
Balancing Environmental Tradeoffs, Societal Issues, and Energy Production

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EXTENDED ABSTRACT

Clean burning natural gas begins with environmentally friendly drilling and production. While industry has made great strides in protecting the environment while increasing production, producers still face challenges to effectively operate in environmentally sensitive areas. The Environmentally Friendly Drilling (EFD) program, managed by the Houston Advanced Research Center (HARC), integrates advanced technologies including rig designs, drilling fluid systems and waste management, into systems that significantly reduce the impact of operations in environmentally sensitive areas. The team focuses on technologies for developing unconventional energy resources that can be used in environmentally sensitive areas to maintain standard of living and preserve quality of life. The program objective is to identify, develop and transfer critical, cost effective, new technologies that can provide policy makers and industry with the ability to develop U.S. domestic reserves in a safe and environmentally friendly manner.

The EFD program began in 2005 and has shown that 90% or more of the impacts on the environment can be reduced if low impact technology is combined into a complete system. Currently, over 100 organizations back the effort, offering financial and in-kind support, as well as advice and guidance concerning the program. New participants from environmental organizations, academia, state and federal agencies, government laboratories, and industry continue to join. The partnership identifies technologies and transfers them to areas that must incorporate new practices to address environmental concerns. Regional partners optimize technologies to fit the needs of their locale. Partners routinely come together to discuss progress with the sponsors/advisors. The program was honored with the Environmental Partnership Chairman's Stewardship Award from the Interstate Oil and Gas Compact Commission at its 2009 annual meeting.

This paper discusses the history of the program, current work efforts, advances in technology made in reducing environmental tradeoffs, and addressing societal issues.

Overview of the Environmentally Friendly Drilling Systems Program

The Environmentally Friendly Drilling Systems (EFD) program, managed by the Houston Advanced Research Center (HARC), integrates advanced technologies into systems that significantly reduce the impact of energy production in environmentally

sensitive areas. The team focuses on technologies for developing unconventional energy sources that can be used in environmentally sensitive areas to maintain our standard of living and preserve our quality of life. The objective is to identify, develop, and transfer critical, cost effective, new technologies that can provide policy makers and industry with the ability to develop U.S. domestic reserves in a safe and environmentally friendly manner.

To date, the EFD program has made over 40 presentations issued over a dozen publications and has held four major workshops. The EFD program has created a University/National Laboratories Alliance to fund and transfer critical new technologies that accelerates development of domestic reserves in a safe and environmentally friendly manner. The research is aimed specifically at identifying and developing safe and environmentally friendly technologies.

The EFD program provides a comprehensive technology transfer effort that includes outreach to industry, non-governmental organizations, government officials, and the general public. In addition, a scorecard system is being developed to recognize those companies which employ the most applicable technologies and systems that minimize the environmental tradeoffs of oil and gas operations in sensitive ecosystems.

The EFD program integrates several projects and programs that are funded by the Research Partnership to Secure Energy for America (RPSEA), the U.S. Department of Energy through the National Energy Technology Laboratory (NETL), and private industry and environmental organizations. Additional funding is expected from the Minerals Management Services (MMS) through the Coastal Impact Assistance Program (CIAP). Example programs and projects include:

- Texas A&M University—Systems Engineering Design Methodology/Low Impact Well Design Optimization: Developing a computer program to enable operators to select and optimize environmentally friendly systems for drilling operations.
- Texas A&M University—Produced Water Studies: Investigating the various issues associated with processing produced water in the Marcellus Shale.
- University of Colorado—Best Management Practices Database: Developing a website that discusses various best management practices and most applicable technologies to address various rules and regulations for operations in the Rocky Mountains.
- University of Arkansas—Dissemination and Decision Support: Replicating the effort performed under the Low Impact Natural Gas Operations program for the Haynesville Shale. Program will develop a geographic information system (GIS) based information site that includes operational information, permits, endangered species, topography, and other information.
- University of Wyoming—Western Mountain States Studies: Work includes the further development of the prototype lay down road system and initial field testing.
- Utah State University & Sam Houston State University—Societal Acceptance: Investigating the public perception of unconventional natural gas operations in eastern Utah.
- West Virginia University—Eastern Mountain States Studies: Identifying barriers associated with unconventional natural gas development in the Marcellus Shale.
- Prototype Small Footprint Drilling Rig: Will perform prototype tests of new technology that have lower cost and lower environmental impact that can benefit domestic exploration and production.
- Application for Semi-Arid Ecosystem: Holding workshops to identify low impact systems for specific regions.

