Geopressured Energy Fighting Uphill Battle

The potential payoff was large, but now a bonanza seems unlikely and the search for profitable prospects will probably be long and hard

The idea is simple enough. Drill down 3000 to 6000 meters into the coastal rocks of Texas and Louisiana, strike the hot, pressurized water that drillers had encountered thousands of times before in their search for oil and gas, and bring the water to the surface to extract its heat energy and the natural gas dissolved in it. Everyone thought that such geopressured-geothermal energy might give a boost to the nation's search for new domestic supplies of energy. A few people believed that it would dwarf the known oil and gas resources of the United States.

This is one of a series of occasional articles about the prospects and problems of alternative energy sources.

It now appears that even the modest hopes for geopressured-geothermal energy will be difficult to fulfill. In the course of its initial drilling of geopressured zones, the Department of Energy (DOE) has found that the natural gas, which is now the main interest of researchers, may be less concentrated than had been hoped. Further dimming its prospects, energy industry experts are putting into print what many of them believed before the latest drilling—that geopressured-geothermal energy is too dilute and is contained in too many small reservoirs to be economically recoverable, even if the price of natural gas were to double. Although the oil industry continues to show minimal interest, the DOE program to determine the size and recoverability of the geopressured resource will continue, albeit at a slightly slower pace, in order to eliminate the remaining uncertainties once and for all.

No one has been uncertain about the magnitude of the resources in the geopressured zones beneath the Gulf coast—they are huge by anyone's calculation—but the amounts that will be practical to recover have always been controversial. The most optimistic predictions have consistently come from Paul Jones, formerly a U.S. Geological Survey (USGS) hydrologist and presently a private consultant in Baton Rouge. He has suggested that the geopressured zones both onshore and offshore along the Texas and Louisiana coasts could contain as much as 50,000 trillion cubic feet of methane (the principal component of natural gas), more than 1100 trillion cubic feet of which might be recoverable (ignoring the economic cost of recovery). That compares with the 20 trillion cubic feet of natural gas consumed each year in the United States. But even one of the most conservative estimates, made by Bill Hise of Louisiana State University in 1976, holds that 125 trillion cubic feet or a 6-year supply could be recovered. The range of recoverable heat energy, which until the rise in natural gas prices was the major target of most studies, is on a similarly grand scale.

The estimates of recoverable energy have such large ranges because researchers still lack the details required for an accurate geological assessment. In general terms, it is known that the rock of today's geopressured zones originated between 15 and 50 million years ago as layers of sand interwoven with layers of clay. As the rivers of the Gulf coast piled on more and more sediment, the sand and clay layers subsided, pushing the salt layer beneath them outward and upward into vertical, finger-like salt domes. The sediments also broke into blocks along faults paralleling the coast and then sank even deeper.

At the same time, the increasing pressure tended to squeeze the seawater out from between the particles of sand and clay and convert the particles into sandstone and shale. But in the case of some layers of sandstone, the seawater had nowhere to go because nearly impermeable shale had sealed it in above and below and along the face of the fault. As a result, the seawater in the pores of the sandstone became pressurized. The seawater also tended to trap the natural heat flow from below, which raised the temperature, and to accumulate natural gas produced from organic matter buried with the sediments. Temperatures and pressures of geopressured zones have been known fairly accurately, but the amount of dissolved gas, the area of a single intact zone, and many properties of the sandstone have remained rather uncertain in most cases.

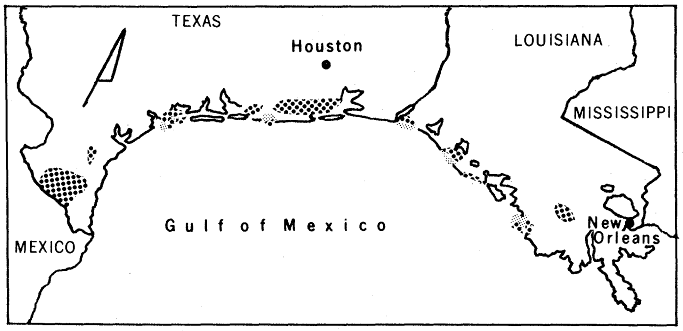
Results from the first well testing by DOE to determine some of these characteristics were a bit puzzling but encouraging. The water flowing from a geopressured zone through the Edna Delcambre No. 1 well, an industry-drilled well depleted of its conventional gas, contained more than the hoped for 40 cubic feet of gas per barrel of water. The failure to detect gas in the well was puzzling because the gas content was more than could have dissolved in the water. Phillip Randolph of the Institute of Gas Technology in Chicago conjectured that, in addition to dissolved gas, the pores of the sandstone contained gas bubbles that could be flushed out by flowing water.

This exciting possibility did not prove true. Subsequent studies convinced Randolph and most other observers that the extra gas did not come from the geopressured zone but rather from a pre-existing pocket of conventional gas that somehow became connected to the Edna Delcambre No. 1 well. The true gas content of the water seems to have been about 25 cubic feet per barrel. Tests of two more abandoned wells showed the same relatively low gas content.

The culprit in all three cases seems to have been salt. The amount of methane that can dissolve in water depends in part on the salinity—the higher the salinity, the less methane can be dissolved. All three wells had salinities of 100 to 190 grams per liter, or three to five times the salinity of seawater. Thus, although the water held as much gas as its temperature, pressure, and salinity would allow, the yield per barrel was still low. Some researchers had expected such high salinities in wells drilled for oil and gas.

