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ECONOMIC POTENTIAL OF GEOPRESSURED AQUIFERS UNDER DIFFERENT SCHEMES OF EXPLOITATION

Robert Quitzau and Dr. Zaki Bassiouni

Petroleum Engineering Department
Louisiana State University
Baton Rouge, Louisiana 70803

ABSTRACT

A calculation technique was developed to evaluate the economic potential of a geopressured aquifer for numerous conditions that could allow the expolitation of this unconventional gas resource. This technique allows for the evaluation of both wells drilled with the sole intent of producing the geopressured resource and of unsuccessful conventional hydrocarbon wells completed in geopressured intervals. The calculation technique allows also for the consideration of different water disposal methods and different taxation schemes.

The technique was applied to a typical Gulf Coast geopressured aquifer. From this application it is apparent that for certain likely conditions the conversion of an unsuccessful conventional hydrocarbon well into a geopressured brine well is economically feasible, provided that any associated environmental and legal problems can be overcome.

INTRODUCTION

Numerous massive, geopressured water bearing strata containing dissolved natural gas exist in the coastal areas of Louisiana and Texas. [1] These strata consist of sands with some interbedded shales. While the areal extent of these geopressured aquifers is considerable. The degree of sand continuity within these areas is uncertain. Individual sands are known to shale out or be cut by small splinter faults.

Properties considered typical of potentially productive aquifers are summarized in Table 1.

The gas concentration seems extremely low when compared to the gas content in most liquid hydrocarbons under pressure. However, because of the tremendous volume of water present, the total gas content in a particular prospect can be quite large. In a study made by the National Petroleum Council [1] on some of the many geopressured prospects in the Gulf coast area, it was estimated that eleven of the best prospects contained approximately 6.7 trillion cubic feet of gas.

TABLE 1

TYPICAL AQUIFER CHARACTERISTICS [1,2]

Depth	10,000-20,000 ft
Pressure Gradient	0.7-0.9 psi/ft
Temperature Gradient	1.5°F/100 ft
Areal Extent	2,600-10,400 Acres
Net Sand Thickness	100-500 ft
Gas Solubility	20-40 SCF/BBL
Porosity	0.10-0.25
Permeability	2.0-100.0 md
Water Visocity	0.2-0.3 cp
Water Density	8.7-8.9 ppg
Avg. Water Comp.	2-10 x 10^{-6} psi^{-1}

AVAILABLE OPTIONS FOR GEOPRESSURED ENERGY PRODUCTION

At best geopressured aquifers containing dissolved gas can be considered a marginal resource at current gas prices. [3,4,5,6] Because of the marginal nature of this resource optimal aquifer conditions and production methods must be found if there is to be a chance for a company to profitably develop a geopressured aquifer.

Numerous different situations that could allow aquifer production may become available to an interested company. The first situation is called the geopressured well case. This is the case in which the well is drilled for the sole purpose of producing from a geopressured aquifer. The second situation is called the dry hole case. This is the situation in which a well intended to produce deep conventional hydrocarbons is found to be dry and is completed in a geopressured aquifer. The third situation is called the marginal hole case. In this situation a well, drilled for conventional hydrocarbons, is logged and found to have a hydrocarbon zone of questionable productivity. The well is completed in this zone and proven to be uneconomical. The well can then be recompleted in the geopressured aquifer.

From the point of view of a company interested in the development of a geopressured aquifer, the difference in the three situations that would allow aquifer production occurs in the capital cost assigned to the well for the purpose of evaluating the economic potential of the aquifer.

Once it is determined that a well will produce from a geopressured aquifer, a method must be chosen for the disposal of the large volume of produced water. Three different water disposal methods may be considered: (1) reinjection of produced water through a single well into a deep formation (depth greater than 5,000 ft); (2) reinjection of produced water through more than one well into shallow formations (depth less than 5,000 ft); and (3) surface disposal of the produced water.

