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POTENTIAL BARRIERS TO INCREASED PRODUCTION OF NATURAL GAS FROM UNCONVENTIONAL SOURCES

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POTENTIAL BARRIERS TO INCREASED PRODUCTION OF NATURAL GAS FROM UNCONVENTIONAL SOURCES

INTRODUCTION

Natural gas wells in the United States produce more BTU's of energy than is produced by all of the domestic crude oil wells. Reserves and production of natural gas (just as crude oil reserves) have been steadily declining in recent years. Current natural gas reserves are estimated to be about 208 Tcf (1 Tcf = 1 trillion cubic feet = 1 quad). Current usage of natural gas is about 20 Tcf/year. At this rate we have barely a ten-year supply of natural gas. (It has been estimated that consumption may rise to 25 Tcf/year by 1985).

If natural gas is to continue to make an important contribution to meeting the energy needs of the U.S., it is obvious that other sources of gas must be identified and brought into commercial production. Sources of gas not currently being produced commercially are generally termed "unconventional." The Department of Energy and the Federal Energy Regulatory Commission have identified four candidate resources as having the highest potential for near-term production of natural gas from unconventional sources. These resources include: (Unconventional Gas Recovery 1979, pg. 5)

- Western Gas Sands with recoverable reserve estimates ranging from 50 to 320 Tcf
- Eastern Gas Shales with reserves estimated to be from 10 to 520 Tcf
- Methane from Coal with reserves estimated at 16 to 500 Tcf
- Geopressed Aquifers with potential reserves from 150 to 2000 Tcf.

The combination of these resources has the potential to increase U.S. gas supplies over current levels by as much as a factor of twenty. DOE has initiated projects directed at accelerating the commercialization of each of these resources. The two largest projects are directed at technology development and demonstration and geological data development in Western Sands and Eastern Shales. These resources appear to have the highest potential for near-term commercial production. Smaller projects were initiated in Coalbed Methane and Geopressed Aquifers in fiscal year 1978. DOE's goal is to achieve at least 3 to 6 Tcf of production per year from these four unconventional resources (Ham and Dewey 1978).

"Unconventional" gas resources will become "conventional" resources when their commercial viability is assured. There are a number of barriers preventing commercial production of gas from the four major unconventional gas resources discussed above. These barriers can generally be classified as:
The goal of the overall DOE program for commercialization of unconventional gas is to identify the major barriers for each technology, to evaluate the potential impact of these barriers and to develop methods of removing or mitigating the impact of these barriers wherever possible.

Responsibility for assuring that new energy technologies are developed in an environmentally responsible manner has been given to DOE's Office of Environment (EV). EV's programs are structured to identify environmental concerns associated with new technologies as early as possible and to work with other DOE offices to assure that appropriate environmental controls are developed in parallel with efforts to develop and demonstrate technology. This approach minimizes the total time required to bring a technology into commercial production. One of the tools DOE uses in the process of identifying and evaluating environmental issues associated with new technologies is called an environmental technology assessment. Preparation of these assessments is the responsibility of the Technology Assessment Division (TAD) in the Office of Technology Impacts of EV. A technology assessment provides an in-depth evaluation or risk assessment of the environmental, health and safety impacts that could result from a particular emerging energy technology.

This paper presents the results to date of an environmental technology assessment for unconventional gas recovery. The work is being performed at Pacific Northwest Laboratory* and Lawrence Berkeley Laboratory. A realistic scenario for recovery of gas from each of the four resources has been developed. This scenario formed the basis for identifying potential environmental impacts from these technologies. Each impact area was then evaluated to estimate the potential magnitude of the environmental risk produced to identify environmental controls that could be expected to be applied and to determine the effectiveness of these controls. This work will be used by TAD to determine if there are significant environmental barriers to commercialization of unconventional gas resources. Other potential barriers to development of these technologies were also identified in the study to place the environmental issues in perspective and to aid in developing schedules for development of any environmental control technologies that might be needed. A summary of the work for each of the four resource areas is presented below.

