

Overview of US Environmental Regulations pertaining to air quality; Implementation and Impact on the Environment and Industry

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Abstract

This will be a comprehensive outline of most government and industrial-led programs, laws, and/or best management practices as it pertains to air quality, methane, and other related environmental concerns. Also to be explored are the impacts and implementations thereof.

Substances for discussion are in the following categories: greenhouse gases, air toxics, volatile organic substances (VOCs) and nitrogen oxides (NOx). Along with a brief discussion on wet vs. dry gas and its implications on air quality. Technologies like 'extended reach drilling' will be explored as one of the best technological advances and it will be looked at from a gas emissions perspective. Other technological advances to help in this regard include synthetic mats to help with traffic movement from already established roads. Government led programs include Greenhouse Gas Reporting Program (GHGRP), New Source Review (NSR) Permits, New Source Performance Standards (NSPS), and National Emission Standards for Hazardous Air Pollutants (NESHAPs) Regulations. Voluntary Best Management Practices include The Environmental Partnership, Natural Gas Star Methane Challenge Program, and The Sustainability Accounting Standards Board (SASB). Other more generalized Best Management Practices (BMPs) will be discussed as well. Case studies will include a gas storage leak and the changes that occurred. Another case study will involve a summary of the Natural Gas Council report.

A comprehensive review of US legislation and voluntary practices that involve air quality. Looking at both government entities and industrial practices including procedures and technology.

Discussion will outline different means used to cut back on methane emissions and other substances that effect air quality. First, a brief discussion on different substances are outlined and why they are a cause for concern. Then a quick overview of government led programs that focus on or effect air quality. Then industry led BMPs will be discussed. This discussion will include technological and procedural advances. A few case histories within the United States involving greenhouse gases will be explored.

Introduction

Shale oil and gas is one several forms of "unconventional oil and gas" which includes oil shale, heavy oil, coalbed methane, tight gas, and methane hydrates. Shale oil and gas is trapped within shale formations, fine-grained sedimentary rock, that serve as both its source and reservoir. Formerly, the cost of extracting this oil and gas from the shale made it uneconomical to produce, so the nation relied instead primarily on conventional oil and gas. However, technological advancements in horizontal drilling and hydraulic fracturing over the past decade have improved the economics of developing unconventional reservoirs, particularly from tight shale.

The following is an outline and description on the different legislation drafted and how industry has responded in regards to technological advancements and procedures with particular focus on air quality.

Chemicals of Concern Greenhouse Gases

As detailed on the EPA website (EPA, n.d.), the main gases of concern are carbon dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), and Fluorinated gases. All of these have the characteristic of trapping heat into the Earth's atmosphere. The basic process is all radiation from the sun comes into the atmosphere but certain chemicals keep the radiation from escaping into space where, through a multitude of processes, eventually, turns into heat (**Figure 1**).

Air Toxics

The Environmental Protection Agency (EPA) defines air toxics as "[h]azardous air pollutants...known to cause cancer and other serious health impacts" (EPA n.d.). The list of known compounds may be found on the EPA's Air Toxics Website (ATW) (EPA 1990). For simplicity's sake the compounds will be cited here in their respective categories from the "2014 NATA (National Air Toxics Assessment) TSD" (EPA 2018), **Table 1** (2-2 in original publication) Pollutant Groups (PAHPOM stands for polycyclic aromatic hydrocarbons-polycyclic organic matter).

Volatile Organic Compounds (VOCs) and Oxides of Nitrogen (NOx)

Volatile Organic Compounds are substances that readily turn into gas and disperse into the surrounding air. According to the National Library of Medicine, VOCs are found in two categories: consumer products and the air (NIH NLM n.d.). People are usually exposed to them in 2-ways: breathing and contact on the skin (NIH NLM n.d.). Besides initial acute and chronic reactions on an individual level, the broader problem with VOCs is they combine with NOx compounds to form ozone. NOx, with particular concern on NO₂, is mainly produced from vehicle exhaust and other equipment that burns fossil fuels.

Dry vs. Wet Gas

Dry gas is primarily methane so that it is more ‘gas-like’ with very little ability to condense at normal ambient temperatures, whereas wet gas can have more complex organics like butane and propane. This can make it more like condensate and thus needs more processing (Weaver 2019).