The taxes imposed by the government on the income received from the geopressured aquifer will also have an impact on the economic potential of this resource. Two different taxation schemes are considered in this study. The first method of taxation is the taxation scheme that is normally applied to the production of conventional hydrocarbons. The second taxation method is a scheme which contains an incentive designed to encourage geopressured aquifer development.

Numerous tax incentives have been proposed for the geopressured resource.[7] One such incentive is a tax credit based on the volume of produced natural gas. In this study a credit of 50¢/MCF is used as the tax incentive. 50¢/MCF is the credit proposed at one time by the Senate version of the Energy Tax Act of 1978.

ESTIMATION OF PRODUCTION RATE FROM A GEOPRESSURED AQUIFER

The economic analysis of a project requires a reasonable estimation of its future revenue. In most cases, technical problems put aside, the optimal revenue schedule will be such that as much of the potential revenue will be recovered in as short a time as possible. A revenue schedule of this nature will tend to maximize the present value of a project. For the case of production of gas from a geopressured aquifer, this optimal schedule can be obtained by flowing the well at its maximum rate for a constant surface pressure. This maximum rate declines continuously with time.

McMullan[8] and Quitzau[9] developed a calculation technique to predict the relationship between flow rate and time for a constant surface pressure. For this relationship, flow rate will decline in a continuous manner as time passes. The technique developed approximates this decline with a series of decreasing flow rates that are each maintained for a set time interval.

THE ECONOMIC POTENTIAL OF A GEOPRESSURED PROSPECT

In trying to determine the economic feasibility of a particular venture, a measurable parameter which is an indication of economic potential must be defined. In this study net present value was chosen as the basis for determining economic potential because it considers the time value of money, and it is applicable to situations in which risk and uncertainty are significant factors.[10] Net present value is the net sum of all present and future cash flows discounted to current time using the average opportunity rate of the developing company.

Since all cash flow is discounted, a net present value greater than zero indicates that the prospect of interest would yield a rate of return greater than the company's average opportunity rate. A company would strongly consider development of such a prospect if sufficient funds are available. A net present value less than zero indicates that the rate of return of the project is less than the average opportunity rate of the company. Such a project would not normally be undertaken.

THE UNCERTAINTY OF PARAMETERS USED TO CALCULATE NET PRESENT VALUE

For a particular prospect, accurate values of all the parameters needed can be difficult to obtain. Many unknown and unforseeable factors affect cost parameters. It is difficult to accurately know the rock and fluid properties if only a few wells have penetrated the aquifer.

At best, a range of possible values of each parameter can be estimated. For a large company that is considering the undertaking of numerous similar projects, this situation lends itself to the use of Monte Carlo simulation as a technique for estimating net present value of a prospect.

THE ESTIMATION OF ECONOMIC POTENTIAL FOR A TYPICAL GEOPRESSURED PROSPECT

The calculation technique was applied to the Southeast Pecan Island prospect in south Louisiana. The data used in this application is summarized in Tables 1, 2, and 3.

It was shown by McMullan[8] that the water production from a geopressured aquifer is heavily dependent on the areal extent of the aquifer. The area covered by many geopressured prospects is known to be quite large. However, the actual extent of the area is uncertain. Estimates of aquifer area vary widely. The presence of splinter faults and the possibility of sand discontinuity are the primary causes for the uncertainty.

Because of the wide variance of possible values, three different ranges of area were used:

Small area	640-2560 acres
Intermediate area	1280-5120 acres
Large area	2560-10240 acres.

The relationship between net present value and gas price was calculated for different possible combinations of production conditions. These results are summarized in Figures 1, 2, 3, and 4. A set of base production conditions can be considered to illustrate the impact of the different production situations. The base conditions are: (1) dry hole case; (2) shallow disposal of water; (3) normal taxation; and (4) intermediate aquifer area.

