 500 companies and large European corporations, further noted, "Over the long-term, environmental, social and governance (ESG) issues—ranging from climate change to diversity to board effectiveness—have real and quantifiable financial impacts".[150]

BlackRock's comments add to the growing list of evidence that consideration of ESG factors is becoming mainstream in U.S. finance.[151] Corporate governance analyst and proxy voting service provider Glass, Lewis & Co. has reported a significant growth in companies linking compensation to sustainability, from 29 percent of companies reviewed in 2010 to 40 percent in 2014.[152] In a 2016 update to its 2014 report, Glass, Lewis & Co. noted the outcome of various studies indicating that an effective way to achieve sustainability goals is to include sustainability targets in CEO remuneration packages.[153]

145. J.L. Adgate et al., "Potential public health hazards, exposures and health effects from unconventional natural gas development", *Environmental Science and Technology* 48, 2014, pp. 8307-8320, http://pubs.acs.org/doi/abs/10.1021/es404621d.

146. Health Effects Institute, "Final strategic research agenda on the potential impacts of 21st century oil and gas development in the Appalachian basin and beyond", 2015, http://www.healtheffects.org/UOGD/UODG-Research-Agenda-Nov-4-2015.pdf.

147. G. Friede et al., "ESG and financial performance: aggregated evidence from more than 2000 empirical studies", *Journal of Sustainable Finance & Investment*, 2016, http://www.tandfonline.com/doi/pdf/10.1080/20430795.2015.1118917.

148. Harvard Business Review, "The Best-Performing CEOs in the World", 2015, https://hbr.org/2015/11/the-best-performing-ceos-in-the-world.

149. BlackRock, "The price of climate change: Global warming's impact on portfolios", 2015, p. 2, https://www.blackrock.com/investing/literature/whitepaper/bii-pricing-climate-risk-us.pdf.

150. Business Insider, "Here is the letter the world's largest investor, BlackRock CEO Larry Fink, just sent to CEOs everywhere", 2016, http://www.businessinsider.com/blackrock-ceo-larry-fink-letter-to-sp-500-ceos-2016-2.

151. See, for example, Morgan Stanley's creation of its Institute for Sustainable Investing, http://www.morganstanley.com/what-we-do/institute-for-sustainable-investing/. As noted in *DTF 2014*, major United States investment banks such as JPMorgan Chase, Goldman Sachs, and Citigroup have been overlaying their traditional financial analyses of energy companies with extra environmental, social, and governance (ESG) questions covering issues such as well integrity, water, air, community impact, and regulatory compliance. For further detail, see *DTF 2014*, note 120.

152. Glass, Lewis & Co., "Greening the green: Linking executive pay to sustainability", http://www.glasslewis.com/blog/glass-lewis-publishes-greening-green-2014-linking-compensation-sustainability/.

153. See Glass, Lewis & Co., "In-depth: linking compensation to sustainability, updated March 2016", 2016, http://www.glasslewis.com/wp-content/uploads/2016/03/2016-In-Depth-Report-LINKING-COMPENSATION-TO-SUSTAINABILITY.pdf.

Bloomberg data terminals used by the global investment community have experienced a doubling of users of their ESG platform since 2014. As of early 2014, $6.6 trillion, or approximately 15 percent of U.S. assets under professional management were invested according to a sustainability mandate, and in Europe, 61 percent of institutional funds have some form of environmental or social mandate.[154]

Importantly, S&P Global Ratings, the world's leading provider of independent credit risk research, has proposed a new ESG assessment framework for issuers of corporate debt.[155] The goal is to assess sustainability risks over the medium- to long-term. The tool aims to rank debt issuers on a five-point scale based on an issuer's exposure to ESG risk factors over a two- to five-year horizon and beyond. The tool assesses a company's environmental and social impact, its governance mechanisms, and potential losses from exposure to ESG risks. More specifically, the tool incorporates greenhouse gas, water, waste, and community impact issues, and looks back over 10 years at a company's history of environmental and social risk mitigation, allowing comparison of that record to industry peers' records.[156]

