Unconventional Resources Development
– Managing the Risks –

Exxon Mobil Corporation
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Unconventional Resources Development – Managing the Risks

Executive Summary

The following report to ExxonMobil shareholders outlines how the company assesses and manages risks associated with developing unconventional resources including through hydraulic fracturing – a process that's been safely used by the oil and gas industry for more than 60 years. ExxonMobil – in everything it does – follows a rigorous and disciplined process to ensure safety, security, health and environmental performance.

The revolution involving unconventional natural gas and oil development in the United States has resulted in widespread economic benefits, including significant job creation, lower energy costs, new sources of government revenue, and improved energy security. This report highlights numerous studies that support these trends.

Unconventional natural gas development has also brought about a substantial reduction in greenhouse gas emissions, which are at the lowest levels in the U.S since 1994. Studies by the U.S. Department of Energy, Energy Information Administration and Environmental Protection Agency and academics have shown greenhouse gas emissions of unconventional gas to be about 50 percent less than those for coal on a full lifecycle basis.

This report presents information on how these significant benefits have been achieved, and can continue to be achieved, through the application of sound risk management practices that protect human health and the environment.

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Introduction

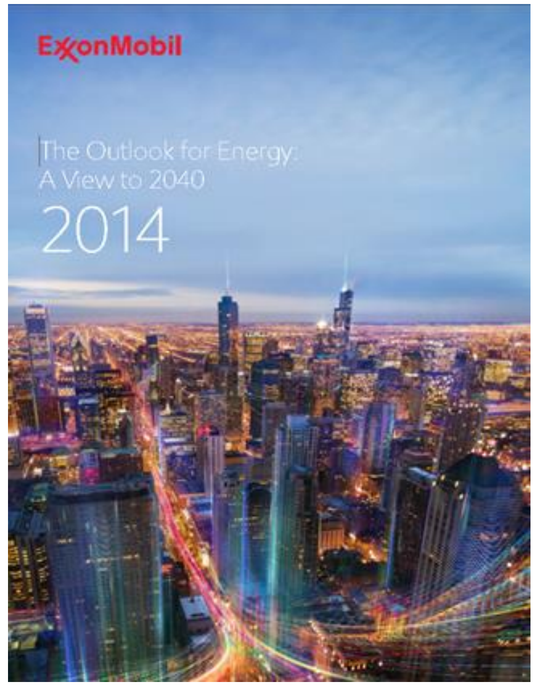
ExxonMobil[1] engages in constructive dialogue with a wide range of stakeholders on a number of energy-related topics. The purpose of this report is to address important questions raised by a number of stakeholder organizations on topics surrounding unconventional resources development. The report discusses how we manage or mitigate the risks associated with developing these resources.

The term "unconventional resources" refers to natural gas and oil found in shale and tight sand formations, as well as coal bed methane, as explained in more detail below. These resources have been known to exist for some time and their production has become increasingly economically viable over the past decade through the industry's continuous technological advancements based upon the combination of horizontal drilling and hydraulic fracturing (the industry has been using hydraulic fracturing for more than six decades). While ExxonMobil has unconventional resources development operations throughout the world, this discussion primarily focuses on ExxonMobil subsidiary XTO Energy Inc. (XTO) and its unconventional resources development activities in the United States.

Unconventional resources have been discussed in ExxonMobil's annual *Outlook for Energy* report and *Corporate Citizenship Report*.

[1] As used in this document, "ExxonMobil" means Exxon Mobil Corporation and/or one or more of its affiliated companies. Statements of future events or conditions in this report are forward-looking statements. Actual future results, including economic conditions and growth rates; energy demand and supply sources; efficiency gains; and capital expenditures, could differ materially due to factors including technological developments; changes in law or regulation; the development of new supply sources; demographic changes; and other factors discussed herein and under the heading "Factors Affecting Future Results" in the Investors section of our website at: www.exxonmobil.com. The information provided includes ExxonMobil's internal estimates and forecasts based upon internal data and analyses, as well as publicly available information from external sources including the International Energy Agency. Citations in this document are used for purposes of illustration and reference only and any citation to outside sources does not necessarily mean that ExxonMobil endorses all views or opinions expressed in or by those sources.

ExxonMobil's long-term investment decisions are informed by a rigorous, comprehensive annual analysis of the global outlook for energy, an analysis that has repeatedly proven to be consistent with the International Energy Agency World Energy Outlook, the U.S. Energy Information Administration Annual Energy Outlook, and other reputable, independent sources. ExxonMobil's *Outlook for Energy* projects a global energy demand increase of 35 percent from 2010 to 2040 as the world's population rises from 7 billion to nearly 9 billion and global economic output more than doubles. Unconventional resources will play a key role in meeting the growth in energy demand and helping ensure economic prosperity, energy security, and continued improvement for billions of people around the world.



The ExxonMobil *Corporate Citizenship Report,* also prepared annually, reaffirms the commitments we make to our shareholders, employees, customers and communities regarding our corporate citizenship performance. We strive to be responsible corporate citizens and our success along that path is underpinned by our technological expertise, operational excellence, safety performance and unwavering ethical standards. For the past several years, the *Corporate Citizenship Report (CCR)* has discussed unconventional resources development issues.

2013 *CCR* Case Study

2012 *CCR* Case Study

We have heard from parties interested in issues surrounding hydraulic fracturing and unconventional resources development and their desire to receive even more information across a broad range of topics than what has been provided in the *Corporate Citizenship Report*. In response, this report provides wider treatment of the key issues related to unconventional resources development as well as a discussion of the risks inherent in our operations and consequent risk management approaches.

As with any industrial process, developing unconventional resources entails certain risks. This report discusses how we identify, mitigate and manage these risks with the same rigorous approach that is used for all of our operations. Figure 1 below illustrates many aspects of unconventional resources development that will be discussed further, from protective well design features and well pad equipment to resource depth and wastewater management.

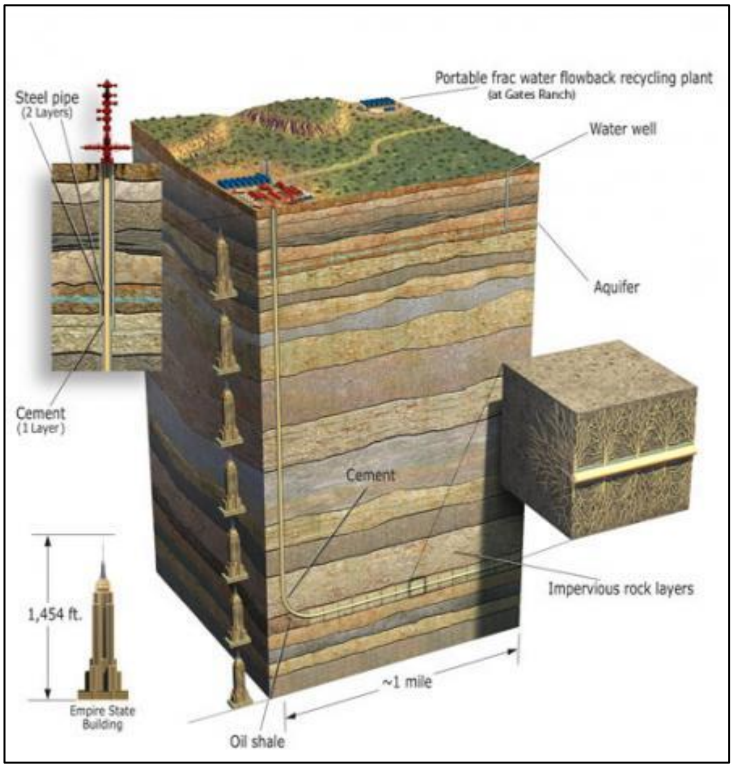


Figure 1 - Representation of a typical Eagle Ford well. Source: FracFocus

Unconventional Resources and Their Development

Unconventional versus Conventional

The oil and gas industry has used the terms "conventional" and "unconventional" resources for decades, though no standard definitions exist. At its most basic level, a "conventional" resource will flow on its own to the wellbore, while an "unconventional" resource will not. Unconventional resources require the application of external stimulation to enable hydrocarbons to flow. Hydraulic fracturing, which cracks underground source rock to release gas or oil embedded within it, is one such form of external stimulation.

While other definitional contrasts exist, for the purposes of this report the need to provide external stimulation – e.g., through hydraulic fracturing – is the critical factor for labeling a resource as unconventional. Most community and stakeholder interest surrounding unconventional resources development today is focused on hydraulic fracturing, including the inputs and operations surrounding the practice.

The "unconventional" resources referred to in this report involve gas and oil found in underground shale and tight sand formations as well as coal bed methane (which can require hydraulic fracturing). This report does not encompass other unconventional resources such as oil sands or oil shale mining, which involve different geological formations and extractive techniques. Generally, a shale layer is the geological source rock for conventional resources. Over millennia, some of the hydrocarbons trapped within shale migrated upward through other formations until reaching a barrier of low, or no permeability rock that acts as a "seal" to trap the free-flowing resource. Figure 2 illustrates conventional and unconventional (shale, tight sands and coal bed methane) resources.

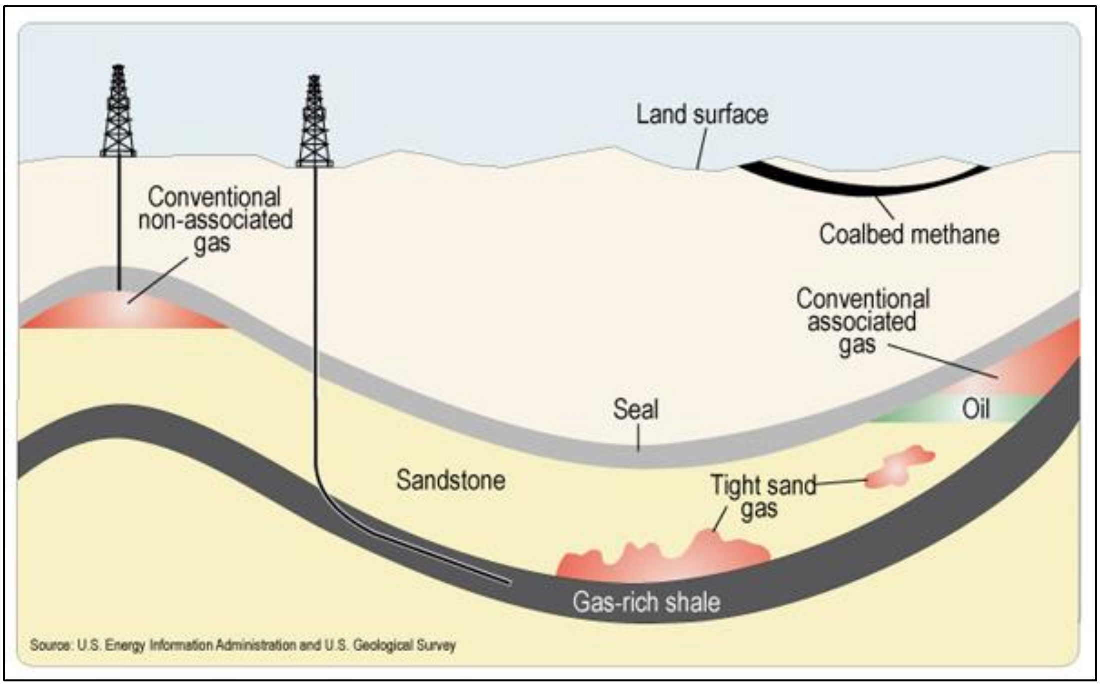


Figure 2 – Conventional and Unconventional Resources. Source: EIA

The terms "unconventional" and "conventional" can cause confusion for the public because they can imply that conventional means simple and unconventional means difficult. As discussed above, the distinguishing feature is whether the oil or natural gas can naturally flow on its own, not the relative ease or difficulty in extracting the resource. The term "unconventional" neither refers to nor requires operational difficulty, just as "conventional" is not defined by operational simplicity. In fact, the unconventional resources discussed in this report can be developed by less complex means than the operations involved with many projects that are accessing and producing conventional resources.