TABLE 2

FIXED PARAMETERS

Working Interest	= 100%
Royalty	= 0%
Average Opportunity Rate	= 15%
Formation Water Density	= 8.75 lb/gal
Water Formation Volume Factor	= 1.05 BBL/STB
Depth of Production Tubing	= 17,200 ft
Wellbore Radius	= 0.375 ft
Production Tubing ID	= 4.90 in.
Tubing Roughness	= 0.00065
Flowing Wellhead Pressure	= 500 psi
Ad Valorem Tax	= $31,500/yr

TABLE 3

CAPITAL COST AND OPERATING EXPENSES

	Maximum Value	Minimum Value
Tangible Capital Costs		
Geopressured Drilling	833,000	614,433
Conventional Drilling	674,800	497,800
Completion	1,088,000	750,000
Recompletion	25,000	18,000
Production Facilities	547,000	350,000
Deep Disposal Facilities	1,631,900	1,019,900
Shallow Disposal Facilities	676,000	400,000
Surface Disposal Facilities	377,200	341,300
Intangible Capital Costs		
Geopressured Drilling	4,609,000	3,128,000
Conventional Drilling	3,733,500	2,533,800
Completion	910,000	650,000
Recompletion	644,000	450,000
Production Facilities	215,000	110,000
Deep Disposal Facilities	2,761,400	1,935,100
Shallow Disposal Facilities	2,400,000	1,700,000
Surface Disposal	150,000	75,000
Operating Expenses		
Normal Operating Cost ($/yr)	60,000	36,000
Deep Disposal Cost ($/bbl)	0.1423	0.1068
Shallow Disposal Cost ($/bbl)	0.0536	0.0402
Surface Disposal Cost ($/bbl)	0.0120	0.0090

Figure 1 shows the impact of the production well situation on economic potential. The marginal and dry hole cases result in net present values significantly greater than the geopressured well case. The marginal hole case yields net present values slightly higher than the dry hole case.

For the marginal and dry hole cases the gas prices required for the prospect to have a positive net present value are near the upper range of current gas sale prices. For the geopressured well case, gas prices in excess of $15/MCF are required to yield a positive net present value.

The impact of disposal method on economic potential is illustrated in Figure 2. High capital and operating costs cause the deep reinjection method to yield net present values far less than the other two disposal methods considered. The very low capital and operating costs of the surface disposal method result in the highest net present values of the three methods studied.

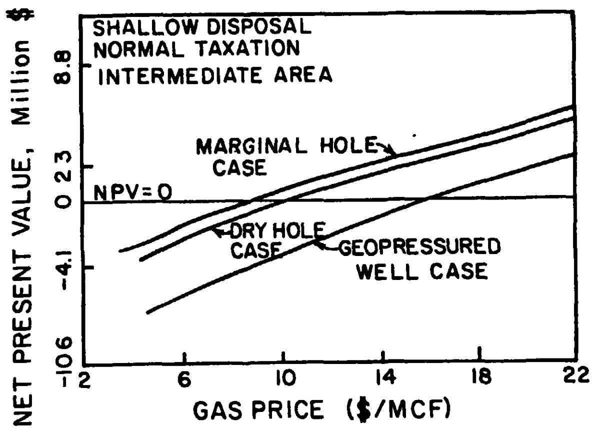

FIGURE 1: EFFECT OF PRODUCTION WELL SITUATION ON ECONOMIC POTENTIAL

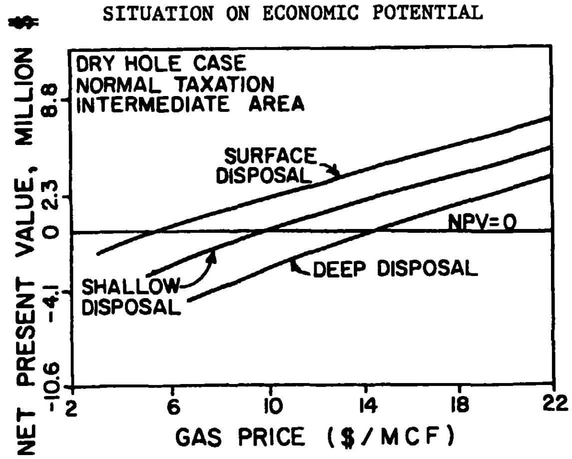

FIGURE 2: EFFECT OF DISPOSAL METHOD ON ECONOMIC POTENTIAL

The effect of the tax incentive on the economic potential is shown in Figure 7. In this situation it appears that the incentive used has only a slight positive effect on the economic potential.