IMAGE: Bill Hughes, OVEC/ohvec.org

Pipeline Construction Impacts

It is within this context that investors are seeking disclosures demonstrating that companies have systems in place to address these important issues. Approximately half of the companies in *Disclosing the Facts 2015* report that they link senior management compensation to health, safety, and environment (HSE). However, in virtually all instances, the indicators used relate to the number of spill incidents, spill volumes, and worker injuries. To encourage companies to look beyond these few indicators, a new question in 2016 asks whether senior management compensation is linked to additional environmental indicators, such as reductions in greenhouse gas emissions or freshwater use.

The *DTF 2016* scorecard asks whether policies are in place to assure that CEOs and corporate boards of directors are receiving regular, appropriate accounting from senior managers about the extent to which the company's policies and practices align with best practices. Policies and systems for reducing risk should include metrics to track impacts, incentives for good performance on health, environment, and safety goals, and tracking of regulatory compliance.

Complementing internal accountability systems, independent third-party assessments of company practices provide both boards and investors with a relatively high level of assurance that companies are in fact implementing their stated policies and programs. Third-party assessors can play an important role in evaluating implementation of policies in the field and qualifying the contractors who perform most of the jobs servicing well sites, both on the pad itself and in the transportation of materials to and from the site. At the end of the day, it is the operating company that hires the contractors and holds land leases that is responsible for use of best practices, avoidance of fines and penalties, and avoidance of health and environmental impacts. Contractor accountability is therefore a critical component of risk management.

Fines and regulatory notices of violation (NOVs), including their number and frequency, are also important indicators of the quality of company oversight and operational management. They can reveal, for example, patterns of

154. CDP, "CDP climate change report 2015: The mainstreaming of low-carbon on Wall Street", 2015, p. 8 and p. 10, https://www.cdp.net/en/reports/downloads/783.

155. S&P Global Ratings, "New green bond and ESG evaluation tools proposed by S&P global ratings", 2016, http://www.prnewswire.com/news-releases/new-green-bond-and-esg-evaluation-tools-proposed-by-sp-global-ratings-300324419.html.

156. S&P Global Ratings, "Proposal for environmental, social and governance (ESG) assessments", 2016, https://www.globalcreditportal.com/ratingsdirect/renderArticle.do?articleId=1705169&SctArtId=399709&from=CM&nsl_code=LIME&sourceObjectId=9783018&sourceRevId=2&fee_ind=N&exp_date=20260906-19:11:59.

equipment failures, contractor errors, reporting failures, and environmental contamination. They further provide insight into a company's continual improvement processes or lack thereof.

The scorecard asks whether companies employ third-party independent auditing of HSE functions for operations; rely on third-party databases for information to evaluate potential contractors before hire; disclose the number of NOVs or equivalent administrative actions and number and amount of fines assessed related to operations; and report changes, if any, in the number of NOVs received year over year.[157]

MANAGEMENT & ACCOUNTABILITY

COMPANY	Senior Management Pay Tied to HES	Senior Pay Link to Other HES Indicators	3rd Party Audit for HES	3rd Party Info Used for Contractor Hiring	NOVs and Fines	NOV Trends	TOTAL
CONSOL	✓	✓	✓	✓	✓	✓	6
BHP Billiton	✓	✓		✓	✓	✓	5
EQT	✓		✓	✓	✓		4
Noble Energy	✓		✓	✓	✓		4
Shell	✓	✓	✓	✓			4
Newfield Resources	✓		✓	✓			3
Anadarko	✓			✓			2
Apache	✓			✓			2
Cabot			✓	✓			2
Carrizo			✓	✓			2
Chesapeake	✓			✓			2
Chevron	✓		✓				2
ConocoPhillips	✓			✓			2
Encana	✓			✓			2
Hess Energy	✓			✓			2
QEP	✓			✓			2
Southwestern Energy	✓			✓			2
Antero	✓						1
BP	✓						1
Devon	✓						1
ExxonMobil	✓						1
Occidental Petroleum	✓						1
Pioneer	✓						1
Range Resources				✓			1
Whting Oil & Gas				✓			1
WPX	✓						1
Continental Resources							0
EOG							0

Scores

- Twenty-two (22) companies report that they provide compensation and incentive packages for senior management linked to HSE and social impact performance.