WESTERN GAS SANDS

Western Gas Sands is a generic description for a number of low permeable sedimentary basins stretching westward from Arkansas to Oregon and northward from Texas to the Canadian border. DOE, through the Bartlesville Energy Technology Center (BETC), has sponsored research, development and demonstration projects in the Western Gas Sands area since 1974. (Actually if the AEC is included, activities started in 1967 with Project Gasbuggy.) The locations of major Western Gas Sands Formations are shown in Figure 1. The costs for most of these projects have been shared by DOE

* PNL is operated for DOE by Battelle Memorial Institute.
FIGURE 1. Location of Tight Gas Sand Basins (Western Gas Sands Project 1978)
and Industry. The major objective of these projects has been to demonstrate the commercial viability of gas production from this resource. The locations of past and current DOE sponsored projects are shown in Figure 2.

The overall technology associated with this resource is indistinguishable from standard oilfield practices. If these practices are adhered to the overall environmental, health and safety impacts are very minimal. Principal sources of environmental impacts are:

- Land usage and restoration
- Wastewater disposal
- Fugitive emissions
- Groundwater contamination

During field operations large areas of land are cleared, killing the local flora and disrupting the fauna. Road traffic may lead to dust pollution and road kills of fauna. After usage, land must then return to its previous state. Current regulatory programs appear adequate to control these impacts.

Since most western gas sands are located in federal lands, all gas recovery steps are doubly regulated. States, through their oil and gas conservation offices (or their equivalent), enforce and regulate all field activities. The U.S. Geological Survey (USGS) has similar rules and regulations which also must be complied with. Thus, there should be very minimal impacts associated with drill pad siting, road construction and site restoration.

A number of western wells produce relatively large quantities of brines which must be disposed of in an environmentally acceptable manner. Current regulations and oilfield practices appear to provide adequate controls for minimizing the impacts from brine disposal. A National Pollutant Discharge and Elimination System (NPDES) report must be filed and complied with before disposal of these brines. If wells produce at levels which preclude obtaining an NPDES, they are usually shut in.

Large numbers of diesel engines operate during drilling, road construction, fracturing and site restoration. While these can produce high localized noise levels and emit CO\(_x\), NO\(_x\) and particulates, these emissions have significant concentrations only for limited times in very localized areas. Minimal impacts are expected from these emissions.

A major potential environmental concern associated with this gas resource is the possible pollution of ground water. During large fracturing jobs the potential for fracturing up to potable water exists. It is also difficult with current techniques to monitor for groundwater contamination. However, to date no groundwater contamination problems have been detected. Current procedures in place to prevent groundwater contamination appear to provide reasonable assurance that groundwater resources will be protected. Implementation of further controls does not appear to be warranted.
Activities have been stimulated in some of these basins by the enactment of the Natural Gas Policy Act of 1978 (NGPA) which allows higher price for gas from these basins. In spite of this the major barriers to commercialization of these resources remain:

- gas price
- limitations of risk capital
- pipeline delays.

A typical 10,000 foot well in the Greater River Basin may cost $1,500,000 to drill and complete. A good well in this area may produce from 1 to 5 MMscfd/day. Prior to the NGPA, this resource was uneconomical but this seems to be changing.

Gas price and risk capital are interrelated since a higher gas price will free more risk capital for drilling. The early estimated need for 3,300 miles of gas pipeline (Ham and Dewey 1978) may be an overestimate. At present there is adequate capacity in both Wyoming and Utah to handle an increase in natural gas production.

In addition to the barriers listed above, several other barriers of a technical nature also exist:

- uncertain well performance
- water availability
- regional manpower shortages.

Stimulation procedures, primarily massive hydraulic fracturing (MHF) and foam fracturing, are being used successfully in many of these areas to improve well performance. The current state of technology appears to be adequate where it has been used.

If large numbers of fracturing jobs are run, water availability could be a problem. At the present time, water is being obtained via local city supplies. A typical massive hydraulic fracture (MHF) job may use upwards of 300,000 gallons of water and a million pounds of sand as a proppant. At the current level of activity water availability does not appear to be a problem.

Regional manpower shortages and a lack of available drilling rigs are caused by a lack of money. Given sufficient dollar availability, drill rigs and crews are available. This is true in spite of an all-time high in drilling activities.

While some barriers to commercialization of this resource exist, they are minimal. Activity is on the increase in this area and it should become an important source of natural gas in the near future.