Developing Unconventional Resources

The economic viability of developing unconventional resources depends upon many factors. These include:

- Geology (nature of resource, nature of source rock, resource depth, size of resource, etc.);
- Geography (e.g., size of markets, proximity of resource to markets);
- Topography (ability to construct well pads, water sources, sand sources, etc.);
- Governance (e.g., nature and stability of laws and regulations, over-arching fiscal regime, mineral ownership, lease/resource access, royalties/taxes, liability exposure, rights of way policies);
- Supporting infrastructure (e.g., roads, railways, waterways, power sources, pipelines, disposal options, worker housing/social services);
- Supporting labor force (availability of trained personnel);
- Materials and equipment availability (drilling, fracturing and environmental management equipment, cement, gravel, sand, chemical additives, trucks, piping, etc.); and
- Pricing (the price being offered for the given oil or gas commodity at the time of investment decisions).

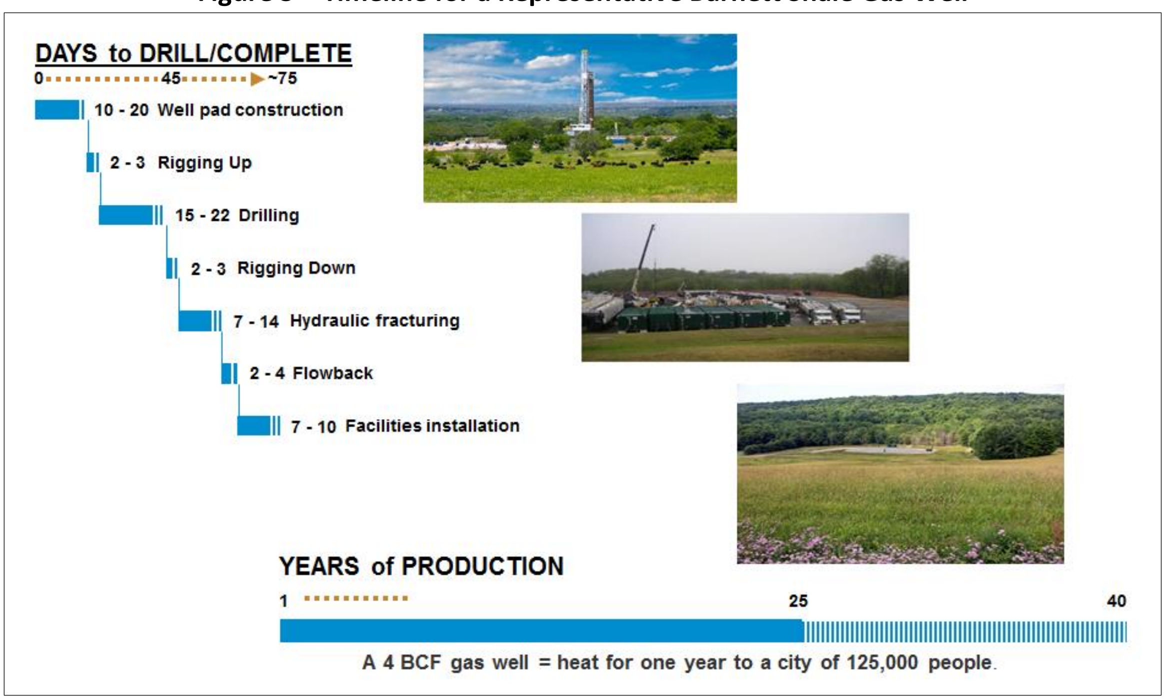
The costs and anticipated development pace associated with each of these factors can encourage or discourage investments in one location relative to other regions or countries. In the United States, supporting infrastructure, labor and supplies, as well as other factors have contributed in many instances to a favorable climate for unconventional resource development investment and expansion.

To develop an unconventional resource, several steps are undertaken to drill a well and begin producing it. Generally, the time to construct a well is relatively short (months) compared with the time the well viably produces a resource for sales (decades). Figure 3 below illustrates the key steps and their relative timeframes:

- After a leasehold is acquired, and once the underground geology is studied and an optimal well pad location is determined, the well pad is constructed. (The well pad is the area where drilling and other operations will occur, and on which the necessary associated equipment will be located.)
- The drilling rig is next assembled on site at the well location.
- Next, multiple wells are generally drilled – including the vertical depth to the resource and the horizontal section through the layer of rock containing the oil or gas that may later be hydraulically fractured. The drilling depth can be more than two miles down and the horizontal leg can run up to a mile or more.

- Once the drill rig is disassembled, the wells are then "completed" or brought to a condition such that they can produce the resource. The main completion process involves well stimulation by hydraulic fracturing, which is a separate process from the actual drilling. Hydraulic fracturing occurs by pumping under pressure a combination of water (to make hairline fractures in the rock) and sand (to prop open the cracks) to release the imbedded oil or gas to enable its flow to the wellbore. The hydraulic fracturing fluid also contains chemicals to reduce friction, prevent microorganisms from growing, inhibit scaling on the pipes, and other functions (as discussed further below).
- After each well is completed, it begins to flow. Initially a substantial amount of the water mixture used to hydraulically fracture the well, as well as water naturally present from deep underground, is returned from the reservoir and collected in a tank, which must be properly handled. Eventually, after the initial flowback, the well will begin to produce hydrocarbons in the form of natural gas or a combination of oil and natural gas, depending on the reservoir.
- Finally, the well is connected to infrastructure, including separation facilities, storage tanks, a gas or oil pipeline, and monitoring equipment so that resource production can begin. (Note: The Timeline below represents a single well; for a multiple-well pad several steps would be repeated.)

Figure 3 – Timeline for a Representative Barnett Shale Gas Well



The oil and gas industry relies upon contract service companies to provide much of the required equipment, materials, and qualified personnel during drilling, completion, and production. When these other companies are performing work on our behalf, we ensure our comprehensive risk management expectations are known to them.

Unconventional Resource Development Benefits

Economic Benefits

The revolution in energy production brought about by the rapid growth of unconventional gas and oil development in the United States has generated widespread economic benefits. The result has been increased economic prosperity, a revitalized manufacturing sector, improvement of millions of lives through direct and indirect employment and lower energy costs, new sources of government revenues, and strengthened energy security for the nation. Dozens of studies and reports discuss these issues, with many focused on regional benefits. Some of the more prominent national-level reports include:

- America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy – Volume 1: National Economic Contributions, IHS CERA (Oct. 2012)
- America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy, Volume 2 – State Economic Contributions, IHS CERA (Dec. 2012)
- America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy – Volume 3: A Manufacturing Renaissance, IHS CERA (Sept. 2013)
- Shale Gas, Competitiveness, and New U.S. Chemical Industry Investment – An Analysis of Announced Projects, American Chemistry Council (May 2013)
- Supplying the Unconventional Revolution: Sizing the Unconventional Oil and Gas Supply Chain, IHS Global (Sept. 2014)
- Shale Gas: A Revolution in Manufacturing?, PwC (Dec. 2011)
- Realizing the Potential of U.S. Unconventional Natural Gas, Center for Strategic and International Studies (April 2013)
- Consensus Report on Opportunities and Challenges for US Shale Gas Development, the Bipartisan Policy Center (Jan. 2012)

These studies have identified significant measurable societal benefits in the form of government revenues, improved infrastructure and municipal services, job and employment growth, and a growing projection of continued benefits long into the future. Other benefits exist which are not measured with hard numbers. For example, the industry's support for millions of jobs enables workers to have better access to health care for themselves and their families. Similarly, new or renewed economic vitality in a location or region can reduce the societal risks associated with economic distress.

Environmental Benefits: Surface Footprint

The development of unconventional resources also can bring substantial reductions in operational surface footprint. Industry's ability to drill multiple wells from a single well pad (more than two dozen wells in some cases) and the technique of drilling long horizontal wells to access the shale or tight sand resource, combine to enable unconventional resources development with fewer surface impacts compared to conventional drilling. The graphic below helps illustrate this benefit.