Particularly important is whether the natural gas extracted is “dry” or “wet” see **Figure 2** (Weaver 2019). **Figure 3** shows dry shale gas production, by play (EIA 2019). “Dry” gas contains mostly methane, while “wet” gas is associated with higher production rates of natural gas liquids (NGLs), including ethane, propane and butane.

Discussion

The exploration and production of oil and gas, as well as downstream processing, distribution and use of hydrocarbon resources, results in emissions of greenhouse gases, air toxics, volatile organic compounds (VOCs) and nitrogen oxides (NOx). The Academy of Medicine, Engineering and Science of Texas (TAMEST) reported that emission sources affiliated with resource production “are diverse, have complex behavior, and are distributed across a large number of individual sites” (TAMEST 2017). These emission sources may be continuous or intermittent. Exceptional events such as equipment failure may also result in temporary emission increases.

Methane, a potent greenhouse gas, is the primary component of natural gas and can be emitted at several points throughout the production-processing-distribution (i.e. supply) chain. Due to local variances in production density and types of equipment, it is difficult to quantify specific impacts. The TAMEST study points out that even though the primary market mission is to produce oil, numerous wells co-produce gas. Further, the study notes that regions such as the Denver-Julesburg in Colorado that produce large amounts of oil relative to natural gas are inclined to have higher methane emissions per volume of gas produced compared to the regions that don’t produce oil with natural gas (i.e. the Marcellus Shale in Northeast Pennsylvania) (TAMEST 2017).

Emissions of VOCs and NOx are of particular concern because they are known precursors of ground level ozone and particulate matter, both of which are listed as criteria air pollutants by the EPA and have been documented as harmful to “sensitive” populations such as children, the elderly, and those

with chronic respiratory conditions (EPA n.d.). With regard to air toxics, the TAMEST study notes, “Air toxic concentrations in production regions would be expected to vary, depending on the amount and composition of the oil produced at individual sites and the activities underway at the sites” (TAMEST 2017). The report summarizes with, “Overall, there is a general lack of information on the spatial distributions of air toxic concentrations in oil and gas production regions.”

Concerns with Silica

In field studies, the National Institute for Occupational Safety and Health (NIOSH) discovered that oil and gas workers may be exposed to high levels of “respirable crystalline silica” during hydraulic fracturing. This silica dust is a major component of the sand used in the hydraulic fracturing process. The moving and transport of sand prior to blending with fracturing fluids produces dust and releases the silica into the air. Inhalation of the silica dust can result in silicosis where lung tissue reacts to the particles and can reduce oxygen intake. NIOSH recommends monitoring and protective equipment to reduce impacts (OSHA 2012).

Extended Reach Drilling

Extended reach drilling and associated technologies have contributed to the reduction of the environmental footprint by allowing multiple wells to be located on a single pad. This reduction of the environmental footprint goes beyond the surface footprint to include reduced truck traffic, noise, and air emissions. A multi-well plan also simplifies the midstream infrastructure and operational requirements, lowering the amount of surface disturbance associated with the production (NPC 2011), (Thuot 2014).

Pertinent Government-Led Programs

Greenhouse Gas Reporting Program (GHGRP) (40 CFR 98)(EPA n.d.)

Each owner or operator of onshore petroleum and natural gas production wells and related equipment reports under Subpart W the combined emissions for all wells that they own or operate within each hydrocarbon basin. Emissions from stationary and portable fuel combustion equipment are reported under Subpart W of the GHGRP.

National Ambient Air Quality Standards (NAAQS) (40 CFR 50) (EPA n.d.)

Regulations issued by the EPA establishing primary and secondary NAAQS that define levels of air quality necessary to protect public health and welfare.

New Source Performance Standards (NSPS) (40 CFR 60) (EPA n.d.)

Regulations issued by the EPA establishing air pollution emission standards for new stationary sources of emissions. NSPS have been established for a number of individual categories related to energy development, including oil and gas production facilities, onshore natural gas-processing plants,

petroleum refineries, bulk gasoline terminals, petroleum liquid storage vessels, coal preparation plants, and steam generators. EPA updated the rule in 2016 to curb emissions of methane, VOCs, and air toxics. In the Fall of 2019, they made amendments to the policy (Regulations.gov 2019).

National Emission Standards for Hazardous Air Pollutants (NESHAPs) Regulations (40 CFR 63)(EPA n.d.)