**EASTERN GAS SHALES**

Eastern Gas Shales refers to those shales, mainly of Devonian age, which are found deposited in the Appalachian, Illinois and Michigan basins. The location of the major Eastern Shales deposits in the U.S. are shown in Figure 3.
Limited production from wells completed in shales has occurred, primarily in the Appalachian area, for at least the past forty years. These wells have been characterized by low flow rates, but very long life (for normal gas well production).

Because of the large potential of these resources and their proximity to major gas load centers in the East and Midwest, DOE through Morgantown Energy Technology Center (METC) has funded a number of projects to exploit this resource.

Environmental impacts of production of gas from Eastern Shales are very similar to those discussed previously for Western Sands. The principal difference is in the area of brine production. Production of brines is not a problem for wells in shale since virtually no water is produced. There are no significant environmental barriers to utilization of this resource.

The principal barriers to commercialization of Eastern Gas Shales are technical. These barriers include:

- Few successful wildcats
- Low productivity
- Poor stimulation procedures
The lack of successful wildcats is the main reason that METC has focused its effort on geological studies. The thrust of this effort is to better understand the reason that certain areas produce gas while similar nearby areas are dry.

Successful wells that have been completed in shale generally produce at a low rate of about 50 Mcf/d and with low wellhead pressures. These low productivity rates may preclude the installation of a long pipeline and transmission system. Stimulation of shale wells to enhance production rates presents many problems. The most successful of these jobs involves either N₂-foam fracturing or CO₂-cyrogenic fracturing. The principal difficulty with these jobs is the interaction between the formation and the water contained in the fracturing fluid. Not all stimulation jobs have been successful. One stimulation technique which has been used consisted of LPG, methanol, and N₂. The one job was very successful, but the fluids are now considered too dangerous for use.

Commercialization of this resource appears to be promising. Low pressure would suggest a local usage. The environmental concerns are minimal. The major thrust in research is to develop better data for use in selecting drilling targets.

METHANE FROM COAL

The Methane from Coal Project is directed at the recovery of natural gas contained in most coal seams. Natural gas is a byproduct of the coalification process and is present in almost all coal formations. In fact, natural gas is a major safety hazard in underground coal mining. The location of the large coal deposits in the U.S. are shown in Figure 4.

The principal barrier to the utilization of the natural gas found in coal seams remains the question of who owns the free natural gas present within coal seams.* Until this barrier is resolved no significant production can occur. In some instances where both the coal and gas rights are owned by a single source this may not be a problem. The European Mining Industry routinely recovers the copresent natural gas. The United Kingdom has recovered this natural gas for over thirty years. Germany recovers approximately 60% of its total coal seam produced natural gas (the other 40% being vented to the atmosphere.) This amounts to $13 \times 10^9$ cubic feet/year. Other European countries recover from 2 to $7 \times 10^9$ cubic feet/year. Borehole drainage is the method normally employed. In 1976, 3,653 boreholes were drilled in Germany alone. The European experience has demonstrated that extraction and commercial utilization of methane from coal is practical.

DOE through METC has funded six projects to date. The principal objective of these projects has been to demonstrate the feasibility of the utilization of this gas.

* This issue has been at least partially resolved in a precedent-setting suit involving U.S. Steel vs. Mary Cunningham et al. The court ruled that the person owning the oil and gas rights could produce the gas as long as no fracturing of the coal seam is attempted.
FIGURE 4. Areal Distribution of Coals in the Contiguous U.S. (adapted from Irani et al. 1973, p. 3)
The principal area of environmental impact associated with recovery of methane from coal seams is the disposal of the appreciable quantities of highly saline waters that are produced. This concern is mitigated by the permitting process for waste water disposal. There do not appear to be any significant environmental barriers to commercialization of this resource. In fact, drainage of natural gas prior to mining has a positive occupational safety effect. The natural gas occluded in coal seams historically has contributed to a large number of fatalities which occurred during mining. Mine operators expend considerable efforts to keep methane levels in underground mines below the 1% maximum methane concentration allowed by the Mining Safety and Health Administration.

Besides the legal question of gas ownership, the principal obstacles to commercialization of this resource are low productivity and the low BTU quality of the produced gas. A typical well in a coal seam may flow at rates below 50,000 cf/d. The gas may have a heating value of only 800-900 BTU/cf. Gob* gas is typically of 500 BTU/cf. This is below what is considered to be pipeline quality gas. This gas must either be upgraded in quality or other uses must be found. Several research projects are underway to examine local usage and generation of electricity directly.