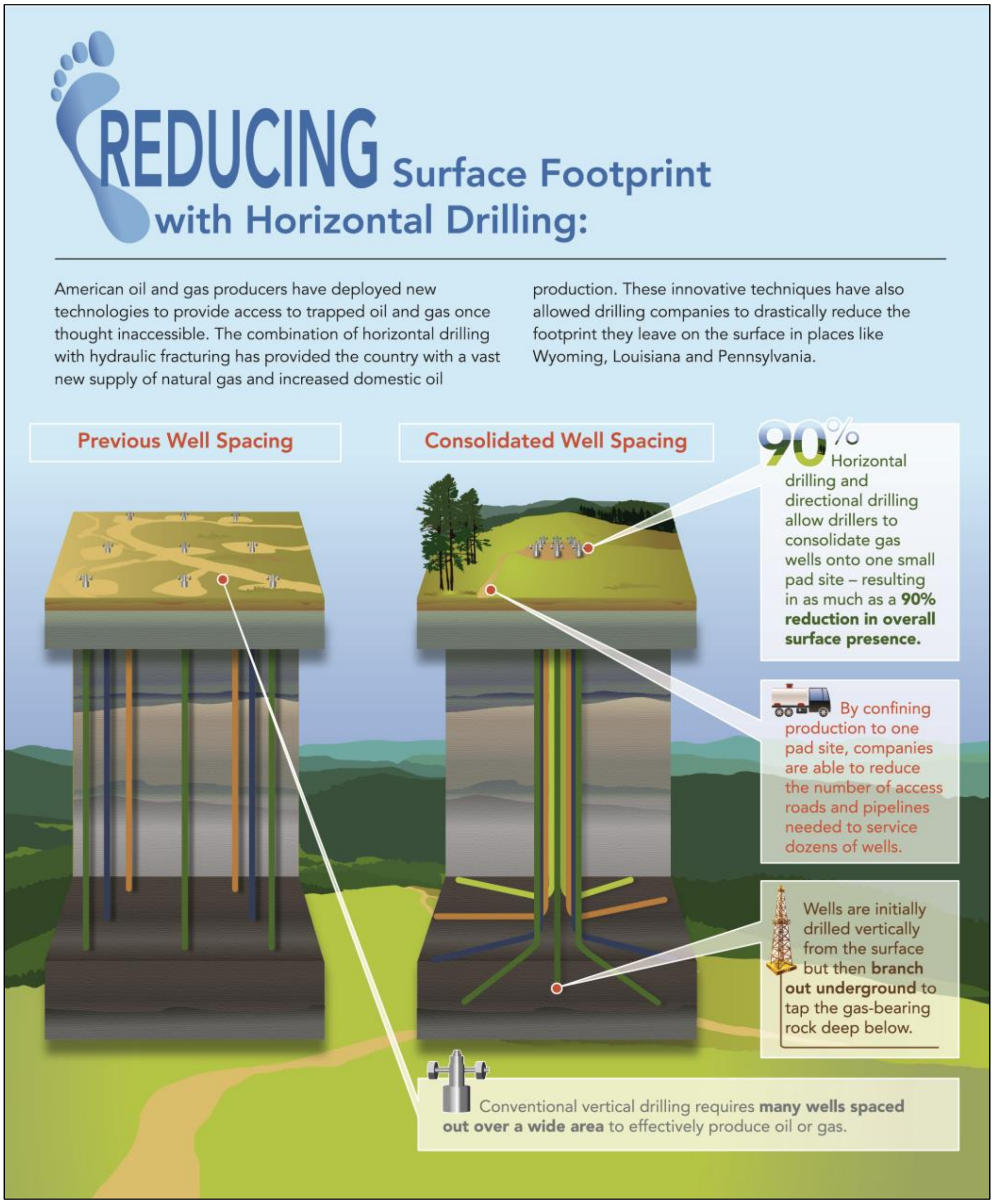


Figure 4 - Comparison of Horizontal Wells on Single Pad to Vertical Wells
Source: Energy from Shale (API)

David Mackay, Regius Professor of Engineering at Cambridge University and Chief Scientific Advisor to the United Kingdom Government's Department of Energy and Climate Change, evaluated the footprint of shale gas operations compared with the footprint of other means of delivering a similar quantity of energy. He evaluated land area, vertical height, and vehicle movements. The study found that a 10-well shale gas pad required the smallest land area, and the land needed for such a pad was 700 times smaller than a wind farm and 450 times smaller than a solar park creating an equivalent amount of energy.

	Shale gas pad	Wind farm	Solar park
	(10 wells)	87 turbines, 174 MW capacity	1,520,000 panels, 380 MW capacity
Energy delivered over 25 years	9.5 TWh	9.5 TWh	9.5 TWh
	(chemical)	(electric)	(electric)
Number of tall things	1 drilling rig	87 turbines	None
Height	26 m	100 m	2.5 m
Land area occupied by hardware, foundations, or access roads	2 ha	36 ha	308 ha
Land area of the whole facility	2 ha	1450 ha	924 ha
Area from which the facility can be seen	77 ha	5200-17,000 ha	924 ha
Truck movements	2900-20,000	7800	3800 (or 7600*)

Figure 5. Source: Mackay, Shale Gas In Perspective (2014)

Environmental Benefits: Greenhouse Gas Reductions

Natural gas development through hydraulic fracturing has brought about significant greenhouse gas reductions in the United States. Natural gas is the cleanest burning fossil fuel, and less carbon intensive than other fossil fuels. When used for power generation, natural gas emits considerably less carbon dioxide than coal. Emissions of mercury, sulfur, and nitrogen oxide are also significantly reduced. Studies by the U.S. Department of Energy, Energy Information Administration and Environmental Protection Agency and academics have shown greenhouse gas emissions of unconventional natural gas to be about 50 percent less than those for coal on a full lifecycle basis.

Greenhouse gas emissions in the United States are at their lowest level since 1994, due in large part to a shift to natural gas from coal in fueling power plants. The latest assessment of the United Nations' Intergovernmental Panel on Climate Change makes clear that the United States has been able to reduce its greenhouse gas emissions so dramatically due largely to the growth of hydraulic fracturing and natural gas:

> "A key development since AR4 (Assessment Report 4) is the rapid deployment of hydraulic fracturing and horizontal drilling technologies, which has increased and diversified the gas supply… this is an important reason for a reduction of GHG emissions in the United States." (Ch. 7, p. 18)

The Intergovernmental Panel on Climate Change is not the only expert organization to come to this conclusion. The International Energy Agency , the Energy Information Administration, the Environmental Protection Agency, and the National Oceanic and Atmospheric Administration have all credited hydraulic fracturing and the increased use of natural gas with reducing greenhouse gas emissions to a 20-year low.

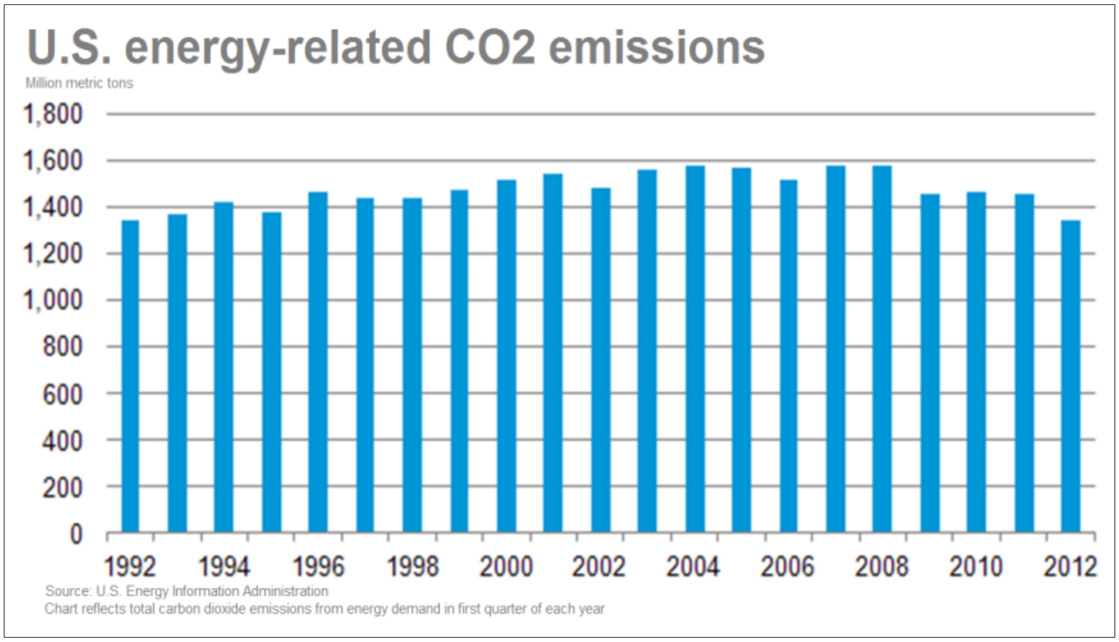


Figure 6. Source: EIA

Moreover, a significant reduction in methane emissions has accompanied the substantial growth in shale gas production. While the overall CO_2 benefits are more well-known and acknowledged, these methane reduction benefits are just being revealed through careful analysis of EPA's inventory of greenhouse gas data. Figure 7 illustrates this decline.

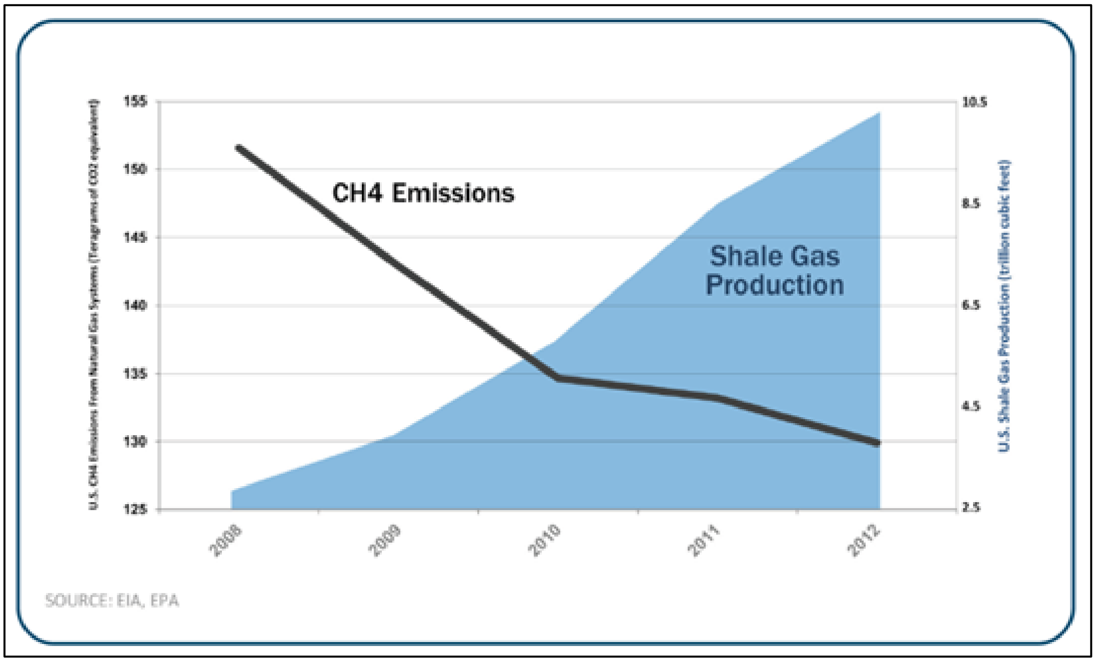


Figure 7. Source: Energy in Depth

XTO Energy Footprint and Perspective

XTO is a significant player in the unconventional resources field. We have activities in virtually every major unconventional basin in the United States and are generally among the top five leaseholders.

XTO Operational Presence

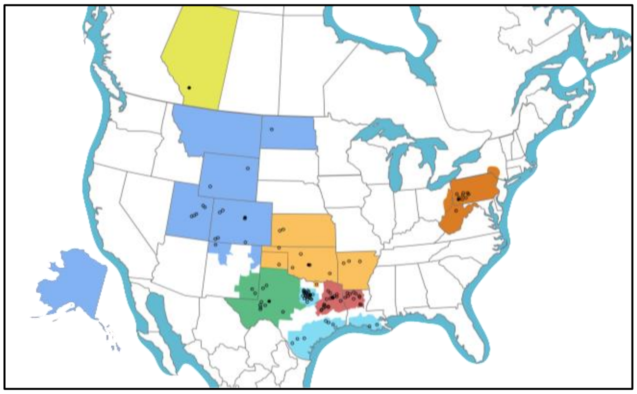


Figure 8.