Regulations issued by the EPA governing emissions of hazardous air pollutants (HAPs), or air toxics, not covered by the NAAQS. Standards have been established for a number of "source categories" that emit one or more of the HAPs in significant quantities, including some categories that may be related to energy development activities.

Best Management Practices

A Best Management Practice (BMP) is a method or technique that has consistently shown results superior to those achieved with other means, and that is used as a benchmark. In addition, a "best" practice can evolve to become better as improvements are discovered. It is a term that is used often in the oil and gas industry. But its real application, and how that application is communicated, can have a profound impact on public acceptance of oil and gas projects and processes.

BMPs vary in terms of origin and enforcement. In many cases, industry groups develop BMPs based on the experience of individual companies. Compliance with BMPs is voluntary in this case. In some cases, the regulation mandates industry developed best practices and in other cases they are developed by regulators (usually with industry input).

Below lists some of the issues that have been recognized as BMPs concerning sustainable shale development (EPA n.d.):

- Reduced land disturbance.
- Reduced water use and disposal.
- Reduced atmospheric methane emissions.
- Model well completion and operating practices.
- Use of non-toxic hydraulic fracturing fluids.
- Reduced air-quality impacts.
- Treatment of naturally occurring radiation.
- Collection of pre-drilling and development baseline data.
- Efficient incident response capability.
- Robust public engagement.

An example of a mandatory BMP is the Bureau of Land Management's (BLM) Oil and Gas Gold Book, which contains the surface operator standards and guidelines for oil and gas exploration and development on BLM managed lands (BLM 2007).

CRSD

An example of voluntary BMP is the Center for Responsible Shale Development (CRSD) standards (CRSD n.d.). The organization consists of energy companies, environmental organizations and philanthropic organizations that have

organized a center for the certification of performance standards for shale development. CRSD established 15 initial performance standards that are designed to "ensure safe and environmentally responsible development of the Appalachian Basin's abundant shale gas resources."

The CRSD participants established "a shared vision of performance and environmental risk minimization for natural gas development" in the Marcellus Shale play. The standards established initially focus on air and water quality and climate, but will be expanded in the future to focus on topics such as safety and health. The CRSD participants see the standards as being a strong complement to the existing strong regulatory frameworks.

Air and climate protection and surface and groundwater protection performance standards include:

Air and Climate Protection

- Limitations on Flaring
- Use of Green Completions/Reduced Emissions
- Reduced Engine Emissions
- Emissions Controls on Storage Tanks

Surface and Groundwater Protection

- Maximizing Water Recycling
- Development of Groundwater Protection Plans
- Closed Loop Drilling
- Well Casing Design
- Groundwater Monitoring
- Wastewater Disposal
- Impoundment Integrity
- Chemical Disclosure

The Environmental Partnership

Another example of voluntary BMPs is The Environmental Partnership, an American Petroleum Institute (API)-led (combined with many companies) effort that have committed to reducing methane emissions by:

- Implementing leak monitoring using the latest detection methods (using Optical Gas Imaging/Forward Looking Infrared OGI/FLIR cameras)
- Replacing or retrofitting highly emitting pneumatic controllers; and
- Attempting to minimize emissions from manual liquids unloading for gas production sources (The Environmental Partnership n.d.)

Natural Gas Star Methane Challenge

EPA's Natural Gas Star Methane Challenge Program is another voluntary methane emissions reduction program managed by EPA with over 40 industry participants (EPA n.d.)

SASB

The Sustainability Accounting Standards Board (SASB) is an independent, private-sector standards setting organization based in San Francisco, California dedicated to enhancing the efficiency of the capital markets by fostering high-quality

disclosure of material sustainability information that meets investor needs.

SASB has developed standards for oil and gas exploration and production that are comprised of disclosure guidance and accounting standards on sustainability topics for use by U.S. and foreign public companies in their annual filings with the U.S. Securities and Exchange Commission (SEC). Topics identified in the SASB guidance include water management, air quality, community relations, biodiversity impacts, security/human rights/rights of indigenous peoples, health/safety, and reserves valuation (SASB n.d.).

Improving Routes to Eliminate Dust

Several service companies offer temporary road mats that are reusable and recyclable rather than lumber which translates to the preservation of over a million of trees (i.e. wooden mats). An added benefit comes from the reduced emissions and road dust associated with transporting mats to/from locations.

