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Project Summary

Unconventional Natural Gas Resources: An Overview Covering the Resources and Environmental Aspects of Production

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As part of our Nation's study of alternative means to achieve energy independence, especially over the critical mid-term period from 1985 to approximately the year 2000, an overview of unconventional sources of natural gas, with emphasis on associated environmental aspects, was produced.

Natural gas is the cleanest fuel at the point of utilization and is currently the major fuel for residential heating, a very dispersed application that environmentally is relatively unregulated. It is therefore in the interest of those having the major responsibility for insuring a clean environment to encourage the use of this clean burning fuel. In order to accomplish this goal we must know the extent of natural gas resources, including the unconventional sources that may supply much of this fuel by the year 2000, and any significant environmental consequences of producing gas from unconventional sources.

This Project Summary was developed by EPA's Office of Environmental Engineering and Technology, Washington, DC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Natural gas is a mixture of the low-molecular weight paraffin-series hydrocarbons consisting mainly of methane, with lesser quantities of ethane, propane and butane and small amounts of higher hydrocarbons. It also frequently contains small proportions of nitrogen, carbon dioxide, hydrogen sulfide and occasionally helium. *Sour natural gas* contains objectionable amounts of hydrogen sulfide and other sulfur compounds. Natural gas accompanying petroleum always contains appreciable quantities of ethane, propane, and butane as well as some pentane and hexane vapors and is known as *wet gas. Dry gas* contains less of these higher hydrocarbons. The exact composition of natural gas varies with locality. The heating value of natural gas is usually over 1,000 Btu/cu ft unless nitrogen or carbon dioxide are important components of the gas. Natural gas is used directly as a fuel and as a chemical feedstock. When the gas comes from an oil well, its higher hydrocarbon content is often extracted and used for blending in motor fuel and as a liquefied gas To be acceptable for injection into a pipeline, gas must meet standards acceptable to the pipeline carrier.

Natural gas reserves are located in underground formations that can be

economically and legally tapped at the time of discovery. Proved natural gas reserves may be divided into drilled, i.e. producible by means of existing operating practices, and undrilled, i.e. underlying areas which are so related to developed acreage and to the known geology and structure that their productive ability is considered assured. The term "reserves" connotes gas deposits of near-term economic interest, whereas the term "resources" embraces marginal, sub-marginal, and latent deposits as well as reserves. As the price level increases, a portion of the resource base is transferred to the reserve base. Even though the natural gas reserve level is well defined, there is considerable uncertainty about the extent of remaining recoverable natural gas resources.

Table 1 indicates our natural gas reserves as of year-end 1979. The bulk of these are found in high permeability sandstone and carbonate reservoirs that are generally located in the Gulf Coast and Southwest regions of the United States.

In addition to conventional natural-gas resources, a number of unconventional gas resources may augment our natural gas supply. The report addresses the potential of unconventional gas sources for providing significant levels of industrial and pipeline quality gas. The following sources are addressed:

- The gas-bearing Devonian shales of the eastern United States (eastern gas shales),
- The low-permeability (tight) gas sandstones of the Rocky Mountain region (western gas sands),
- The free methane (natural gas) present within coal seams (methane from coal),
- The high-pressure, methane-saturated saltwater aquifers of the Gulf Coast region (geopressured aquifers), and
- Landfills where residential, commercial, and industrial waste have been disposed.

Gas from landfills is not generally categorized as unconventional. However, since this gas is currently being commercially extracted, it is included.

Table 1. *Year-end 1979 Natural Gas Reserves*

	Lower-48 States	*Total U.S.*
Proved Reserves	*163.0 Tcf*	*194.9 Tcf*
Reserve Additions in 1979	*13.7 Tcf*	*14.3 Tcf*
Production in 1979	*19.7 Tcf*	*19.9 Tcf*
Reserve to Production Ratio	*8.3 years*	*9.8 years*

Table 2. *Resource Base of Unconventional Sources of Natural Gas*

	Base (Tcf)	
Source	*In-place*	*Recoverable*
Western Tight Sands	*50-600*	*25-310 (170)*
Devonian Shale	*75-700*	*10-500 (30-285)*
Coal Seam Methane	*70-860*	*15-490 (300)*
Geopressured Methane	*3,000-50,000*	*150-2,000 (150)*
Total	*3,200-52,000*	*200-3,000 (650-905)*

Table 3. *Potential Gas Supply from Unconventional Sources — 1985 and 2000*

	Supply (Tcf)	
Source	*1985*	*2000*
Western Tight Sands	*0.35-0.78*	*3.0 - 6.9*
Devonian Shale	*0.12-0.26*	*1.0 - 2.3*
Coal Seam Methane	*0.3 -0.8*	*2.5 - 5.6*
Geopressured Methane	*0*	*0.22- 0.5*
Total	*0.75-2.0*	*7.0 -15.0*

Table 4. *Recent Production from Unconventional Resources*

Resource	*Recent Production Level (Tcf/yr)*	*Comment*
Western Tight Sands	*0.10*	*In 1980*
Devonian Shale	*0.15*	*In 1979 from 9600 wells*
Coal Seam Methane	*(none identified)*	
Geopressurized Aquifers	*(none identified)*	
Recovered Landfill Gas	*Less than 0.004*	*In 1980*

Discussion

Natural gas currently supplies approximately 27 percent of the energy consumed in the United States. Since 1970, the proved U.S. natural gas reserves have been declining, with production exceeding additions. Currently the proved reserve to annual consumption ratio is less than 10. The Energy Information Administration indicates that over the last 15 years, the return-to-drilling value (reserve additions per foot drilled) has rapidly declined. This implies that unconventional gas resources will need to be used to support our natural gas requirement.