Major Shale Gas and Oil Basins

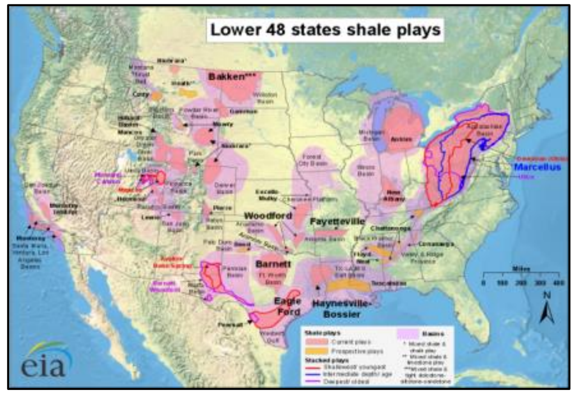


Figure 9. Source: EIA

This nationwide presence brings familiarity with unconventional resources development challenges across the country. We strive to bring this broad perspective into policy and regulatory discussions.

Management and Accountability

Established procedures, technologies and practices exist to manage the risks associated with oil and gas production. Over the years, many means of addressing key operational risks have been developed. For example, well casing and cement to protect groundwater, testing methods to ensure casing is sound, standardized piping connections to avoid leaks, etc. The American Petroleum Institute (API) has been at the forefront of transitioning industry experience and evolving practices into formal guidance and standards. API's American National Standard Institute's accredited standards program has developed more than 200 standards pertaining to oil and gas extraction, many of which are applicable to unconventional resource development and hydraulic fracturing. See Figure 10 below.

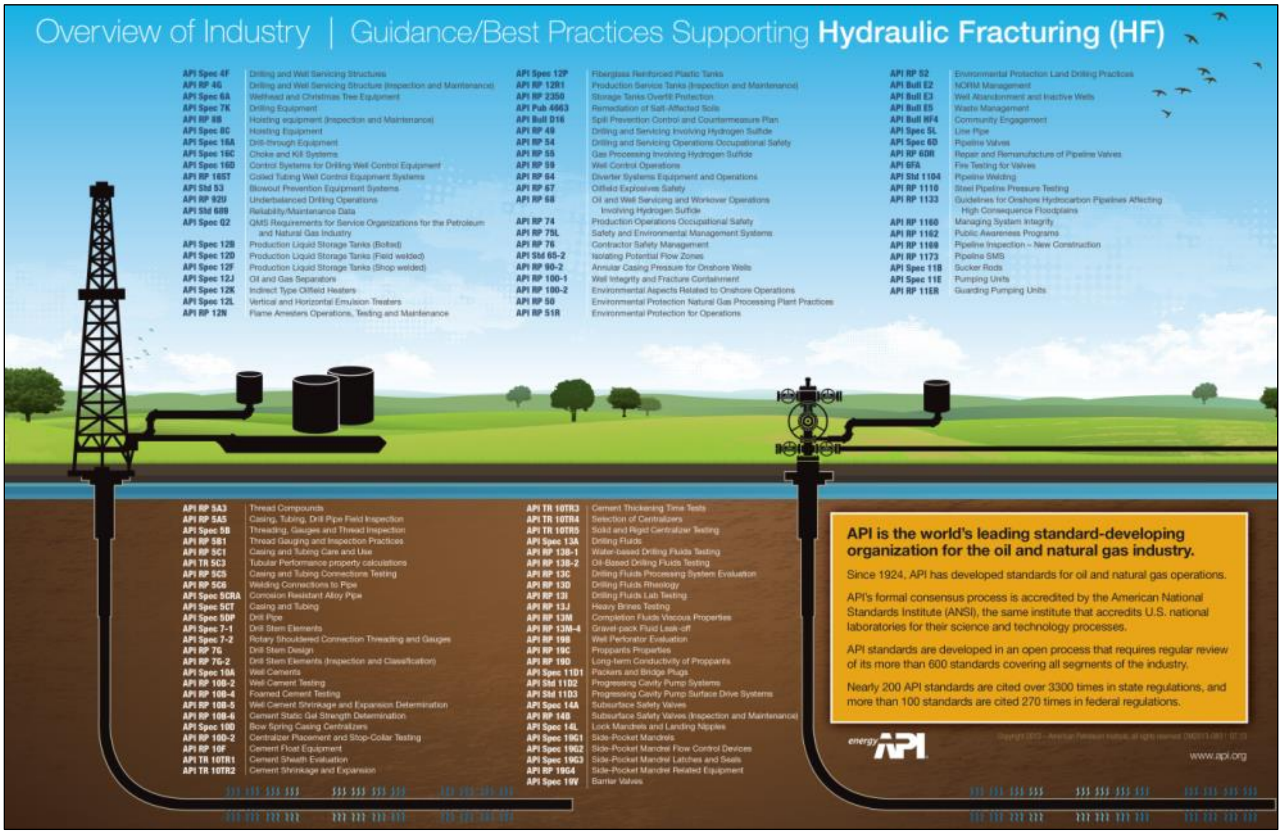


Figure 10 – API Guidance/Standards Supporting Hydraulic Fracturing. Source: API

Additionally, API has developed a set of six documents[2] which specifically address the risk management issues accompanying unconventional well construction and management. These robust practices help to protect the public by providing a blueprint for strong, carefully tended wells, and provide the flexibility necessary to accommodate the variations in state regulatory frameworks due to fundamental differences in regional geology and other factors. The scope of this suite of documents provides the framework for considering and addressing the full range of well design and operations, environmental and local community issues, including those related to air, water, waste, landscape, noise and traffic issues.

This extensive body of work is well known by those working within industry and regulatory agencies. XTO designs operations using these responsible practices that are suitable for local conditions, such as geology, hydrology, topography, and reservoir characteristics.

[2] HF 1, Well Construction and Integrity; HF 2, Water Management; HF 3, Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing; RP 51R, Environmental Protection for Onshore Oil and Gas Production Operations and Leases; STD 65-2, Isolating Potential Flow Zones During Well Construction; and ANSI/API BULLETIN 100-3, Community Engagement Guidelines.

Internal Risk Management

The safe and efficient development of unconventional resources depends on two important elements. A company should have both a responsible operations philosophy and an established and effective risk management approach or framework. All businesses have risks and it is important to identify these risks, make assessments based on real data, and put in place mitigation measures to reduce the risks to an acceptable level for both the operator and the community where it is operating. Risks should be assessed by their probability and consequence, using operational expertise complemented by technical studies that enable companies like XTO to mitigate and manage risks based upon real data from actual developments.

An unconventional resource development operator should have a systematic means of ensuring that risks associated with a given well or other operation (e.g., laying pipelines) are properly identified and understood and that appropriate responsible practices are brought to bear for each operation. Ideally, the internal system will not only perform these functions, but also measure results and work toward continuous improvement. In this regard, and building on its pre-existing safety program, XTO now applies ExxonMobil's systematic and disciplined approach to safety, security, health and environmental performance that is managed through our Operations Integrity Management System (OIMS), a rigorous regime of 11 separate elements that measures and mitigates safety, security, health and environmental risk.

The Operations Integrity Management System calls for analyses of every significant operation ExxonMobil undertakes around the world – in refineries, service stations, offshore platforms, onshore well pads, and even in its offices. It identifies the risks to people and to the environment that are inherent in our business and it requires procedures and processes to make sure it is operating safely while minimizing environmental impacts. OIMS enables us to speak with one language on our most important work – protecting people and the environment.

Figure 11 – ExxonMobil OIMS Framework

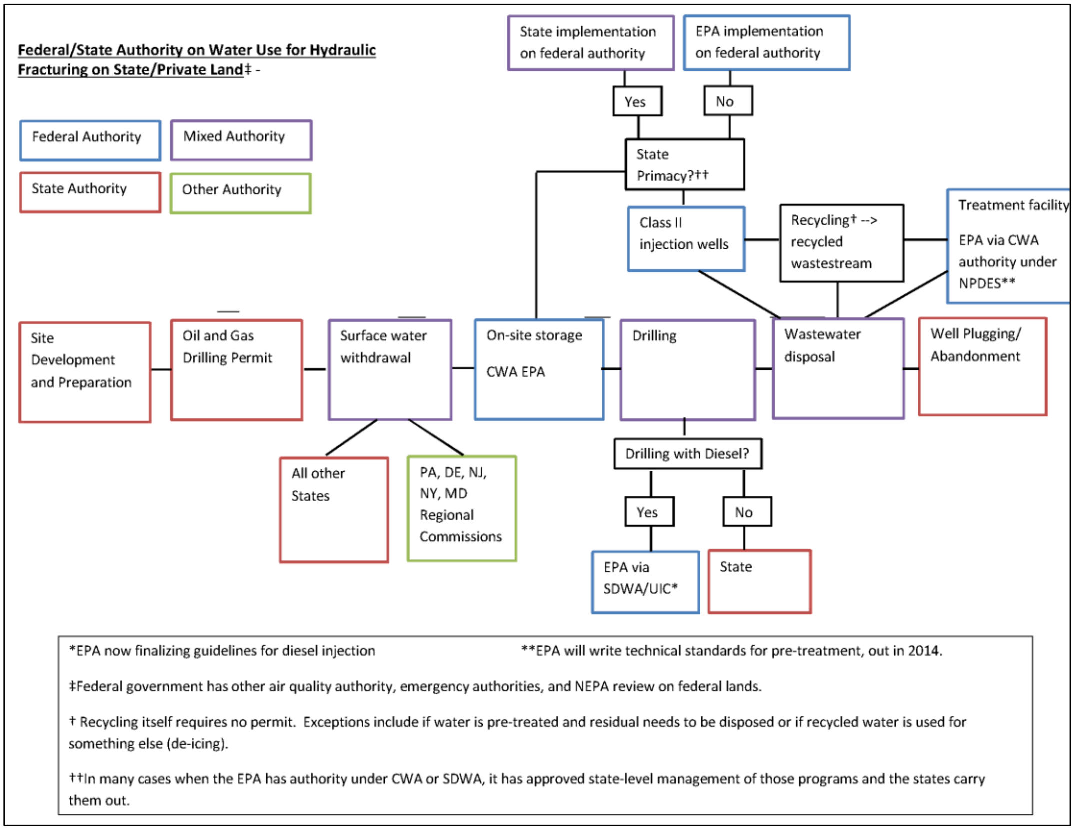
Fundamental to risk assessment is a culture of hazard identification and mitigation. The assessment evaluates preventive measures and mitigation plans to enhance the on-going management of risk associated with operations. This approach to operations integrity requires extensive training of personnel, full utilization of processes by our employees and contractors, and documented procedures that are tested and proven over time.

External Accountability

We believe that a strong regulatory framework is essential to compliment voluntary industry standards and proven practices. A strong regulatory system is fundamental to providing the public with confidence that the criteria for safe and environmentally protective operations are in place, administered, and strongly enforced. Effective regulations also create a level playing field for all industry participants.