Final Thoughts

The oil and gas industry has various BMPs that it can point to and utilize in the shale plays. They include:

- Pad drilling, which reduces land impacts, also saves money by improving rig efficiency and reducing pit construction costs.
- Treating and recycling water used in fracturing which can reduce truck traffic and cuts costs.
- Investments to capture methane emissions during well testing and production that generate additional revenues that far exceed their costs.

Air and Climate Protection

As a past example (the funding for this ended in December of 2019 as this paper is being written the webpage’s information is still viewable), The Intermountain Oil and Gas BMP Project, is a best management practices database managed by the University of Colorado Law School's Getches-Wilkinson Center (Intermountain... 2019). The website addresses BMPs best applied to oil and gas activities in the Rocky Mountain Region, many of which are applicable to (but not limited to) western states shale plays. Issues addressed include Air Quality and Emissions, Aquatic and Riparian Values, Community, Cultural/Historic, Grazing and Agriculture, Human Health and Safety, Land Surface Disturbance, Noise, Soils (Conservation, Pollution, Reclamation), Vegetation, Visual Aesthetics, Water Quality and Pollution, Water Quantity and Rights and Wildlife. It also features a library on oil and gas development issues, links to laws and policy documents and links to workshops and training.

Tables

Table 1 Pollutant Groups (EPA 2018)

Group
Chromium VI (Hexavalent)
Cresol cresylic acid (mixed isomers)
Cyanide compounds
Glycol ethers
Nickel compounds
PAHPOM
Polychlorinated biphenyls (aroclor)
Xylenes (mixed isomers)

Figures

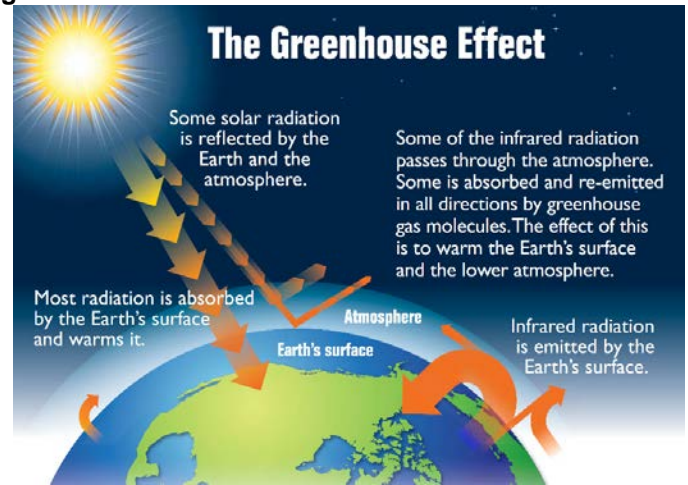


Figure 1 Greenhouse Effect (EPA 2012)

Wet vs. Dry Natural Gas Know the difference What can you do with it?

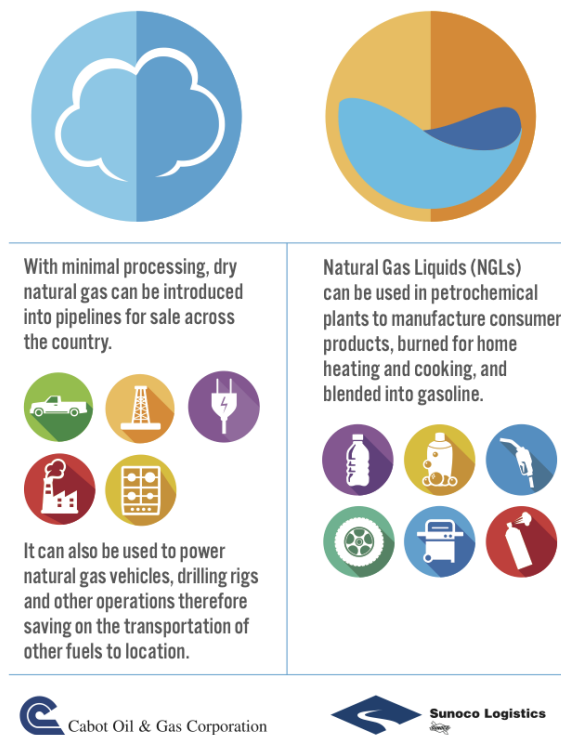
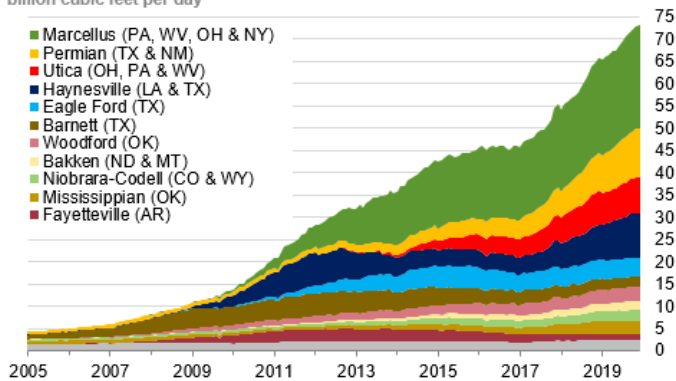