Hopes were higher for DOE's Pleasant Bayou No. 2, the first well ever drilled specifically for geopressured-geothermal energy research. Researchers at the University of Texas at Austin had selected the site in Brazoria County, Texas, largely on the basis of the anticipated high temperatures and pressures and favorable sandstone properties, but they also expected moderate salinities of 60 to 80 grams per liter on the basis of data from nearby wells.

The preliminary results from the Brazoria well have met or exceeded expectations, except in the case of salinity. The temperature was high (about 150°C), the water flowed readily, and there appeared to be no obstructions to water



Locations of the most promising geopressured zones onshore and offshore along Texas and Louisiana. [Source: U.S. Department of Energy]

flow for some distance around the well. But the salinity was 132 grams per liter, which apparently kept the gas content down to only about 22 cubic feet of gas per barrel. About 35 cubic feet per barrel had been expected, according to Keith Westhusing of DOE's Houston office.

No one is certain how the additional salt got there. It might have leached out of a nearby salt dome or been concentrated from the original seawater. Whatever happened, studies of the neighboring wells and thousands of other wells on the Gulf coast proved to be poor guides to the salinity of the new well. Jones maintains that the geological structure in the area is too variable for a well 3 to 4 kilometers away to be of any use as a guide. Cliff Carwile of DOE points out that the failure of the salinity to decrease toward the bottom of the Brazoria well, as had been predicted by some studies, may mean that data from geopressured wells cannot be interpreted in the same way as data on oil and gas wells. Robert Morton of the University of Texas suggests that either the laboratory studies of methane solubility are in error or the water has dissolved even less gas than its salinity allows, which would also run contrary to expectations. These researchers do agree that only the examination of more wells will show whether the methane content will match expectations.

Even before the Brazoria well disappointment, some experts were playing down the potential of geopressured-geothermal energy. Three studies, two of which are yet to be published, conclude that too many expensive wells would be required to recover the small amount of methane in a large amount of water. For example, at the current price of natural gas (about $2.50 per 1000 cubic feet), each barrel of water containing an optimistic 40 cubic feet of gas would be worth 10 cents rather than the $30 per barrel that oil brings. In addition, geopressured wells cost considerably more than oil wells and each would require several shallower wells to dispose of the water.

In one study, Todd Doscher and his colleagues at the University of Southern California (USC) have concluded that the typical geopressured well would not be able to deliver enough of such a low-valued commodity to make the effort worthwhile. Assuming 40 cubic feet of gas per barrel, they calculate that the gas would still cost $4 to $15 or more per 1000 cubic feet to produce. The lower figure, Doscher says, would require that the geopressured reservoir have a volume of over 10 cubic kilometers. That is unlikely, he believes, because the largest layers of sand were probably no larger than that when deposited and have in all likelihood been broken into smaller blocks by faulting. Using the hot water to produce electricity would not improve the situation enough to make it practical, according to Doscher. A study commissioned by the Electric Power Research Institute (EPRI) arrives at a similar minimum cost of methane production, according to Vasel Roberts of EPRI. Researchers expect a forthcoming report on unconventional natural gas sources by the National Petroleum Council to express serious reservations about geopressured-geothermal energy as well.

More optimistic observers, generally those outside of the oil and gas industry, tend to emphasize the remaining uncertainties. Perhaps the greatest uncertainty, according to Raymond Wallace of the USGS in Bay St. Louis, Mississippi, is the volume of a geopressured zone that can be effectively drained by a single well. The short-term tests conducted so far cannot determine how much water a well will produce in the long run. The amount depends not only on the overall size of the zone but also on how water flows through it.

Such uncertainties might work to brighten geopressured energy's prospects, according to Myron Dorfman of the University of Texas at Austin. He points out that the ease with which water flowed through the pores of the Brazoria sandstone was considerably greater than the most optimistic estimations in the USC study. Most of the negative economic evaluations, Dorfman and others note, draw heavily on experience in the oil industry that, as in the above example, may not always apply to geopressured zones. "Answers come from the field," Dorfman argues. "You don't get answers from paper."

A few people believe that the answers are already known in the oil industry, but that the industry is covering them up so that the huge amounts of geopressured gas will not lower prices. Jones, a longtime advocate of geopressured-geothermal energy, insists that industry wells in the geopressured zone are producing large quantities of gas today without having to handle large volumes of water. The trick, he says, is to rapidly remove some of the water and thereby reduce the pressure in the formation. Then, the dissolved gas would bubble out of solution and be drawn off to form a conventional gas pocket. Jones likens the process, called exsolution, to popping the cork on a bottle of champagne.

Most researchers do not believe that the exsolution process is being used or could ever be used. Charles Matthews, a consultant for Shell Oil Company in Houston, argues that, even if all of the 20 to 30 cubic feet of gas per barrel were to bubble out, it would still fill only about 2 percent of the pore space of the sandstone. That is too little to prevent the bubbles from hanging up in the larger pores and never forming a free gas pocket, according to Matthews.

Even if enough bubbles did form to flow as free gas, as a patent obtained in 1978 by Exxon Production Research Company claims, it appears that a gargantuan effort would be necessary, not the simple "popping of a cork." According to the patent, the pressure 4600 meters down in the geopressured zone would have to be reduced from 13,000 pounds per square inch (900 atmospheres) to less than 2000 pounds per square inch (140 atmospheres) before the exsolved gas would begin to flow. No one knows if this would be physically possible, and the patent does not claim that it would be economical. Preliminary calculations by Randolph indicate that the pumping required once the natural pressure subsides would soon be consuming all of the energy produced and more before free gas flows after years of pumping.

The exsolution method per se will not be tested in the foreseeable future, but the planned DOE drilling program should resolve many of the uncertainties about the methane content and the properties of the geopressured zone within 1 to 2 years. —RICHARD A. KERR