Figure 8 shows the effect of the distribution of area on economic potential. As expected the net present value increases significantly as the area increases.

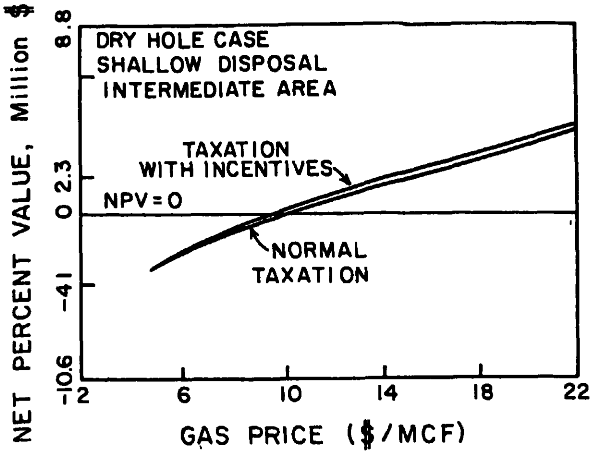

FIGURE 3: EFFECT OF PRODUCTION WELL SITUATION ON ECONOMIC POTENTIAL

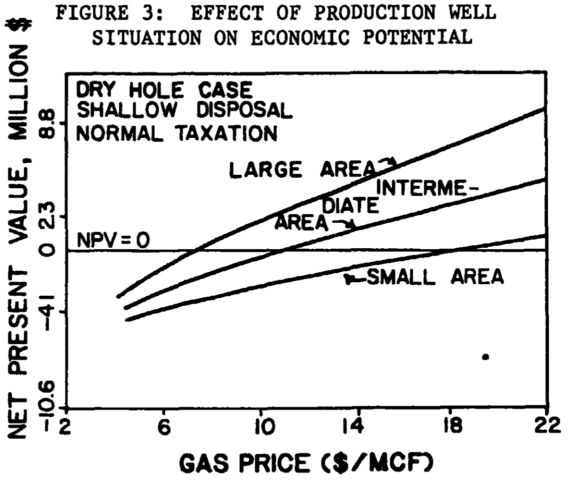

FIGURE 4: EFFECT OF DISPOSAL METHOD ON ECONOMIC POTENTIAL

CONCLUSIONS

(1) It appears that the development of geopressured aquifers will not be economically feasible in the near future if production wells are drilled for the specific purpose of producing from the aquifer. However, results indicate that the conversion of unsuccessful conventional hydrocarbon wells to geopressured brine wells may be economically advantageous, provided legal and environmental problems can be overcome. For these cases the gas price required to yield a positive net present value to a company can be within the range of current gas sales prices.

(2) The high capital and operating costs of using deep disposal methods can greatly reduce the economic potential of a prospect. Shallow reinjection or surface disposal of produced water can result in a significantly higher economic potential than obtained using deep disposal. Efforts should be undertaken to resolve any associated environmental problems.

(3) The economic potential of a geopressured prospect is significantly affected by areal extent. However, results obtained for certain situations using areas similar to those currently drained by some conventional gas wells indicate a positive net present value for gas prices near the upper limit of current gas sales prices.

(4) The tax credit of 50¢/MCF used in this study as an incentive resulted in only a slight increase of net present value for a typical geopressured prospect. A tax credit greater than 50¢/MCF or additional tax incentives should be considered by government institutions in order to significantly increase the attractiveness of the geopressured resource.

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