Figure 2 Wet vs Dry Gas (Weaver 2019)

Monthly dry shale gas production

billion cubic feet per day



Sources: EIA derived from state administrative data collected by DrillingInfo Inc. Data are through December 2019 and represent EIA's official tight gas estimates, but are not survey data. State abbreviations indicate primary state(s).



Figure 3 Shale Gas Production per Play (EIA 2019)

Conclusion

Overall, it is probably best that if a person is interested in this subject, they should begin with where in the country they want to focus on first. As is illustrated above, there is a plethora of circumstances to consider and, ideally, each one should be

handled one subject area at a time with a multi-disciplined and experienced team.

Worthy of reemphasis, is the concept of the ‘Social License to Operate’ or the industry’s ‘softer’ interactions with the public and environment (Shipman 2019). Increasingly, oil and gas producers are expected to do more than just meet the criteria required by law in order to receive their permits and other licenses to operate. They are expected to contribute to the communities, societies and ecosystems in which they operate. This involves not just avoiding impacts, but provide offsets and net gains to communities, societies and ecosystems. This planning would involve reaching out and forming authentic relationships to the appropriate local personnel. As an example, perhaps, provide an open, well-advertised town-hall meeting to introduce the company and key-contact individuals if a concern or problem should arise. Also, providing information that educates the public involving typical ground water and well depths as well as the well plans for the casing and cementing (e.g. via website).

Of course, this paper does not cover everything to be considered. For example: one also needs to take in to account the matter of court cases setting precedents on certain matters, these may be accessed at this source (and are not all US oil and gas related) (Wikipedia n.d.). Hopefully, this will serve as a guide for anyone seeking more information centering on the industry with a focus on air quality. This publication sought to cover and define what was inherently obvious for the topic as well as shine light on topics and situations that might have not been known and worthy for deeper consideration. The ongoing debate on what is the appropriate framework for the current industry carries on. It does appear to be the wish and desire of most of those involved (private, government bodies, and oil and gas entities) that the legislation that is produced continue to be fair and reasonable for both the operator and the surrounding environments (natural and human).

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Nomenclature

- ATW=Air Toxics Website
- API=American Petroleum Institute
- BMP=Best Management Practices
- CH₄=Methane

CO₂=Carbon Dioxide
 COGCC=Colorado Oil and Gas Conservation Commission
 CRSD=Center for Responsible shale Development
 EIA=Energy Information Administration
 EPA=Environmental Protection Agency
 GHGRP=Greenhouse Gas Reporting Program
 HAPs=Hazardous air pollutants
 N₂O=Nitrous oxide
 NAAQS=National Ambient Air Quality Standards
 NATA=National Air Toxics Assessment
 NESHAPs=National Emission Standards for Hazardous Air Pollutants
 NGLs=natural gas liquids
 NGO=nongovernmental organizations
 NIH NLM=National Institutes of Health-National Library of Medicine
 NIOSH=National Institute for Occupational Safety and Health
 NO₂=nitrogen dioxide
 NO_x=Oxides of Nitrogen, Nitrogen Oxides
 NPC=National Petroleum Council
 NSR=New Source Review
 NSPS=New Source Performance Standards
 OGI/FLIR=Optical Gas Imaging/Forward Looking Infrared
 OOOO, OOOOa=Quad O, Quad Oa
 OSHA=Occupational Safety and Health Administration
 PAHPOM=polycyclic aromatic hydrocarbons-polycyclic organic matter
 SASB=Sustainability Accounting Standards Board
 SEC=Securities and Exchange Commission
 TAMEST=The Academy of Medicine, Engineering and Science of Texas
 TSD=Technical Support Document
 VOCs=volatile organic compounds