- **NOx Air Emissions Studies:** Developing guidelines for reducing emissions from large diesel engines associated with unconventional natural gas operations.
- **Reduced Hydraulic Fracturing Footprint:** Identifying alternatives to reduce the footprint including offsite operations and innovative fracturing technologies such as a novel process involving minimal pumping equipment, low volumes of frac fluid, and materials that are environmentally green and non-damaging.
- **Measuring the Effectiveness:** Developing the Environmentally Friendly Drilling scorecard. Prototype tests of the measurement methodology to occur during late 2010.
- **Ecosystem and Biodiversity—Measurement and Assessment:** Developing tools for adaptive ecosystem management to assist integrated management of land, water and living resources that promote conservation and sustainable use.

The EFD management team is pursuing various sources of long term funding. Industry funding covers specific projects through 2012 at which time funding for the next phase will be pursued. The program is positioned to receive funding from the Coastal Impact Assistance Program (CIAP) beginning in late 2010 that could extend into 2018. EFD management is also working with industry to identify Supplemental Environmental Projects.

The EFD management team is building relationships with state (Texas, Colorado, Wyoming, New Mexico, New York, Pennsylvania, and others) and federal agencies administrators and policy makers.

Reducing the Drill Site Size

One of the major goals of this project is to reduce the ‘physical’ footprint of the drill site and access road. The project’s stated goal is a footprint of less than one acre. This can be accomplished if an environmentally friendly drilling system is employed. Technologies that could be used in an EFD system to meet this goal have been identified. Two industry sponsors—Huisman and National Oilwell Varco (NOV)—manufacture rigs and have supported our project. Our work incorporates information from meetings with these sponsors, plus other companies which build and operate rigs including Helmerich & Payne, Nabors Drilling, and Xtreme Coil Drilling. The evolution of rigs in the drilling industry is evident as other companies are introducing new smaller footprint rigs including Schramm, Honghua America, MD Cowen (DC Electric super single), Pioneer Drilling, IDM Quicksilver, and others.

These companies and others are building the next generation small, efficient rigs. The features include:

- Minimized rig-up/down time,
- Compact well site footprint,
- Reduced environmental impact,
- Smaller crew size,
- Lower transport cost,
- Fast, efficient pipe handling,
- Minimized accident exposure,
- Smaller equipment size,
- Reduced transport loads by as much as two thirds,
- Smaller access road requirement,
- AC driven—minimized hydraulics, reduced emissions, and
- Meet the majority of drilling conditions.

There are over 250 drilling contractors in the U.S. These companies range from very large contractors including Patterson-UTI, Nabors, and Helmerich & Payne to small companies who only operate one or two rigs. The current fleet of rigs is old and many rigs are out of date, they are too big and expensive to move, and have a large footprint. According to an annual report published by Hadco International the average rig in the field is 20 years old and there are some rigs that are 50 years old and still running.

The depth capability of the rig is controlled by the input horsepower (HP [0.82 kW]) of the draw works. On average the drill depth rate per HP is 11 ft/HP (0.41 m/kW) (but this depends upon the size and weight of the drill pipe), so that a 1,000 HP (746 kW) rig is generally capable of drilling 11,000 ft (336 m). The modular rigs covered in this report have on average a 1,500 draw works HP rating (1,119 kW). Most gas wells today are drilled horizontally. It is reasonable to expect a modern 1,500 HP (1,119 kW) rig can drill the majority of gas wells that are 10,000-12,000 ft (3,050-3,660 m) in depth with 4,000 ft (1,400 m) plus horizontal sections. These rigs also have two 1,600 HP (1,193 kW) mud pumps and are set for top drives.

It is important to note that there is also a number of shallow (>8,000 ft or >2,440 m true vertical depth [TVD]) oil and gas wells drilled in the U.S. Many coal-bed methane wells are less than 2,000 ft (610 m) in depth, and even including a horizontal section, the total wellbore is relatively shallow. A 1,500 HP (1,119 kW) rig is “overkill” for drilling these wells. While not thoroughly covered in this report, most rig manufacturers build smaller, more compact and even more mobile rigs for these conditions. Many are truck mounted and are easily transported, such as the coiled tubing rig shown in [Figure 1](#).