In the United States, the industry is regulated by an integrated network of federal, state, and sometimes local controls. As illustrated in Figure 12 below, there is strong federal and state oversight of unconventional resources development. Figure 12 provides an example of water management across federal, state and regional authorities. These regulations and processes encompass site development, drilling permitting (which would include hydraulic fracturing), water withdrawals, on-site storage, disposal and reuse/recycling, and well plugging and abandonment.

Figure 12 – Federal/State Authorities for Water Use in Hydraulic Fracturing



Source: CSIS, Realizing the Potential of U.S. Unconventional Natural Gas (April 2013)

Today, more than a dozen federal department and agencies are currently pursuing initiatives or new regulations related to unconventional resources development. These include the Environmental Protection Agency (13 separate initiatives); the Departments of Energy (7 efforts), Interior (9 efforts across 5 agencies), Defense (Army Corps of Engineers), Agriculture (Forest Service), Transportation (2 agencies), Health and Human Services (3 agencies), and Commerce; and the Securities and Exchange Commission.

The federal government's Clean Air Act, Clean Water Act, and Safe Drinking Water Act all apply to oil and gas operations and the Environmental Protection Agency has recently adjusted key regulations to account for unconventional resources development issues under these statutes, or begun processes to do so. The Bureau of Land Management and the United States Forest Service are undertaking processes to update regulations and guidance for hydraulic fracturing on federal lands. The link cited above provides further explanation on activities of all the federal departments and agencies.

In many cases, the federal government has delegated to the states the authority to implement the federal regulatory programs. Additionally, the states generally control well-pad and down-hole operational issues, which is the most appropriate and effective approach to protecting human health and the environment while accounting for local geology and other local factors. The states have developed additional rules and regulations to safeguard the public and the environment, as required. Moreover, the states are taking action to account for unconventional resources development through hydraulic fracturing. Virtually every state with unconventional resources has adjusted its oil and gas regulations over the past few years, and the states continue to revise laws and regulations address their particular circumstances.

We take a leadership role and engage across the board with federal and state regulators as they seek to develop and implement new regulations, or adjust existing regulations, to manage and oversee unconventional resources development in their jurisdictions. We do this individually as a company and also by working with state and national trade associations. In our operations, we have developed deep expertise and can share experiences on geology, well dimensions, location footprint, emissions, water use, economic activity, etc. We also have access to the knowledge base and technical capabilities across the corporation. Working with trade associations such as the American Petroleum Institute, America's Natural Gas Alliance, and the Independent Petroleum Association of America, as well as state oil and gas associations, enables our company to share important information to help inform policy makers and regulators as they develop future policies and regulations.

In further support of strong state regulatory capabilities including enforcement, we also helped establish, along with General Electric, a regulator training institute at the Colorado School of Mines, Penn State University and the University of Texas at Austin. Faculty-led and designed training programs are helping ensure that regulators have access to the latest technology and operational expertise to assist in their important oversight of shale development, essentially training the regulators of tomorrow. The program has been well received by regulatory officials and could eventually lead to the re-establishment of a state regulator certification program via the Interstate Oil and Gas Compact Commission.

Figure 13 – "TopCorp" Training Session, Sept. 2013

Water

We recognize that stakeholders have concerns about the use and protection of water resources. While there have been no instances of contamination due to the hydraulic fracturing process – as again recently confirmed by a comprehensive study by the U.S. Department of Energy's National Energy Technology Laboratory – risks to water from other aspects of the oil and gas development process need to be carefully managed.

We focus our efforts on preventing adverse impacts to water resources and prudently managing the water we use in operations and development activities. As part of our comprehensive risk management approach, we are committed to protecting human health and the environment, considering local water availability and needs, continuously improving our capabilities and performance regarding our use of water, and engaging stakeholders in the development of sustainable solutions.

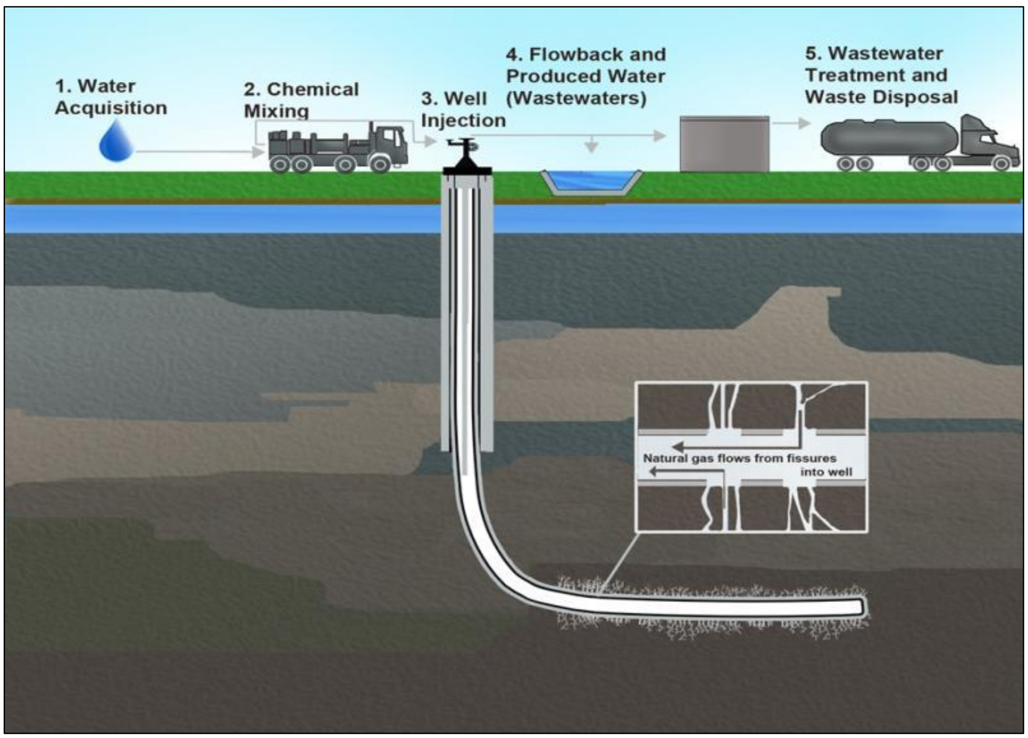


Figure 14 – Water Use in Hydraulic Fracturing (not to scale)
Source: Environmental Protection Agency

Drinking Water Protection: Well Construction and Integrity

For many people, the most pressing question concerning nearby unconventional resources development is: "Will my drinking water be safe?" We address this question by explaining the protective aspects provided by a properly designed and constructed oil and gas well. As illustrated in Figure 15, these protective measures consist of multiple layers of steel casing and cement that separate the well from the aquifer and also serve to isolate production streams within the center of the well. In particular, the surface casing pipe is cemented in place to isolate the aquifer from the wellbore. Additional casing and cement are added as the well is drilled deeper to ensure integrity of the wellbore and that fluids remain within the pipe. This is not only a sound operating practice, but also a standard regulatory requirement.

A representative well in the Barnett shale in Texas provides an example of how XTO approaches this well design and water protection issue. The producing Barnett zone is 7,500 feet below the surface. That is the equivalent of six Empire State Buildings stacked on top of each other. The groundwater aquifers are less than 1,000 feet below the surface. To ensure the safety of this aquifer, several layers of protective steel pipe known as casing are set and cemented below the aquifer as follows:

1. *Conductor Casing* – initial layer of casing that attaches the system to the surface (40-100 feet).
2. *Cement,* sealing the conductor casing to the surface.
3. *Surface Casing* – extending below the fresh water aquifer at the given location, typically set 600 to 1,000 feet below the surface.
4. *Cement,* sealing the surface casing in place above any freshwater aquifers.
5. *Intermediate Casing* – extending down toward or into the reservoir/shale layer (thousands of feet). (Note: depending on local conditions, including in the Barnett, intermediate casing may not be needed or used.)
6. *Cement,* sealing the intermediate casing into place.
7. *Production Casing* – the final set of piping, including the horizontal line, in which the gas will flow back to the surface.
8. *Cement*, sealing production casing into place.

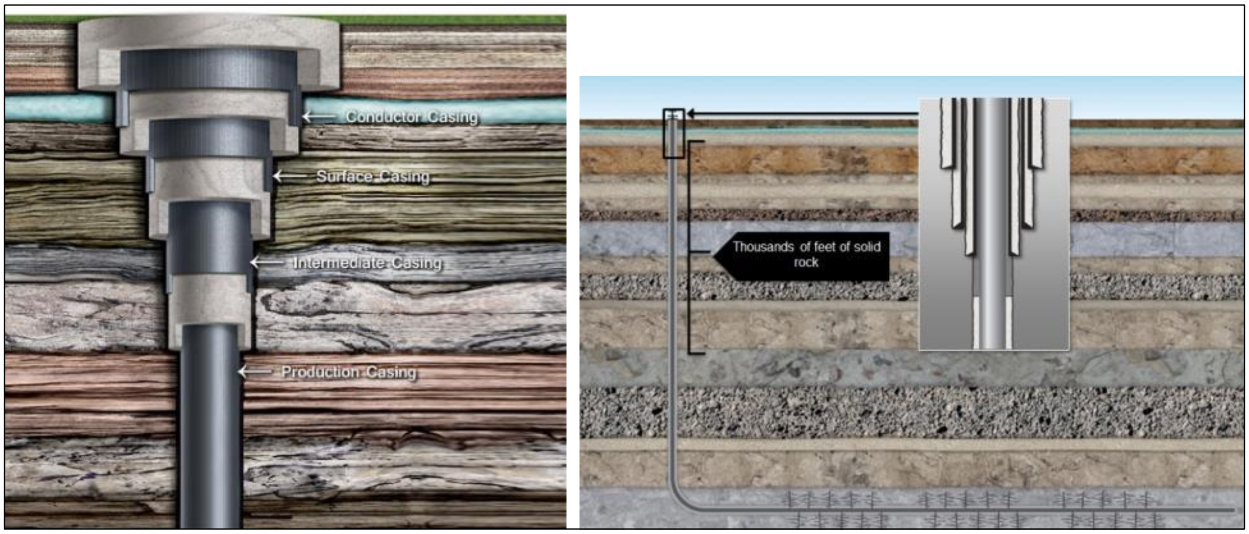


Figure 15 – Well Design Protects the Water Table. Source: FracFocus

We test the casing and cement jobs to ensure they do not create a pathway for oil and gas to enter the water table. In addition, hydraulic fracturing completions are closely monitored and managed to ensure that the pressures involved do not exceed well design parameters.

Water Management – Disposal/Reuse/Recycling/Seismicity

Wastewater on the surface must be carefully managed. The infrastructure required to gather, store and move wastewater associated with unconventional resources development is not overly complex, but provides opportunities for human error, accidents and spills. We seek to mitigate these risks with a disciplined approach to water management through our Operations Integrity Management System and through close tracking and reporting on spills.