157. See *DTF 2014*, pp. 38-40. In Pennsylvania, violations at unconventional wells have decreased over the last several years, even as inspections have increased. See "Shale gas violations down as DEP steps up inspections", *Pittsburgh Tribune-Review*, 2015, http://triblive.com/business/headlines/8942973-74/shale-wells-conventional#axzz3kbUUF7Kx. For a capsule listing of the many ways this trend can be explained, see Samantha Malone Rubright, "What can violations data tell us?" FrackTracker Alliance Blog, 2015, http://www.fractracker.org/2015/03/violations-data/. For a review of regulators' disclosure and nondisclosure practices for violations and an assessment of companies in those three states where violation information is readily available, see Natural Resources Defense Council and FracTracker Alliance, "Fracking's most wanted: lifting the veil on oil and gas company spills and violations", 2015, http://www.nrdc.org/land/drilling/files/fracking-company-violations-IP.pdf.

- Three (3) companies—*BHP Billiton*, *CONSOL*, *Shell*—report they provide compensation and incentive packages for senior management linked to HSE performance on metrics other than spills and worker injuries.
- Eight (8) companies report requiring third-party independent auditing of HSE operations.
- Eighteen (18) companies report relying on third-party databases for information to evaluate potential contractors before hire.
- Four (4) companies—*BHP Billiton*, *CONSOL*, *EQT*, *Noble Energy*—disclose, on a play-by-play basis, NOVs received and numbers and amounts of fines assessed.
- Two (2) companies—*BHP Billiton* and *CONSOL*—report, on a play-by-play basis, changes, if any, in the numbers of NOVs received compared to the prior year.

Notable Practices

- *EQT* received certification of its risk management practices in the Appalachian Basin based on independent third-party audits, joining *CONSOL Energy*, *Shell*, and *Chevron*, which had previously done so.[158] The audits are based on standards established by the Center for Responsible Shale Development (formerly the Center for Sustainable Shale Development or CSSD). As discussed in greater detail in *DTF 2014*, CSSD was founded by a consortium of companies, foundations, and environmental groups to develop third-party certification standards.[159] CSSD developed 15 performance standards for shale operations in the Appalachian Basin, which includes the Marcellus, Utica, and other shales, and recruited an independent auditing firm to assess company performance against the 15 standards. The CSSD standards include a sizeable number of practices highlighted in this scorecard, such as using recycled waters; employing closed-loop systems for drilling waste and flowback water management; identifying and addressing risks from offset wells and faults; conducting pre- and post-drilling groundwater monitoring; avoiding use of diesel fuel in fracturing fluids; using green completions where technically feasible; using low-bleed pneumatic controllers; and conducting inspections and maintenance on a regular basis. The CSSD has had to deal with skeptics at companies, which see it as a forerunner of regulation, and environmental groups, which seek stronger standards.
- *CONSOL* has introduced key performance indicators (KPIs) into its agreements with contractors designed to evaluate safety, compliance, and continuous improvement. The company conducts monthly contractor performance reviews.[160]
- *CONSOL* discloses assessed fines and penalties in its CDP water report and continues to publicly disclose in its sustainability report notices of violations received annually by each of its business segments. The company also links executive compensation to the number of violations incurred. The company reported a 50 percent increase in violations in 2015. (Most violations relate to on-site spills.) CONSOL has since been taking actions to reduce spills at its active sites, though it continues to see an increase in the number of violations incurred at unmanned/producing sites. The company found most releases originated from on-site tanks, and reports that the releases were contained. The company self-reports releases to regulators, who in turn issue NOVs.[161]

