

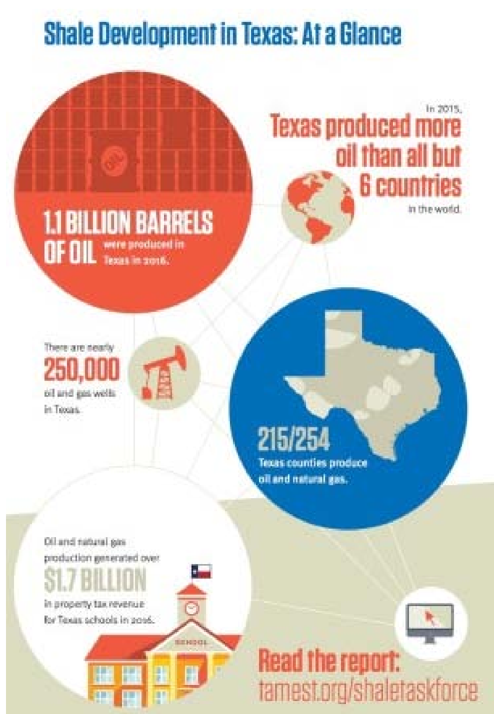

Environmental and Community Impacts of Shale Development in Texas

Posted by Content Coordinator on Tuesday, July 18th, 2017

THE ACADEMY OF MEDICINE, ENGINEERING AND SCIENCE OF TEXAS (TAMEST)

Summary

By many measures, including annual revenues and number of employees, the oil and gas industry is one of the world's largest business sectors. It includes not only U.S.-based firms, but also major energy corporations based in China, the Netherlands, the United Kingdom, and many other nations. Major changes in the oil and gas industry have substantive implications for and effects upon all other business and commercial sectors, both in the United States and around the world.



The biggest change in the global oil and gas industry during the past decade has been the proliferation of horizontal drilling and multi-stage hydraulic fracturing. Improvements in many aspects of the technologies and materials used in the horizontal drilling and hydraulic fracturing processes have opened up vast shale deposits that previously were not viable economically for oil and gas production.

A significant portion of this major energy development and technological breakthrough since the mid-2000s has taken place in Texas. Today, Texas produces more crude oil than any other state, and is responsible for more than one-third of the nation's total oil production (EIA, 2017a). Texas oil production in 2015 was larger than that of all but six countries (EIA, 2017b).

Texas has long been a major producer of domestic oil and gas supplies and products. Texas remains a leading United States oil and gas producer and, in fact, the state today is on par with many of the world's major energy-producing nations. These changes in the Texas oil and gas sector have important implications not only for Texas, but also for the entire United States as well as other parts of the world. These new technologies have opened access to vast new supplies of natural gas that in many areas are partly displacing coal for power generation.

The development of shale and related hydrocarbon resources continues to expand. At the same time, there is opposition to this expansion in many places, including some U.S. states, such as New York, and some nations, such as France. However, hydraulic fracturing for shale development will continue to be an important and likely growing part of the Texas and United States energy production portfolio. A better understanding of the many implications and effects of shale development will help identify research priorities that, in turn, will support improved management of many different risks and environmental mitigation activities. One theme common to several chapters in this report is a call for easier and wider access to data from shale development operations to all interested parties.

The Academy of Medicine, Engineering and Science of Texas (TAMEST) convened a task force to prepare this report on the Texas shale development experience. This report covers the underlying science for six topic areas as it pertains to shale exploration and production activities: 1) geology and earthquake activity; 2) land resources; 3) air quality; 4) water quantity and quality; 5) transportation; and 6) economic and social impacts.

There is a need and opportunity to improve the broad understanding and awareness of the impacts of shale production. This study aims to help all Texans better understand what is and is not known about the impacts of shale oil and gas development in Texas, and offer recommendations for future research priorities.

Beyond this report's explicit six topic areas, in its deliberations the task force noted there are numerous transdisciplinary connections across these six topic areas. For a variety of reasons, these connections generally have not been evaluated systematically. A better integration and evaluation of factors that cross multiple subject matter areas would provide a more comprehensive understanding of shale development activities, and its implications for Texas communities and biophysical, economic, and social systems.

Furthermore, time and spatial scales regarding the dynamics of geophysical systems, ecosystems, public entities (such as schools and health care facilities) and investments in road construction and maintenance vary considerably. A more sophisticated analytical approach to integrating across these topic areas, and to developing policies and investments accordingly, requires better understanding and appreciation of these different scales and processes.