The potential contribution of unconventional gas to our eventual supply is unknown. Unconventional sources have not been well exploited. They include gas-bearing geologic formations that are hard to reach and/or low-permeability formations that must await technical and economical feasibility. Large uncertainties include: (1) the magnitude of the gas resource contained in these sources, (2) the capability to extract the gas, and (3) the economics of extraction. Estimates of the resource base, the reserves, and the potential gas supply in the foreseeable future (i.e. to year 2000) are widely varied. The low- and high-estimates clearly indicate that knowledge of the geology and feasibility of unconventionals is tenuous. It should be noted that relatively small amounts of gas have been and are currently being produced from unconventional resources.

Tables 2, 3, and 4, based on references and considerations contained in the full report, indicate the uncertainty in both the resource base and the potential gas supply from these sources.

In general, gas obtained from the above unconventional sources is either of pipeline quality or can be upgraded to pipeline quality through the use of existing, commercially available technology.

Pipeline and near-pipeline-quality gas is currently being obtained from

Devonian shales and western (tight) gas sands. The well-completion techniques (e.g. explosive shooting and hydraulic fracturing) have been used for some time and environmental considerations have not inhibited well development. In addition, small amounts of gas have been obtained from landfills and coal deposits. To date, no gas has been obtained from geopressured aquifers. Of the considered unconventional gas resources, only methane-from-coal and gas from geopressured aquifers appear to pose any associated environmental concerns of significance.

Many factors could impede the recovery of methane from coalbeds. These include legal considerations (e.g. ownership of gas) and the effects of gas recovery on the mineability of the inplace coal.

Since coal beds are hard to penetrate, production of methane from coal seams at commercial flow rates is impeded. The pockets containing gas must be tapped and the flow of gas stimulated (e.g. by means of hydraulic fracturing). The acceptable disposal of the wastewaters that have collected in the gas pockets is an environmental problem. Although the amount of wastewater produced from the operations has not been quantified, data describing the water quality from three coalbed operations indicate that the two largest constituents are chlorides and dissolved solids, and calcium and magnesium are other important components. Techniques normally used for treating wastewaters are applicable to this problem.

The environmental impacts of gas extraction from geopressured aquifers are generally thermal and mineral pollution, and subsidence. One estimate suggests that five trillion barrels of brines would ultimately be produced from geopressurized aquifers. This is the equivalent of the total two-year flow of the Mississippi River. The brines are known to be saline, extremely hot, and to contain boron, which, in minute quantities, is toxic to marine life.

Economic utilization of gas from geopressured aquifers dictates the extraction of large volumes of fluids. The extraction of these fluids will cause a reduction in reservoir pressure and an increase in effective stress in the reservoir framework. In those areas of the Gulf Coastal Plain where groundwater extracted from shallow aquifers has caused stress changes, surface subsidence often resulted. Consequently, the major environmental concerns associated with the development of geopressured resources relate to the possibility of subsidence of land surface in the immediate vicinity of the producing wells and the disposal of the large volume of produced brine.

Landfill gas is typically comprised of about 50% methane and 50% carbon dioxide, and the percentage by volume of both can vary widely. Nitrogen and oxygen are normally present in small amounts as a result of air being trapped as the waste is deposited or as a result of a negative internal pressure when landfill gas is extracted. In addition, there are trace amounts of numerous compounds in the landfill gas.

If raw landfill gas is to be used for space heating or hot water heating, the only processing required is simple water and particulate removal. An elaborate and expensive control technology is unnecessary. Furthermore, since such uses do not require large volumes of gas, many smaller landfills across the country may be tapped. Landfill gas, upgraded to pipeline quality (i.e. to close to 1,000 Btu), can be used interchangeably with natural gas. Consequently, the gas from most large landfills may be applied as a substitute for natural gas. In addition to moisture and particulate removal, the processing of landfill gas upgraded to pipeline quality would include CO_2 removal. Although the technology necessary to achieve this quality is relatively straightforward and relatively available, large capital expenditures are involved.

In general, the degree of upgrading and/or cleanup required for gases from the considered unconventional sources are as follows:

Gas Source	Gas Cleanup Required
Western Gas Sands	None to minimal
Devonian Shale	None to minimal
Coal Seams	None to moderate
Geopressured Aquifers	Possibly moderate or greater
Landfills	Minimal to moderate, depending on use

A mature technology base and numerous processes are available for upgrading gas quality and removing undesirable components such as H_2O, CO_2, H_2S, carbonyl sulfide (COS) from gases. The removed sulfur compounds may be converted to marketable elemental sulfur or sulfuric acid or may be disposed of in accordance with environmental regulations. In this regard, many proprietary and non-proprietary processes continue to be used.

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The complete report, entitled "Unconventional Natural Gas Resources: An Overview Covering the Resources and Environmental Aspects of Production," (Order No. PB 82-260 886; Cost: $7.50, subject to change) will be available only from:
National Technical Information Service
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