158. The audits are conducted by Bureau Veritas, a well-known global risk management firm. See Center for Sustainable Shale Development, "Initial Certification Audit Report Summary: EQT Production Company", 2016, http://www.responsibleshaledevelopment.org/wp-content/uploads/2016/09/EQT-Initial.pdf; Center for Sustainable Shale Development, "Initial Certification Audit Report Summary: CONSOL Energy Inc.", 2016, http://crsd.wpengine.com/wp-content/uploads/2016/09/CONSOL-Assurance.pdf; Center for Sustainable Shale Development, "Initial Certification Audit Report Summary: Shell", 2016, http://www.responsibleshaledevelopment.org/wp-content/uploads/2016/09/Shell-Assurance.pdf, and Center for Sustainable Shale Development, "Initial Certification Audit Report Summary: Chevron", 2016, http://www.responsibleshaledevelopment.org/wp-content/uploads/2016/09/Chevron-Initial.pdf. Since all of EQT's and CONSOL's operations are in plays in the basin, on the scorecard they receive credit for all those practices for which play-by-play reporting is required. Even though Shell and Chevron participate in the CSSD, not all of their plays lie within the Appalachian basin, thus Shell and Chevron do not receive automatic scorecard credit on those practices for which play-by-play reporting is required. Chevron remains substantially silent on its operations in Texas, where in 2015, according to FracFocus, the company completed nearly three times as many wells as it completed in the Appalachian Basin's Marcellus Shale.

159. *DTF 2014*, p. 38.

160. CONSOL Energy, "2015 Corporate Responsibility Report", p. 39 and p. 66, http://2015crr.consolenergy.com/.

161. CONSOL Energy, "2015 Corporate Responsibility Report", p. 39, http://2015crr.consolenergy.com/. Also see p. 36 of CONSOL's 2016 proxy statement: http://phx.corporate-ir.net/phoenix.zhtml?c=66439&p=irol-SECText&TEXT=aHR0cDovL2FwaS50ZW5rd2l6YXJkLmNvbS9maWxpbmcueG1sP2lwYWdlPTEwODUxNTE4JkRTRVE9MCZTRVE9MCZTUURFU0M9U0VDVElPTl9FTlRJUkUmc3Vic2lkPTU3. To be credited in the *DTF 2016* scorecard for disclosures in a CDP report, the CDP report must be posted on a company's own website for easy access.

Progress and Prospects

Third-party auditing and certification provide investors with enhanced assurance that company policies and best current practices are being implemented in the field. Through CSSD certification, the four founding companies of the CSSD have secured third-party audits of a number of their systems. *Chevron's* certification led to substantially increased disclosures about its Marcellus Shale operations. Though certification is viewed with suspicion by some environmental activists and some companies may fear the CSSD to be a forerunner of regulation, companies operating in the Appalachian Basin may be well-served by seeking this third-party certification. Companies operating in other areas might explore with stakeholders the creation of similar third-party auditing and certification schemes.

Although the current depressed financial state of the industry may discourage companies from incurring the expense associated with securing certification or third-party audits, investors believe the short-term costs are outweighed by the benefits of ensuring safe and efficient operations, especially because contractors and companies under pressure to slash costs may be tempted to cut health, safety, or environmental corners.

More companies should follow the example of *CONSOL* and *BHP Billiton* in reporting details of NOVs received and their resolution. Since regulatory agencies generally do not provide easy access to compliance records, companies that fill this void demonstrate a willingness to be publicly accountable for compliance.

APPENDIX A: SCORECARD QUESTIONS*

* *Italicized questions marked with an asterisk are new in 2016.*

Toxic Chemicals

1. Does the company provide quantitative reporting on progress in reducing the toxicity of hydraulic fracturing fluids, including information indicating a baseline year for calculations?

2. **Does the company state a practice to use dry fracking chemicals in place of liquid chemicals wherever feasible to reduce risk?*

3. Does the company state a practice to not use diesel fuels, as defined by EPA, in hydraulic fracturing fluids?

4. Does the company state a practice to not use BTEX in hydraulic fracturing fluids?

5. Does the company clearly state on its website that FracFocus and/(or its own reporting) may exclude chemicals protected by claims of confidential business information (CBI)?