Water management is highly dependent on local factors and disposal is subject to federal and state requirements. XTO examines the options in each operating region and weighs them based upon availability and practicability. In most cases, wastewater is injected into deep underground reservoirs through disposal wells, which are regulated by federal Safe Drinking Water Act requirements.

While water for drilling and hydraulic fracturing typically comes from surface or groundwater sources, when available water or disposal wells are limited, XTO reuses produced water for completion operations. We tailor our water management plans based on the resources available and circumstances within each area. There are many challenges to water reuse and recycling and there are not universal solutions. The majority of XTO locations use freshwater for completions.

Reuse and recycling present increased surface water management challenges. In some circumstances, these approaches may be the preferred methods of wastewater treatment, but they require additional infrastructure such as centralized storage and recycling facilities which can increase risks and surface land use.

We strive to use water wisely and participate in research to evaluate new solutions. For example, in 2013, XTO and Halliburton studied whether it was possible to use recycled produced water in hydraulic fracturing. The results were published in a Society of Professional Engineers paper, *Development and Use of High-TDS Recycled Produced Water for Crosslinked-Gel-Based Hydraulic Fracturing*. The study involved a series of oil well stimulations performed in the Bone Springs formation in the Delaware basin located in Texas to evaluate the validity of laboratory testing under field conditions. The laboratory and field results of the study demonstrated that under the conditions evaluated it was feasible to use treated produced water as the base fluid for crosslinked-gel-based hydraulic fracturing. This allowed 8 million gallons of produced water to replace fresh water use, reduced about 1,400 truckloads of fresh water from off-site, and saved $70,000 to $100,000 in water procurement costs per well. This work has enabled us to consider non-freshwater sources for some operations.

A final issue associated with wastewater disposal is induced seismicity. A comprehensive two-year study by the U.S. National Academy of Sciences (NAS) published in 2012 concluded that the injection of waste water from oil and gas activities into disposal wells does pose some risk of inducing seismicity when such wells are located near pre-existing critically stressed faults. The report also noted that over the past several decades there have been only a few documented cases relative to the large number of disposal wells in operation. Since the NAS report was issued, seismic events in many states – Arkansas, Ohio, Texas, Kansas, Colorado and Oklahoma – have been examined for possible links to oil and gas wastewater disposal wells.

In light of these emerging developments, in January 2012 ExxonMobil with XTO created an internal scientific team, comprised of XTO and other ExxonMobil resources, to understand seismicity issues and facilitate the development and application of science-based risk management principles. Members of the team have discussed findings and mitigation approaches with industry colleagues, academics and government officials at the state and federal level in the United States, as well as internationally in Canada, Europe and South America. Our technical experts are highly engaged in discussions to find solutions and make appropriate regulatory adjustments.

For example, our experts have consulted with the Environmental Protection Agency as it studies issues on induced seismicity related to its oversight of the Safe Drinking Water Act salt water disposal injection well control program. We have also been highly engaged with state regulators, including their formation of the multi-state Induced Seismicity by Injection Work Group through the Groundwater Protection Council and Interstate Oil and Gas Compact Commission. We are also supporting a leading academic consortium, the Stanford Center for Induced and Triggered Seismicity.

In addition to being an active participant in federal, state and academic discussions, XTO established its own internal salt water injection well siting protocol for use in conjunction with applicable regulations. Under this protocol we review available event data, including seismic information from the United States Geological Survey or state authorities, evaluate and analyze data, and conduct a risk assessment prior to siting a salt water injection disposal well.

Water Use

Water usage is a global issue that plays out locally. Water is a key part of the industry's supply chain for oil and gas development and can be a scarce resource, depending on location, when projected global demand is compared with available water resources.

Water is an essential part of the drilling and hydraulic fracturing process. For a typical well, 10 percent of the water is used for drilling and the remaining 90 percent is used to hydraulic fracture the well. During the drilling process, water is used in drilling fluids to maintain well control, stabilize the wellbore, cool the drill bit and carry rock cuttings to the surface. In the hydraulic fracturing process, water is mixed with sand and a small amount of chemical additives to help create small fractures in deep subsurface rock layers.

For hydraulic fracturing operations, a typical well in the Barnett and Marcellus shale regions requires 3-to-5 million gallons of water. To put this volume in perspective, a golf course will utilize 4 million gallons of water in one summer month and New York City uses 4 million gallons every 6 minutes.

From another overall perspective, ExxonMobil conducted an analysis of the full lifecycle of water associated with the production of natural gas from XTO wells in the Barnett and Marcellus shale regions. In both areas, the primary freshwater consumption occurs in the cooling water system for the power plant. Hydraulic fracturing constitutes 6 to 7 percent of the freshwater consumption over the gas life cycle in these regions.

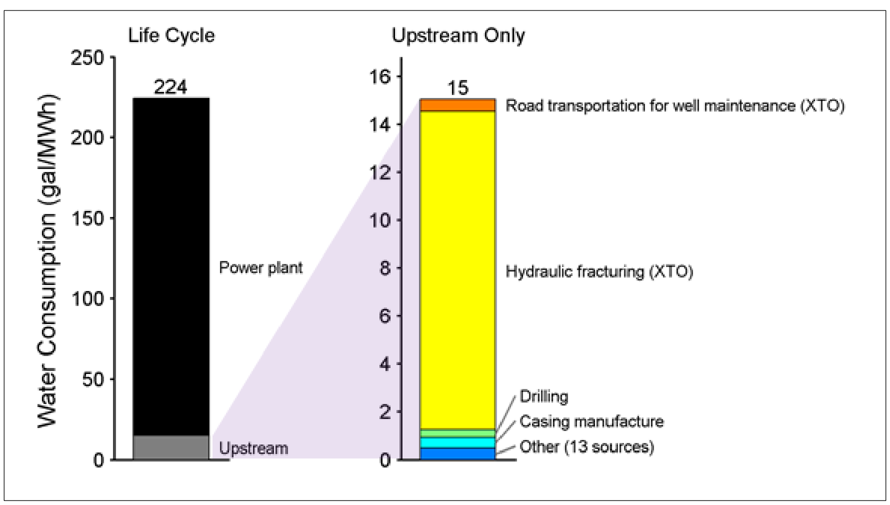


Figure 16 – Lifecycle Water Consumption, Marcellus Dry Gas
Source: ExxonMobil Life Cycle Analysis

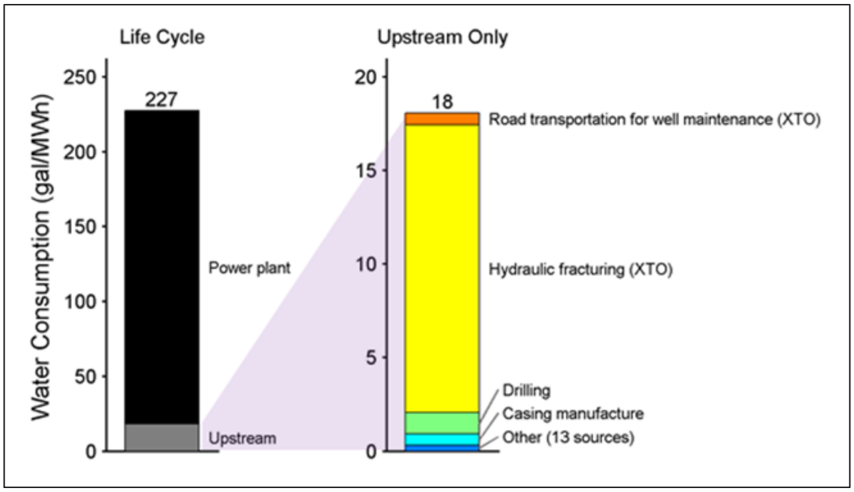


Figure 17 – Lifecycle Water Consumption, Barnett Wet Gas
Source: ExxonMobil Life Cycle Analysis

Evaluations show water consumption associated with hydraulic fracturing operations to be a very small fraction of total regional water consumption. In rural areas agricultural use of water dominates demand and in urban areas municipal consumption dominates demand. In Pennsylvania, approximately 20 times more water was used for recreational purposes, such as watering golf courses and maintaining ski slopes, than for hydraulic fracturing operations.

Figure 18 is from a 2014 study by the U.S. Department of Energy's National Energy Technology Laboratory (NETL) that compared water usage by sector across various unconventional resources development regions. In every case but one (in the Eagle Ford), shale gas usage was the lowest; and in the Eagle Ford it was in the lowest tier—far below public water use and irrigation for farming.

Exhibit 4-3 Total water use for four major shale plays ([1]Arthur, 2009; [2]Chesapeake Energy, 2012a; [3]Chesapeake Energy, 2012b)

Play	Public Supply (%)	Industry & Mining (%)	Power Generation (%)	Irrigation (%)	Livestock (%)	Shale Gas (%)	Total Water Use (Bgals/yr)*
Barnett[1]	82.7	4.5	3.7	6.3	2.3	0.4	133.8
Eagle Ford[2]	17	4	5	66	4	3 – 6	64.8
Fayetteville[1]	2.3	1.1	33.3	62.9	0.3	0.1	378
Haynesville[1]	45.9	27.2	13.5	8.5	4.0	0.8	90.3
Marcellus[1]	12.0	16.1	71.7	0.1	0.01	0.06	3,570
Niobrara[3]	8	4	6	82		0.01	1,280

[Bgal/yr = billion gallons per year]*

Figure 18 – Water Use in Major Shale Plays. Source: NETL

According to the same report, as reflected in Figure 19, shale gas is one of the most water-efficient sources of energy. It uses 10 times less water than coal and 1,000 times less water than renewables such as fuel ethanol or biodiesel.

Exhibit 4-2 Ranges of water intensity of energy sources (Mielke, et al., 2010)

Energy Source	Range in Water Intensity (gallons/mmBtu)
Conventional Natural Gas	~0
Shale Gas	0.6 – 1.8
Coal (no slurry transport)	2 – 8
Nuclear (uranium at plant)	8 – 14
Conventional Oil	1.4 - 62
Oil Shale Petroleum (mining)	7.2 - 38
Oil Sands Petroleum (*in situ*)	9.4 – 16
Synfuel (coal gasification)	11 – 26
Coal (slurry transport)	13 – 32
Oil Sands Petroleum (mining)	14 – 33
Synfuel (coal Fischer-Tropsch)	41 – 60
Enhanced Oil Recovery	21 – 2,500
Fuel Ethanol (irrigated corn)	2,500 – 29,000
Biodiesel (irrigated soy)	13,800 – 60,000

Figure 19 – Water Intensity of Energy Sources. Source: NETL

For XTO operations, water needs vary by formation and water availability is a highly local issue. We review water usage in all of our development areas and operations have not been limited by water unavailability.