When the EFD project was initiated, an illustration ([Fig. 2](#)) from the University of Kansas was used that showed a “Present” footprint size of six acres. The evolution, as



Figure 1. Coiled tubing rig on location.

shown, documented the progress the industry has made to reduce the footprint and produce more oil and gas. “Present” was in 2004. We believe it is possible to reduce this footprint to a one acre site and still achieve the depth targets required for the majority of gas and oil wells being drilled in the U.S. by incorporating a system of EFD technologies.

The rigs highlighted here have a footprint of 25,000 to 30,000 sq. ft (2,325 to 2,790 sq. m). The total drilling footprint must also include the other equipment used in drilling process, this requirement can double the size of the pad. Even doubled, at 60,000 sq. ft (5,580 sq. m), the site is only 1.4 acres (0.567 hectares), well below the 2004 benchmark. In addition, more than one well can be drilled from a pad, so that the drill site may slightly increase when multiple wells are drilled, but the per-well average can be less than one acre.

Figure 3 shows an Helmerich & Paynerig pad site for Williams Company, where 11 wells were drilled from this one site. This is similar to how wells are drilled offshore and is becoming more common in areas where it is critical to eliminate the number of well sites. Figure 4 shows the various conductor pipes for the wells and the rail system that was used for skidding the rig.

Horizontal drilling, illustrated in Figure 5, is another offshore drilling technology that has been applied to onshore locations, enabling long-throw wells to be economically drilled and completed.

Pad drilling enables multiple wells to be drilled from one surface location. Steerable drilling technologies enable these wells to be safely drilled as illustrated in Figure 6.

This report shows the average footprint from using newer generation rigs and rig capabilities. Added benefits include the reduced size of work crew, improved safety performance, and improved environmental performance in emissions, roads, discharges, and land impacts.

Statistics show that pipe and material handling cause almost 50% of the recorded accidents during drilling. The fully automated pipe handling, with its automated drill floor, eliminates the need for personnel on the drill floor and thus eliminates the potential for accidents. In addition, the simple modular rig-assembly process—with smaller loads, less rig crew involvement, and improved overview and visibility—effectively mitigates the risk for the crew and the potential for accidents and damage during rig moves.

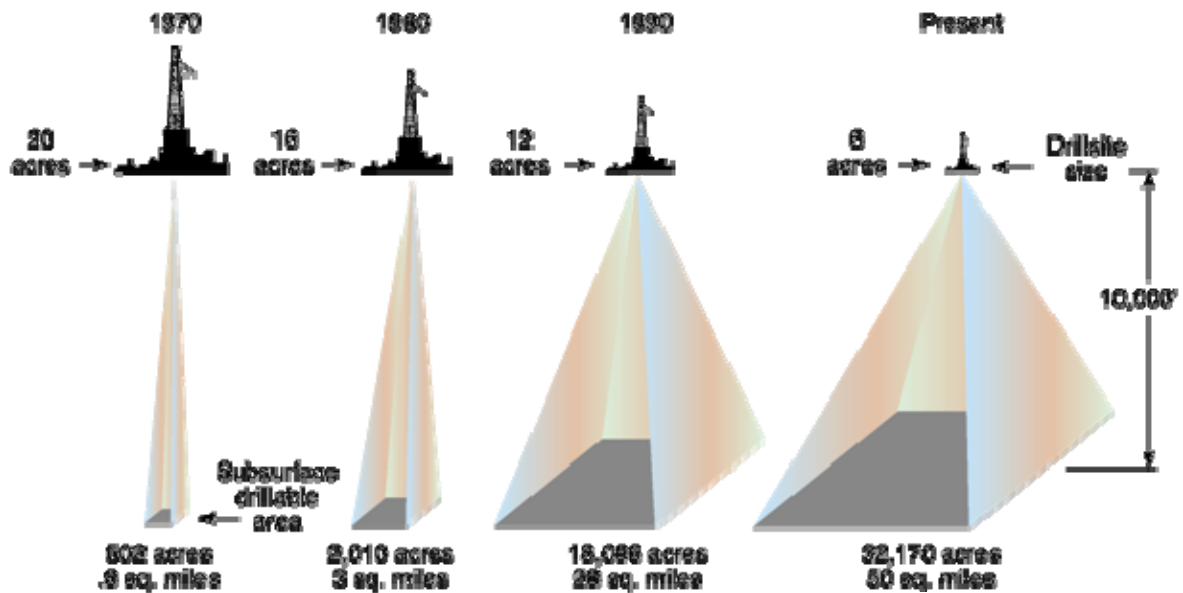


Figure 2. Kansas graphic.