This summary presents findings and recommendations, in bold-faced print, from the six topic areas addressed in this project, followed by findings and a recommendation regarding transdisciplinary connections and trade-off decisions among the six topic areas. These findings and recommendations are also presented within and at the end of each chapter.

Geology and Earthquake Activity

The scientific knowledge base of Texas geology and earthquake activity is extensive. Research in this broad scientific field dates back over 100 years, and data collection and studies have been led by experts in the state's numerous large universities, private industry, and some nongovernmental groups. Considering that body of research and knowledge as a collective whole, and attempting to issue broad statements regarding its general adequacy in helping understand a given topic, is a daunting task.

One reason simply is the size of Texas. It is the nation's second-largest state; only Alaska covers more territory. For a frame of reference, its areal extent of 268,580 square miles makes it larger than the Colorado River Basin of the Southwestern United States, which covers large portions of seven U.S. states. The systematic and sustained collection of subsurface data across an area of this size, and the geologic heterogeneity that exists across Texas, represents a considerable challenge and undertaking. A great deal of scientific information has been collected and analyzed, and there have been many advances in this knowledge. Further studies will be necessary to develop a more detailed and sophisticated understanding of these large and complex systems.

The geology of Texas is highly complex, which inhibits clear understanding of the many geological faults across the state and their dynamics. There are significant differences across the state in the composition of the underlying geologic formations, strata, and subsurface geophysical processes. Texas' geology also is unique. It is interesting to note that in comparison to Oklahoma, for example, seismicity in Texas is substantially different. The ratio of the number of magnitude M3.0 earthquakes between Oklahoma and Texas is approximately 60 to 1. The historical record of seismicity in Texas is based on written records and sparse, sometimes limited, instrumental data. Available data indicates increased rates of seismicity in a limited geographic area over the last several years.

As specified in the language of Texas House Bill 2 of 2015, a program—referred to as TexNet—was initiated to provide additional resources to enhance geophysical monitoring across the state. Overseen by multiple universities in the state, research currently being conducted using TexNet funds is focused on understanding the potential relationships between subsurface injection of fluids related to oil and gas production and earthquakes in the vicinity of faults. Chapter 3 provides additional details on the TexNet initiative. These narrow, yet highly complex research goals cannot be accomplished without also performing more fundamental research tasks. In response to increased rates of

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seismicity in some areas, the Railroad Commission (RRC) of Texas has amended rules to address seismicity in oil and gas regions.

There is ongoing, vigorous research collaboration among academia, industry, and state regulatory agencies. Parties and initiatives include The University of Texas at Austin Bureau of Economic Geology Center for Induced Seismicity Research (CISR); the $4.7 million TexNet seismic monitoring program that includes collaborators from universities, federal and state governments, and industry; and States First, an induced seismicity workgroup initiative that is a multi-state and multi-agency collaborative effort. Improved understanding of potentially-induced seismicity will require these types of long-term, sustained, cross-disciplinary research efforts.

Findings

- Geologic faults are ubiquitous across Texas; these faults are poorly and incompletely characterized.
- The majority of known faults in the subsurface in Texas are stable and are not prone to generating earthquakes.
- There has been an increase in the rate of recorded seismicity in Texas over the last several years. Between 1975 and 2008 there were, on average, one to two earthquakes per year of magnitude greater than M3.0. Between 2008 and 2016, the rate increased to about 12 to 15 earthquakes per year on average.
- Under certain unique geologic conditions, faults that are at or near critical stress may slip and produce an earthquake if nearby fluid injection alters the effective subsurface stresses acting on a fault.
- Mechanisms of both natural and induced earthquakes in Texas are not completely understood, and building physically-complete models to study them requires the integration of data that always will have irreducible uncertainties.
- To date, potentially induced earthquakes in Texas, felt at the surface, have been associated with fluid disposal in Class II disposal wells, not with the hydraulic fracturing process.
- The TexNet goals address an integrated research portfolio that considers seismicity analysis, geologic characterization, fluid-flow modeling, and geomechanical analysis.

Recommendations

- Future geologic and seismological research initiatives should develop improved and transparent approaches that seek to balance concerns surrounding data handling and sharing, and that promote sharing of data.
- Development of a common data platform and standardized data formats could enable various entities collecting data to contribute to better data integration. It also could facilitate interdisciplinary collaboration directed toward mitigation and avoidance of induced seismicity.

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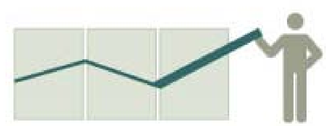

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