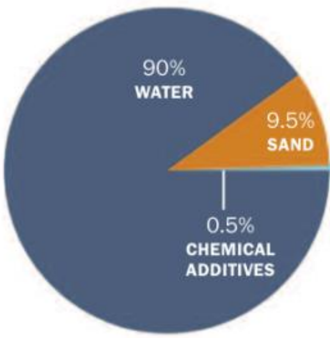
In most states, groundwater is owned by the landowner and the dominant mineral estate is allowed to use water for drilling and production purposes. In many states, the industry can purchase water directly from a surface water rights holder. In some states, groundwater districts formed by the legislature can assess taxes and regulate groundwater usage.

Chemical Use and Transparency

Chemical Use

Chemicals used in hydraulic fracturing have raised concerns about their potential for water contamination, and many discussions have focused on the necessity of chemicals for hydraulic fracturing and maintaining well integrity. See for example, www.FracFocus.org.

While chemicals are fundamental to the hydraulic fracturing process, the fluids used for hydraulic fracturing in shale gas are almost entirely – between 98 percent and 99.5 percent – comprised of water and sand. Chemical additives are required to help ensure safe and effective performance and different geologic formations require different blends of ingredients. These chemicals, many of which are commonly found in household products, have various purposes. The functions include friction reduction, clay stabilization, temperature stabilization of the fluids, suspension and transport of sand, control of bacterial contamination, and corrosion inhibition.



Compound	Purpose	Common application
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
Ethylene Glycol	Prevents scale deposits in the pipe	Automotive anti-freeze, deicing agent, household cleaners
Borate Salts	Maintains fluid viscosity as temperature increases	Laundry detergent, hand soap, cosmetics
Sodium/Potassium Carbonate	Maintains effectiveness of other components, such as crosslinkers	Washing soda, detergent, soap, water softener, glass, ceramics
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment
Guar Gum	Thickens the water to suspend the sand	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring

Source: DOE, GWPC: Modern Gas Shale Development in the United States: A Primer (2009).

Figure 20 – Chemical additives used in hydraulic fracturing. Source: FracFocus

Wells are constructed to ensure these chemicals remain safely contained within the wellbore system and specific steps are taken to manage the chemicals at the well site to prevent spills. In the wellbore, the likelihood of hydraulic fracturing fluids migrating from a gas reservoir to a water table is extremely low because the two zones are typically separated by thousands of feet of rock and there are impermeable natural barriers within this rock that preclude upward migration. In order to protect against accidental release, XTO employs responsible operational practices when designing, drilling, and maintaining the well to ensure that fluids and the produced gas are properly handled in the well and on the surface (see Drinking Water Protection section above).

XTO also seeks to minimize the use of chemicals in its hydraulic fracturing operations. Not only is chemical usage an important stakeholder concern, but chemicals are also an expensive input into the cost of drilling and hydraulically fracturing a well.

Transparency

ExxonMobil has long supported the disclosure of ingredients used in hydraulic fracturing fluids on a well-by-well basis. We consulted with the Ground Water Protection Council and Interstate Oil and Gas Compact Commission as they developed the FracFocus online registry. We continue to work with industry associations, state governments, and the Bureau of Land Management on having the registry being accepted as the best approach to optimally and effectively focus on the appropriate disclosures. Today data from 60,000 wells have been uploaded to the FracFocus site. As states strengthen their regulations to include additive ingredient disclosure, they are commonly requiring input into FracFocus and the federal government is on a similar course. We continue to evaluate the system and identify areas for improvement.

We understand and respect the intellectual property concerns of service companies when it comes to disclosing the proprietary formulations in their exact amounts. However, we believe community members have a right to full disclosure of all ingredients used in these fluids.

ExxonMobil also discloses hydraulic fracturing fluid's chemical additives when we perform hydraulic fracturing operations internationally. We supported the development in Europe of an online disclosure registry similar to FracFocus.

Use of Diesel Fuel

XTO has not used diesel fuel in its hydraulic fracturing operations since 2011 and stopped using kerosene in 2012.

In February 2014, the Environmental Protection Agency released guidance on the use of diesel fuel in hydraulic fracturing operations. This guidance was issued pursuant to the agency's authority under the Safe Drinking Water Act and that act's prohibition of the use of "diesel fuel" in hydraulic fracturing without an underground injection control program permit. The guidance defined "diesel fuel" for the first time and in doing so included kerosene.

Air Emissions

There are three categories of air emission risks associated with hydraulic fracturing and unconventional resource development: (1) greenhouse gas emission from carbon dioxide released when the gas is burned and from emissions of methane; (2) flaring of associated gas in unconventional oil operations; and (3) local ambient air quality impacts of well pad operations.

Greenhouse Gas Emissions

Overall, the benefits of natural gas in reducing greenhouse gas emissions are clear. Natural gas is the cleanest-burning fossil fuel and less carbon intensive than other fossil fuels. As discussed previously, increased use of unconventional natural gas in power generation has helped reduce U.S. greenhouse gas emissions – both methane and carbon dioxide.

While these broad benefits are widely acknowledged, there exists great interest in how various phases of unconventional resources development may contribute to greenhouse gas emissions.

To improve understanding of these issues, ExxonMobil undertook a life cycle greenhouse gas emissions analysis, which was peer reviewed and published in April 2013 in *Environment Science and Technology.* We used actual emissions data from XTO operations in the Marcellus shale region and employed the most extensive data set of any lifecycle assessment of shale gas, encompassing data from actual gas production and power generation operations. Field data for drilling, completion, production and power plant operations were used, focusing on the carbon and water footprints of Marcellus gas from "well to wire" (i.e., from drilling the well to generation of electricity at a power plant).

The study compared the life cycle impacts of Marcellus gas and U.S. coal and concluded that the carbon footprint of Marcellus gas is 53 percent lower than coal and its freshwater consumption is about 50 percent of coal. Substantial greenhouse gas reductions and freshwater savings result when coal-fired power generation is replaced with gas-fired power generation. The study also concluded that activities associated with hydraulic fracturing contributed 1.2 percent of the life cycle greenhouse gas emissions associated with the produced gas. Approximately 78 percent of emissions are attributable to power generation and approximately 7 percent are associated with the use of natural gas to fuel compressors. These results are consistent with other credible studies.

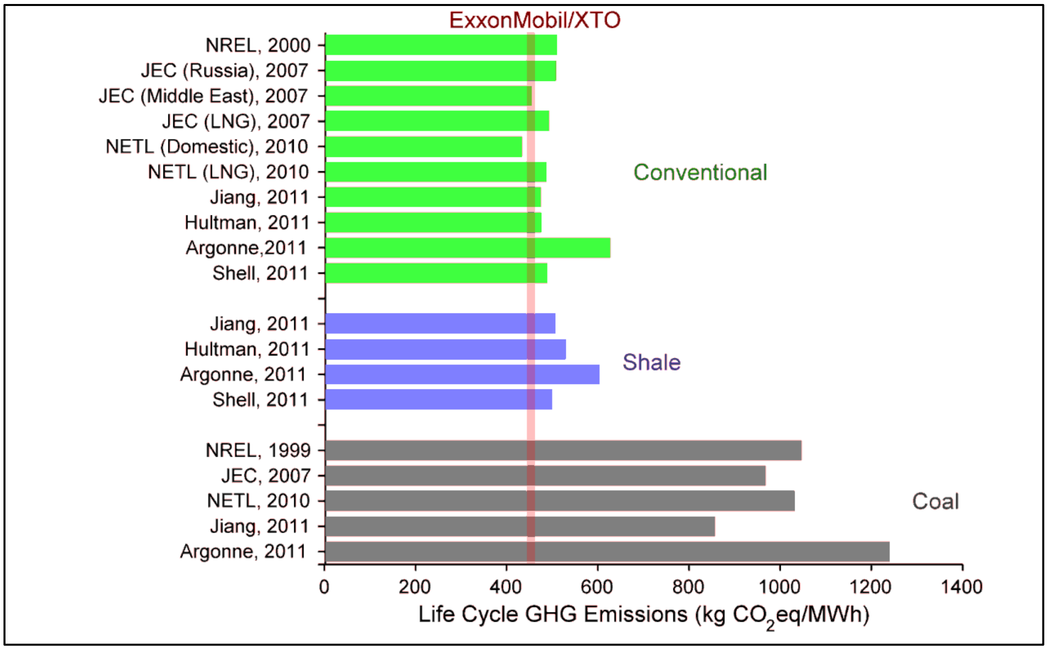


Figure 21 – ExxonMobil Shale Gas Life Cycle Analysis Compared to Other Studies
Source: ExxonMobil Life Cycle Analysis

Methane

Methane emissions from unconventional resources development have been subject to considerable research activity and public attention. While methane dissipates much more quickly in the atmosphere than carbon, it is 25 times more potent than carbon dioxide as a greenhouse gas. It is therefore important to understand and control the level of methane emissions from unconventional resources development.

XTO manages the risks of methane emissions in several ways. First, methane leaks are controlled as a matter of worker and public safety. Natural gas leaks could ignite and therefore constitute an urgent safety matter. Responsible leak management practices are diligently applied at all stages of drilling, completion and production.

Second, XTO has been applying “reduced emission completions” technology on its gas wells, even prior to the Environmental Protection Agency’s New Source Performance Standards rules required such completions. Reduced emission completions capture or burn emissions including methane during the initial phase of water flow back from the hydraulic fracturing operations. XTO has an understanding of its emission footprint by source equipment and by area and utilizes this information to optimize its operations.

Finally, XTO has actively participated in several research studies on methane emissions from unconventional resources development to help improve understanding to optimize operations, to consider new control methods and to inform new government regulations. XTO assisted in an important comprehensive direct measurement study by the University of Texas at Austin by making well pad operations available to researchers. Several other companies and the Environmental Defense Fund also participated in the 2013 study, which found overall shale gas production methane emissions to be 0.0042 of gross production, in line with recently lowered Environmental Protection Agency estimates.

The direct measurements validate the assumptions used by prior studies that found natural gas to have considerable comparative emissions benefits. Interestingly, the study identified that methane emissions from hydraulic fracturing completions were quite low relative to other methane emission sources. This interesting fact further demonstrates that an assumption by some that completions flowback constitute a significant source of methane emissions was incorrect. The study also revealed that about 20 percent of operations result in 80 percent of emissions, which will help focus development of cost-effective practices to reduce emissions.

XTO is participating in a second phase of the direct measurement research study, which focuses on methane emissions from well unloadings and pneumatic devices. We believe that further study will show methane leakage is even lower than previously reported.

XTO is also supporting a study coordinated by the National Energy Technology Laboratory that is seeking to resolve discrepancies between direct measurement studies that measure directly from the equipment source and scale upwards based on total production, and so-called "fly-over" studies that rely upon air measurements from aircraft and then allocate calculated emissions to agriculture, landfills, industry, and other activity on the ground. A key assumption made by fly-over studies is that they have up to date and accurate information of the potential sources. (Some have simply assigned all uncertainty to oil and gas operations.) These fly-over studies have consistently yielded an order-of-higher magnitude reading than direct measurement and have an extremely wide range.