Social and Environmental Issues

For the EFD program to be successful, it must engage, listen to, and address the energy exploration and production concerns of the general public and key stakeholders. The economic value of oil and gas resources is continually increasing. Concomitantly, the intrinsic value of protecting human communities and the natural environment are also incessantly increasing. Solutions to problematic issues associated with the social and environmental costs of energy production must take precedence. From the outset of the EFD program, we have empirically examined and documented the associated social and environmental issues through comprehensive research-based scientific studies and disseminated our findings in a variety of venues.

In multiple sites across the U.S., we have surveyed government and regulatory agency personnel, non-governmental organization representatives, community leaders, and members of the general public to measure: (a) their interest, knowledge, attitudes, experience, current behaviors, and behavioral intentions with respect to energy exploration and production issues; (b) the degree to which they would accept (or not accept) increased energy exploration and production in ecologically sensitive areas (i.e., coastal wetlands, desert ecosystems, and hardwood forests); (c) the degree to which they would accept (or not accept) increased energy exploration and production on various ownership-types of land (i.e., private lands, state lands, and federal lands); (d) their level of familiarity with environmentally friendly energy exploration and production practices; and (e) their level of agreement that environmentally friendly energy exploration and



Figure 3. Helmerich & Payne rig drilling for Williams Company.



Figure 4. Cellar showing various conductor pipes for wells. Also shown is the rail system for moving the rig.

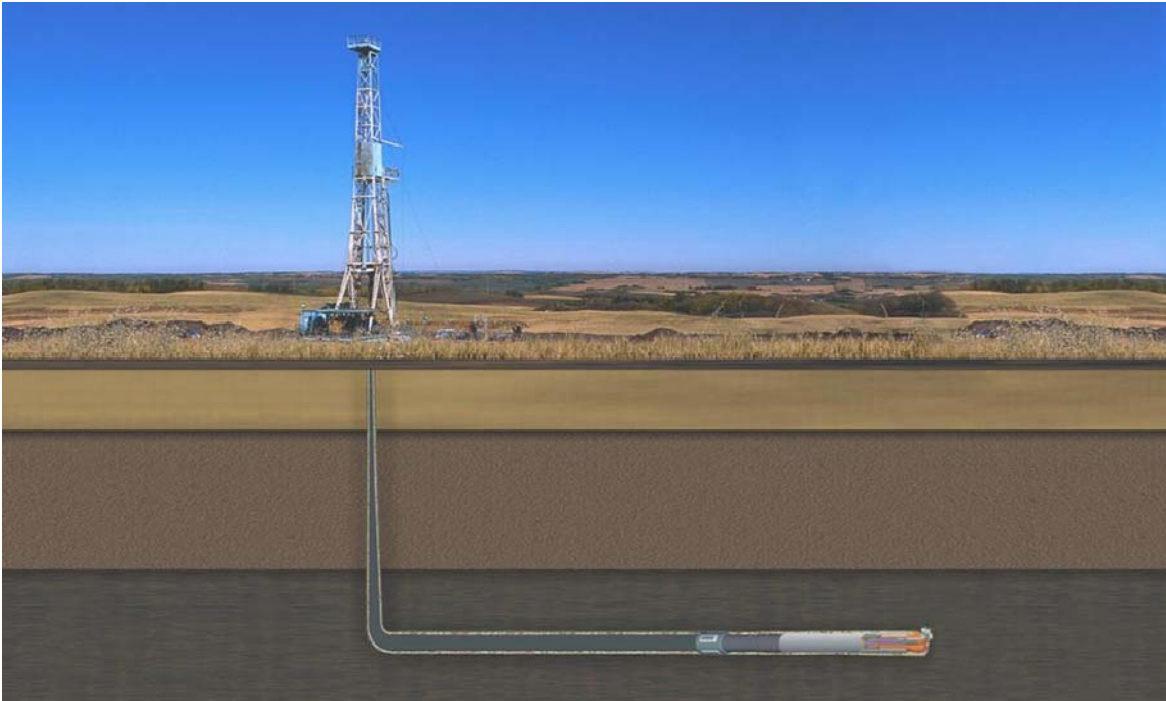


Figure 5. Illustration of horizontal drilling.

production practices can be used in environmentally sensitive areas that are currently off-limits or highly restricted, should such areas be opened. Data collected in these studies are leading to improved theoretical and empirical understanding of the social and environmental issues associated with energy exploration and production. The findings from these studies have been, and continue to be, disseminated at appropriate professional meetings (Theodori, 2008a, 2009a; Theodori et al., 2006, 2009b, 2010) and in manuscripts for publication in academic and applied journals (Anderson and Theodori, 2009; Haut et al., 2009; Theodori, 2008b, 2009b; Theodori et al., 2009).