6. **Does the company state measures it and/or its third party contractors, take to reduce CBI claims for chemicals used in its hydraulic fracturing operations?*

Water Management: sourcing, well integrity, waste management, and monitoring

1. Does the company describe under what circumstances it uses cement evaluation logs, or temperature, acoustic, or ultrasonic measures to assess well integrity e.g., for some or every new or refractured well, when entering new plays, and/or addressing well integrity anomalies?

2. **Does the company report the percentage of its well integrity failures that result in a release to the environment?*

3. Does the company report steps it takes, when planning to drill and complete new wells, to minimize the risk that nearby offset oil and gas wells (both active and inactive) and faults and fractures will provide pathways for fracturing fluids, hydrocarbons, and other contaminants to enter the environment, including the atmosphere or surface or ground water?

4. For each play, does the company state the practices it uses, or requires of its third party contractors, when planning completion of new production wells, drilling and operating its own deep disposal wells, or disposing of wastewater, to avoid seismic activity that can be felt at the surface?

5. For each play, does the company disclose whether it assesses groundwater quality before it drills?

6. For each play does the company disclose whether it routinely assesses groundwater quality after it drills?

7. For each play does the company disclose the percentage of produced and/or flowback water from wells that is reused for subsequent well completions?

8. For each play does the company report the aggregate quantity of water used for operations?

9. For each play, for the quantity of water reported in response to the question immediately above, does the company report the share of water sourced from various types (e.g., x% potable, x% non-potable, x% groundwater, x% surface water, x% municipal, x% water recycled from operations or other forms of recycled water, or other such categories.)?

10. Does the company state its practices for how and when it uses non potable water in its operations?

11. **Does the company report whether it operates in water-scarce areas (and how this is determined) and its program or practices for limiting or reducing water in water-scarce areas it identifies?*

12. For each play does the company report the intensity of its water use—the amount of water required to produce measurable units of energy (e.g., gallons/million BTU [MMBTU] on an annual basis)?

13. For each play, does the company state whether it uses tanks and/or open impoundments to store produced water; its criteria for such selection(s); and steps it takes to reduce spills, leaks, volatile emissions, and hazards to wildlife?

14. For each play does the company report whether it routinely uses closed loop systems for management of drilling residuals containing oily wastes or other toxic or hazardous materials?

15. Does the company report its practices for identifying and managing the hazards from naturally occurring radioactive materials (NORMs), including both contaminated equipment and contaminated wastewater, and for tracking its own and its contractors' management of such wastes?

Air Emissions

1. For each play does the company report the methods it uses to reduce air pollution associated with powering well pad operations, e.g., solar, natural gas, low emission diesel engines, solid state generators, micro-grids, or other emission reduction methods?

2. Does the company report the percentage of its vehicle fleet converted to lower emission fuels, including CNG, electricity, or other non- petroleum-based fuels?

3. **For each play, does the company report the voluntary practices it takes, in addition to those practices required by law, other than reduced truck use and fuel substitutions for engines, to reduce air pollution emissions to the atmosphere from its drilling, completions, and production operations?*

4. For each play, does the company report whether it substitutes pipelines for trucks to transport water or wastewater, including, e.g., criteria for making this choice, percentages of water/wastewater transported by pipeline, or individual examples of operating or under construction pipeline systems?

5. Does the company report the percentage emissions rate for methane from its drilling, completion, and production operations, measured as methane emissions per methane production on an annual basis?

6. Does the company report the percentage or number of high-bleed controllers replaced with low-emission alternatives, or a program for their replacement?

7. Does the company describe the practices through which methane leak detection and repair, or other leak detection methods, are conducted, including descriptions and proportions of facilities assessed, and methodologies employed?

8. Does the company report, for each of the facility categories described above, the frequency of leak detection and repair efforts?

9. Does the company disclose an active methane emissions reduction target and progress toward achieving this target?

10. Does the company disclose an active greenhouse gas emissions reduction target and progress toward achieving this target?