None of these barriers are insurmountable. The major obstacle to commercialization remains the ownership of the natural gas. Once this obstacle is overcome this resource should produce gas commercially.

GEOPRESSURED AQUIFERS

Lying along the Gulf Coast, stretching from southern Texas up through Louisiana are regions which have abnormally highly pressured brines, the geopressed zones (see Figure 5). Natural gas is contained within these zones with the brines. To date there has been very limited testing of these zones. DOE through BETC is currently sponsoring two tests, one well in Louisiana and a two-well test in Texas. These tests are being done to determine if it is possible to recover energy from this resource in an economical manner.

The principal barriers to the utilization of this resource base are:

- Environmental
- Economics
- Geologic

All of these barriers represent major obstacles which must be overcome before any significant gas production can begin. Potential environmental, health and safety problems associated with production of gas from this resource include:

- Produced water disposal
- Probable subsidence
- High formation pressures.

* A "Gob" is the area within a coal mine in which the roof has collapsed. Gob gas is the gas from the gob area.
FIGURE 5. Location of Geopressed Aquifers

It has been generally estimated that up to 100,000 BL/day/well of brines will be produced from a commercially viable well. This level of brine production from one well is comparable to that from an entire oil field undergoing full waterflood. These brines, having high salinity (up to 100,000 TDS), represent potential environmental control problems. Control techniques must be developed before this resource can be utilized extensively.

Withdrawal of large quantities of fluid from reservoirs is known to contribute to subsidence (e.g., Wilmington Field Long Beach, California). This resource is located in a fragile marsh region in which subsidence of a few feet could significantly change the local ecology. This could represent an almost insurmountable barrier to commercialization.

The geopressed regions are characterized as being regions of abnormally high pressure normally exceeding .95 psi/ft. This substantially increases the potential for blowouts. The drilling industry has developed blowout prevention techniques that work effectively in other regions with similar high pressures. The high pressures associated with this resource are therefore not felt to be a major barrier to commercialization.

There is a general lack of knowledge about the geologic strata of this region, caused by a lack of active wells. It is currently unknown how these reservoirs will act during production making any predictions about this resource impossible.
The economic viability of this resource is unknown. There is not sufficient production history to make a realistic assessment. Current estimates indicate that the best treatments show that it is not economical to develop this resource (Todd Dosher 1979).

The current exploitation of this resource appears to be very questionable. The general technical, geological and economic uncertainties and high probable chance of adverse environmental impacts indicate that development of geopressed aquifers is a long way off. Commercial production is not expected before 1990, at the earliest. New information obtained using ongoing research may, however, lead to further utilization of geopressed aquifers.

CONCLUSION

As with any technological endeavor, exploration and production of gas from unconventional sources will result in some environmental effects. For Western Sands, Eastern Shales and Coalbed Methane, it appears that application of environmental controls currently in use in gas field production will result in these effects being localized and temporary. Environmental concerns do not appear to represent significant barriers to commercial production of gas from these resources. The principal barrier to commercial production of gas from Western Gas Sands remains one of gas price. The barrier appears to be disappearing. Lack of adequate geological information for use in selecting potential drill sites appears to be the principal barrier to production of gas from Eastern Shales. The legal question of gas ownership and the conflicting interests of coal and gas producers seems to be the principal hurdle that must be overcome before significant quantities of Methane from Coalbeds will be utilized commercially. For Geopressed Aquifers, the environmental barriers of subsidence and disposal of produced brine water appear to be major constraints. These are expected to preclude significant production of gas from this resource in the near future.

The resource with the largest near-term capability for commercialization appears to be Western Gas Sands. This resource is estimated to yield 1-2 Tcf/year by 1982. It is more difficult to estimate the probable contribution from the next two most likely resources; Methane from Coal and Eastern Gas Shales. These resources might be capable of yielding from .01 to 1 Tcf/year by the mid-1980's. Current engineering evidence seems to indicate that no significant quantities of gas will be produced from geopressed aquifers in the foreseeable future. Information from current tests now underway in Texas and Louisiana should permit better evaluation of the long-term viability of this resource.
REFERENCES