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Appendix - Table on Case Histories

Event	ST	Regulatory Changes/Impacts	Operator Changes/Impacts
Methane Emissions	NA (US)	<p>The U.S. EPA issued three final rules that, together, were intended to curb emissions of methane, smog-forming volatile organic compounds (VOCs) and toxic air pollutants such as benzene from new, reconstructed and modified oil and gas sources, while providing greater certainty about the Clean Air Act. These rules were based on limited data from the EPA and environmental/NGO studies.</p> <p>The rules known as NSPS OOOO and OOOOa (also referred to as 'Quad Oa') amended 40 CFR 60 Subpart OOOO (ECFR 2016) in August 2016 and were challenged by the oil and gas industry as unnecessary and over-reaching. In 2018, the rules were updated due to industry feedback and maybe reviewed per the reference (EPA 2016)</p>	<p>In April 2016, a publication prepared for the Natural Gas Council (NGC 2016) examined studies related to methane emissions.</p> <p>The appendix of the report mentioned above summarizes 75 studies from myriad organizations within and outside of industry. The report finds that, overall, industry has and continues to reduce methane emissions through voluntary actions as well as existing regulations.</p>
Aliso Canyon (Gas storage leak) Midstream	CA	<p>A gas company in California, owned/operated the well that leaked approximately 100,000 metric tons of methane over four months in October, 2015 to February, 2016.</p> <p>The final investigation into the root cause has not been published, however poor operator practices and a breakdown in regulatory oversight have been identified.</p> <p>Congress passed the Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act in June, 2016. This act created an interagency task force led by the U.S. Secretary of Energy.</p> <p>In the California legislature, Senate Bill 380 placed a moratorium on new gas injections and Senate Bill 887 established new safety standards for and rigorous inspections/monitoring of natural gas storage wells across California.</p>	<p>The gas company was ordered to close this well permanently and enact processes to prevent further leaks. They were also required to temporarily cease injection of gas at the Aliso Canyon reservoir, monitor field for further leaks, develop a community alert system and fund a public health study. Estimated costs as of Feb, 2018 are ~\$1 Billion. In May 2019, investigators reported that groundwater corroded the metal lining of the well that led to a rupture at about 900' below ground.</p> <p>California is now promulgating new regulations and has hired and trained new inspectors for all oil and gas activities.</p> <p>The other states under the umbrella of the State's First Initiative assembled a group of state regulators and subject matter experts to develop a guide book on underground gas storage (States First 2017). This 'Primer' was a direct result of the Aliso Canyon event. It included studies of prior gas storage events. State regulators have since utilized this information to strengthen their regulations and practices. The body of work also provides the public with a good understanding of gas storage safety as well as associated risks. These recommendations go beyond API recommended practices on gas storage (API RP 1170 and 1171).</p> <p>This report and subsequent state actions are</p>

			also reactive to Federal Legislation passed in 2015 on pipeline safety which is administered by the Pipeline Hazardous and Materials Safety Administration (PHMSA n.d.).
Firestone (Pipeline explosion) Midstream	CO	<p>Colorado proposed comprehensive regulatory changes to safety rules and practices governing gas wells and pipelines (COGCC 2018). Beginning May 1, 2018, companies are required to:</p> <ol style="list-style-type: none"> 1. Perform routine tests on smaller flowlines (previously unrequired). 2. File a new Form 44 with information about locations of flowlines. 3. File more specific geodatabase information with flowline locations with the COGCC. <p>COGCC also issued rules to:</p> <ul style="list-style-type: none"> • increase distances between drilling and neighborhoods; • reduce the effects of light, noise and odors; • protect groundwater; • reduce air emissions in partnership with the Colorado Department of Public Health and Environment; • disclose hydraulic fracturing chemicals; • tighten requirements for spill reporting; • significantly elevate penalties for operators violating Commission rules; • toughen requirements for operating in floodplains; and • amplify the role of local governments in siting large operations near communities. 	Operators disputed the publication of specific mapping of flowlines stating that sharing such information may cause public safety issues. After negotiations with regulators, the decision was made to only allow local governments access.