Presently, our attention is turning to outreach education efforts. Drawing upon the scientific knowledge gleaned from our research, we are preparing to develop and distribute fact-sheets and other educational materials regarding the acceptance and assimilation of environmentally friendly energy exploration and production practices. Furthermore, we are arranging to conduct workshops in several areas of the country. The primary focus of the workshops will be to establish mature, meaningful dialogue among members of the general public, community leaders, representatives of oil and gas associations, regulatory agency personnel, non-governmental organization representatives, and other interested individuals with respect to the acceptance and assimilation of environmentally friendly energy exploration and production practices. We believe that transparent, honest, and full communication is paramount. As Theodori et al. (2010) stated:

The energy industry must inform local residents about the potentially positive aspects and negative consequences of energy development in and around their communities. At the same time, community leaders, government and regulatory agencies, environmental organizations, and other stakeholders must effectively communicate their hopes, fears, and/or anxieties associated with unconventional gas development to each other and, in turn, to industry. Open and honest communica-

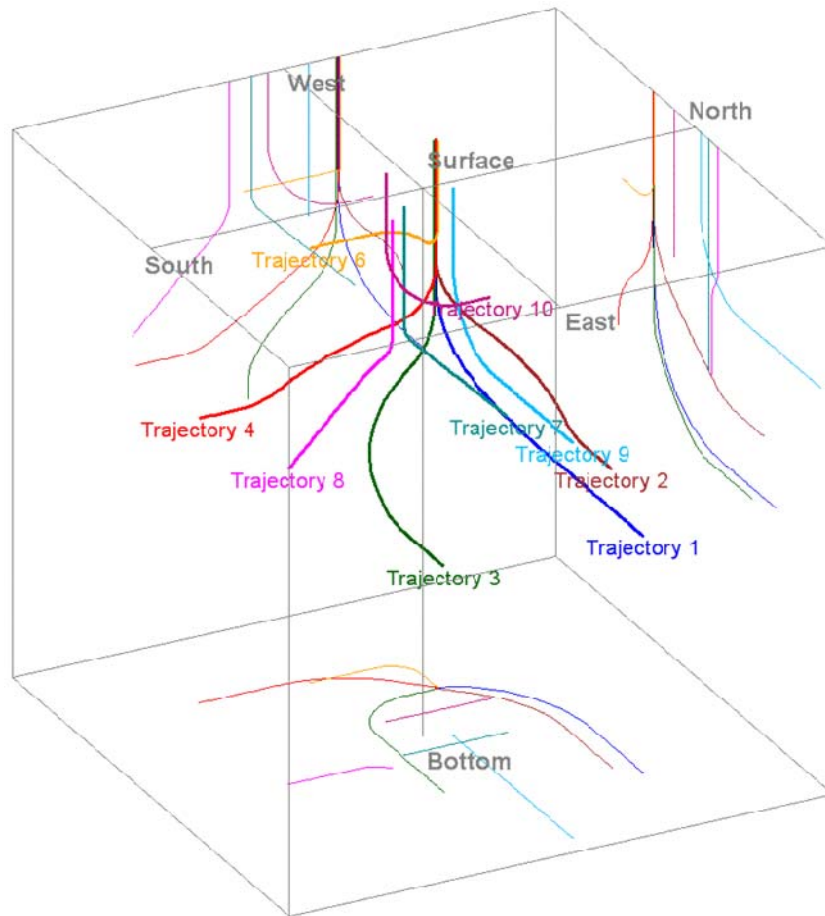


Figure 6. Well planning software allows drillers to use drilling steerable technologies that enable multiple wellbores to be drilled.

tion will reduce the spread of rumors and inaccuracies about perceived negative consequences of current activities and proposed developments at the local level. Furthermore, county and municipal leaders must communicate the concerns of their constituents to industry and work with them to minimize the negative “objective” aspects of the unconventional gas recovery process.

For industry, these workshops will serve as a venue to showcase low-impact technologies and other environmentally friendly drilling systems which have substantially reduced adverse impacts in the social and environmental arenas. By informing and educating the various stakeholders, industry can begin to change the misconceptions of problems associated with energy development and gain the public’s trust. Moreover, the outcome of the workshops is expected to result in revised regulatory controls, lower development cost and reduction of the environmental footprint associated with operations.

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