Community Impacts

1. For each play does the company describe major identified community concerns and the company's response or actions to resolve such concerns?

2. Does the company disclose its internal processes, including data systems, for capturing and addressing local concerns before, and after, the drilling process begins?

3. Does the company disclose its internal processes for reporting local concerns and response data upward within the company?

4. Does the company disclose a practice to adjust activity schedules to prevent or reduce traffic congestion from operations?

5. **To reduce risks of accidents, and to ensure compliance with designated routes, does the company describe driver training and/or tracking methods for its own employees and third party contractors?*

6. **Does the company describe routine measures to minimize light, noise, and odor pollution from its drilling completion, and production operations?*

Management and Accountability

1. Does the company report it provides compensation and incentive packages linked to Health, Safety, Environmental, or social impact performance, in the proxy statement?

2. **In the proxy statement, does the company link management compensation to environmental indicators other than spills, e.g., methane/GHG reductions, increased water efficiency, etc.?*

3. Does the company require third party independent auditing of Health, Safety, and Environmental operations, other than verification of data in CSR reports?

4. Does the company use third party databases, such as ISNetworld, or others providing equivalent information, to obtain information to evaluate potential contractors before hire?

5. For each play does the company disclose notices of violation numbers (or equivalent administrative actions) and numbers and amounts of fines related to its operations?

6. For each play does the company report reductions, if any, in numbers of notices of violations received over the past year?

APPENDIX B: METHODOLOGY

Scorecard Goals

Disclosing the Facts 2016 has three goals: (1) assess the overall state of industry disclosure; (2) identify those issues about which most disclosures are made; and (3) distinguish industry leaders from laggards with regard to disclosure.

Company Selection

The scorecard reports on 28 publicly traded companies producing shale gas and oil in the United States and Canada. Twenty-seven (27) of 30 companies were carried over from the second edition of this scorecard based on their gas production and their prominent position in major shale plays. For the 2016 edition, Antero Resources, one of the most active drilling/completing companies in the Marcellus Shale, was added.

Geographic Coverage

The scorecard addresses onshore operations in the United States and Canada.

Chronological Coverage

The scorecard addresses reporting on specific, identified metrics principally from October 1, 2015 to October 21, 2016, while also accounting selectively for disclosures in prior years.

Indicator Selection

Indicators are both qualitative and quantitative. The goal was to select indicators that would enable clear "yes/no" answers, with minimal interpretation required by participating companies. This fourth edition of the scorecard contains 43 indicators, reflecting additions and deletions from the prior edition.

Company Scoring

Each company was scored based solely on documents and information available through its public website, including SEC proxy and annual report filings, climate change and water management reports submitted to CDP and posted directly on the company website, and sustainability/social responsibility reports. Companies were scored independently by two or more project staff. Companies received a copy of the questions on which they were scored, the corporate disclosures found pertinent to the questions, and their draft scores. Companies were given an opportunity to provide feedback on the accuracy of the scorecard information compiled and to update their public disclosures. Final scoring was based on staff reviews of corporate disclosures published on company websites by October 21, 2016.

The report text cites examples of exemplary disclosures by numerous companies even where particular disclosures did not earn credit on the scorecard. Some low-scoring companies may in fact be broadly implementing best management practices to manage and reduce risks, but absent the play-by-play disclosures sought by the scorecard, investors and communities remain unaware of these activities.

Play-by-play Reporting

The scorecard emphasizes play-by-play reporting. Such reporting is critical to understanding corporate risk management because most impacts of concern are regional and local. Atmospheric, geological, demographic, and other pertinent characteristics vary greatly among plays. We emphasize plays as the appropriate unit of analysis, but this term is not intended for literal use; rather, it is intended as a proxy for appropriate regional reporting. For example, plays can comprise thousands of square miles and conditions can vary dramatically within plays. Furthermore, shale and other formations accessed by horizontal drilling and hydraulic fracturing can be stacked on top of one another, such as in the Appalachian Basin in Pennsylvania and the Permian Basin of West Texas.

NOTES

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