Figure 22 – Emissions being measured directly at well sites, and by "fly-over" aircraft

Studies using actual methane emissions measurement are continuing to discredit the erroneous assertion that shale gas development could be even worse than coal from a greenhouse gas emissions perspective. The most well-known was a 2011 paper by Cornell Professor Robert Howarth, et al, which has been soundly refuted by many other papers and reports, including the results from the University of Texas/Environmental Defense Fund study, an IHS-CERA Mis-Measuring Methane report, and a paper by Prof. Howarth's own colleagues at Cornell. According to IHS-CERA, Prof. Howarth "misused and severely distorted" IHS data.

Flaring

Flaring is used in various stages of exploration and production operations throughout the world, primarily as a safety measure to prevent the accumulation of gases that could pose a potential safety hazard. Flaring safely burns gases such as propane and methane. Flaring methane reduces its greenhouse gas impact by converting it to carbon dioxide and water. In some cases, natural gas produced as part of oil production, known as associated gas, is also flared prior to the establishment of gas gathering infrastructure. Often during early stages of exploration and development of oil and gas resources, there is an initial phase to evaluate the commerciality of the resource, before capital investment into new infrastructure is made.

In the Bakken formation and Permian basin, XTO has put in place management systems to reduce flaring by monitoring and investing in flowlines and additional gas treating infrastructure and working with third parties to support further infrastructure investments and development. For example, XTO invested over $10 million to expand process capacity at its Nesson gas plant in North Dakota, which came online in 2013 and significantly increased gas handling capability to 25 million cubic feet per day.

Local / Ambient Air

Unconventional resources development operations require the use of over the road and non-road mobile machinery and stationary machinery that result in local or ambient air emissions. Heavy mobile equipment is required to construct the well pad, many truckloads may be required to provide water for drilling and hydraulic fracturing as well as to remove waste water, and engines burning diesel or natural gas are typically required to power the drilling rig and hydraulic fracturing operations. Compressor stations, necessary to transfer gas to interstate trunk lines for sales, also can require large natural gas fueled engines that power compressors.

XTO addresses these localized air emissions in a variety of ways. Initially, federal standards for mobile engines must be met through a given state's vehicle emissions testing program, or manufacturer certification of emissions. Where stationary equipment is proposed to be installed, an evaluation of air permit requirements is conducted and any required federal, state or local air permits are obtained before operations begin. These permits typically contain limits for various air pollutants that are based on government air standards derived from health criteria. Permit conditions and control requirements vary based on specific stationary equipment, site emission totals, location, and state rules specific to the oil and gas industry sector.

Very few peer-reviewed research studies have been conducted on the local effects of industry emissions. One notable study in the Barnett Shale used an the extensive monitoring system installed in the Dallas-Fort Worth area by the Texas Commission on Environmental Quality in early 2000. This network includes seven monitors at six locations and measures up to 105 volatile organic compounds. The peer-reviewed study, *Evaluation of Impact of Shale Gas Operations in the Barnett Shale Region on Volatile Organic Compounds in Air and Potential Human Health Risks* (Bunch, et al, 2013), represents the first large-scale evaluation of potential human health risks and impacts. Air sampling included a range of shale gas activities, including drilling, hydraulic fracturing and production. Based on a comparison of the measured chemical concentrations in ambient air to federal and state health-based values, results showed shale gas production activities have not resulted in exposures that would pose a health concern.

Wildlife Protection

In certain areas, the individual well pads, service roads and associated infrastructure such as gathering lines, can intersect wildlife habitat. The issues involved can become particularly acute when the habitat of a threatened or endangered species under the Endangered Species Act is potentially affected by unconventional resources development activities.

As a general matter, as previously discussed, unconventional resources development operations through multi-well pads and horizontal drilling techniques result in significantly less habitat disruption by reducing the potential impact compared to other methods and energy sources. As a result, oil and gas activities generally affect only a small portion of the surface estate within any habitat.

Oil and gas companies, including ExxonMobil, have a long history of working with the Fish and Wildlife Service and others to mitigate impacts to species that are protected, threatened or endangered. We believe all stakeholders, private land owners, agriculture, state and local governments, manufacturers and others, should be included in conservation plans. We also believe any conservation measures adopted by the Fish and Wildlife Service should include a mitigation plan to restore species and allow access within a habitat based on mitigation. Such conservation measures should not rely on avoidance of habitat as the sole mitigation measure.

XTO continuously monitors all potential Endangered Species Act impacts through trade associations and internal working groups. We actively work on mitigation concerning impacts from near-term species listing decisions and seek means to adjust operations to minimize species impact when practicable. Using geospatial analysis as a preliminary screening tool, we have identified 47 candidate species that could potentially impact operations.

We support and participate in research to better understand wildlife protection issues. For example, in 2010, we initiated a substantial multiyear, cooperative wildlife research program in conjunction with Colorado State University and the Colorado Parks and Wildlife Commission. The research program is designed to identify ways for industry to reduce its environmental impacts and improve the compatibility of resource extraction activities with wildlife. XTO has provided $5 million to assess and enhance habitats for large animals and sage grouse in the Piceance Basin in Colorado. See Figure 23 below.

Figure 23 – Production in the Piceance Basin; Researchers Collecting Habitat Data and Tagging Wildlife

XTO also initiated a joint research project with Oklahoma State University to study how oil and gas activities may affect the American Burying Beetle in Oklahoma. Begun in 2011, the study spans five years and we committed $1.1 million in support.

Health

Concerns about possible health risks from unconventional resources development focus mainly on the proximity of industrial activity to local populations. Many federal and state agencies, academic consortia, individual researchers, and members of industry are all examining potential health effects of unconventional resources development. We recognize these concerns and are working to address them through internal and external activities, involving multiple collaborations with experienced researchers.

To date, no sound peer-reviewed study has identified a plausible route of exposure through air, water, or other means and related adverse health effects from unconventional resources. However, there have been many claims of health impacts that have caused understandable concerns that should be evaluated. Because high stress is one proven means to cause adverse health effects, special care should be taken by all participants in this discussion to remain grounded in science and a responsible search for evidence-based findings. The challenge for responsible, objective stakeholders is to critically assess all reports to distinguish scientific, evidence-based findings from unsupported claims.

We manage the risks from our unconventional resources development operations in a responsible manner. We proactively participate in health-related discussions and conduct research to assess potential health risks and whether further management of risk is needed. We have a long history of involvement in health research and a proven record of studying and responding to health concerns associated with our business activities in a responsible fashion.

ExxonMobil helped create an "Exploration and Production Health Issues Group" within the American Petroleum Institute devoted to upstream oil and gas health effects, and currently serves as the group's chair. Through API, we seek to highlight and support studies that are conducted according to accepted scientific protocols. In particular, we believe such studies should define:

- An examination of potential hazards originating from unconventional resources development;
- A plausible route or routes by which humans are exposed;
- Assessments of risk to health; and
- Clinically confirmed adverse health effects that can plausibly result from those exposures, through epidemiological studies that follow standard, acceptable protocols.

Increasingly, media reports give strong prominence to screening level studies that do not conform to the necessary protocols. Sound epidemiological research is needed to clinically confirm potential health impacts and such research is not quick or easy to conduct. The characteristics of a sound epidemiological study are the following:

- Accepted study design (e.g., cohort, case-control, cross-sectional, the latter with acknowledged limitations regarding temporality of cause/effect);
- Properly selected exposed and unexposed groups (or cases and controls), with matching or stratification of potential confounders (e.g., age, socio-economic status, smoking);
- Clinical documentation of health outcomes or another form of verification of health outcomes other than self-reporting;
- Plausible exposure pathway scenario from source to receptor, verification of the plausibility of the pathway, proper exposure metrics to describe the pathway;
- Adequate control of potential selection bias, not self-selection;
- Adequate control of potentially confounding variables;
- Adequate statistical analysis, incorporating effects of confounding, interaction, temporality, co-exposures, possible bias, model selection, etc.;

- Adequate population sizes with proper documentation of precision (preferably confidence intervals);
- Adequate control of exposure classification bias, quantification of bias or sensitivity analyses;
- Proper interpretation of results with strengths and weaknesses properly reflected, attention to internal consistency, coherence, multiple hypotheses testing, and alternative explanation of effects (e.g., co-exposures, socio economic changes); and
- Expert peer review and publication in a reputable journal.

One study rarely satisfies all of these criteria, but they provide a means for interested stakeholders to judge the quality and credibility of studies they may see in the media that purport to present findings on the health effects of unconventional resources development. A short-hand checklist would be: use of established protocols, peer review by experts in the field, and publication in a reputable journal.

Communities are exposed to a range of information of varying quality regarding hydraulic fracturing and unconventional resources development. We will continue take a leadership role to assess and manage health risks, promote sound research, and provide clear communication to address concerns and advance understanding of the benefits and risks of developing unconventional resources.

Community Engagement

While controversies such as methane emissions and disputes over seismicity or water contamination play out in the national media, our operations occur on the local level. Community members see our rigs, must drive behind trucks, and live together with our employees. We place great emphasis on how our operations affect local communities and strive to establish and maintain strong relationships at the local level.

We seek to have a positive impact in the communities in which we operate. We want to understand, discuss, and appropriately address any community concerns with our operations. The well-being of the communities in which we operate is more than a business concern – it's personal. Many of XTO's operations are in or near communities where our employees live alongside other residents.

Each community's needs and concerns are different. We work with residents, local officials and regulatory authorities to address concerns regarding the impact of our operations on the local community. For example we:

- Meet with community and elected leaders about our operations and practices.
- Provide speakers and technical experts for community events and educational briefings.
- Deliver regular operational updates to inform local officials and community leaders of planned local activity.
- Participate in local industry forums or host open houses to allow community residents to meet with XTO personnel and learn more about our operations in their area.

- Post our company name and contact information at all operating sites.
- Post appropriate safety signage at all operating sites.
- Address concerns/inquiries in a timely manner.

To address local community concerns about our activities, we take steps such as:
- Limiting truck traffic during school transit hours and through neighborhoods and, where practicable, through installation of temporary freshwater pipelines for completion activities.
- Using sound mitigation technology at compressor stations and around active drilling sites, where applicable.
- Working with conservation organizations on site restoration projects, involving reintroducing native plant life and trees.

We also invest in efforts to enhance the quality of life in communities where we operate by:
- Providing grants to local organizations and school districts.
- Working with conservation organizations on site restoration projects.
- Participating on non-profit boards.
- Encouraging active employee participation in their communities. Our employees have volunteered countless hours of their personal time to a wide variety of community organizations including local schools, fire departments and food pantries.

Finally, we place great emphasis on emergency response and preparation. Our personnel are trained to deal with emergency situations and regularly team up with local responders to conduct preparedness exercises. XTO also works closely with local first responders to inform the public about its operations and provides training for emergency responders.