GULF COAST GEOPRESSURED-GEOTHERMAL PROGRAM SUMMARY REPORT COMPILATION

DOE/ID/13366--T1-Vol.1

VOLUME I

EXECUTIVE SUMMARY

WORK PERFORMED UNDER U.S. DEPARTMENT OF ENERGY
CONTRACT NO. DE-FG07-95ID13366

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JUNE, 1998

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ACKNOWLEDGMENTS

This summary compilation was funded by the U.S. Department of Energy Grant No. DE-FG07-95ID13366 from the Idaho Operations Office, Idaho Falls, Idaho, to the Basin Research Institute, Louisiana State University, Baton Rouge, Louisiana. We would like to thank Mr. Robert J. Creed, Jr., DOE Project Officer, Ms. Kara L. Twitchell, DOE Contract Specialist, and Mr. Brad Bauer, DOE Contract Officer, for the valuable help and assistance provided to us during the course of this project. We also extend our thanks to Mr. Raymond Fortuna, DOE headquarters, Washington, DC, Mr. Ben N. Rinehart, INEL, and Dr. Dan Keeley, University of Southwestern Louisiana (USL) Lafayette, Louisiana, for assistance in obtaining a large number of project reports. Recognition is also extended to Ms. Cherri Webre and Mr. Reed Bourgeois, Basin Research Institute, Louisiana State University, Baton Rouge, Louisiana for word processing and computer support.

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EXECUTIVE SUMMARY

Introduction

The United States Department of Energy established a geopressured-geothermal energy program in the mid 1970's as one response to America's need to develop alternate energy resources in view of the increasing dependence on imported fossil fuel energy. This program continued for seventeen years and approximately two hundred million dollars were expended for various types of research and well testing to thoroughly investigate this alternate energy resource. The main goals of this program were to define the extent of the geopressured reservoirs, determine the technical feasibility of reservoir development including downhole, surface and disposal technologies, establish the economics of production, identify and mitigate adverse environmental impacts, identify and resolve legal and institutional barriers and determine the viability of commercial exploitation of this resource (Division of Geothermal Energy, 1980).

The geopressured-geothermal reservoirs are essentially subsurface reservoirs containing hot pressurized brine saturated with dissolved methane at the temperature, pressure and salinity of the formation. They contain three forms of energy: (1) chemical energy: methane dissolved in brine under pressure; (2) thermal energy: hot brines with temperatures from over 225°F, which could be utilized for direct heating secondary hydrocarbon recovery, or generation of electricity, and (3) mechanical energy: high brine flow rates (over 20,000 barrels per day) and high well head pressures could be used for driving turbines to generate electricity. During the course of this research program involving industry contractors, private sector consultants and companies, university research groups and national laboratories, sixteen wells were tested to achieve the main goals of this research program enumerated earlier.

Geopressured-geothermal reservoirs occur in the United States most prominently along the northern Gulf of Mexico basin and the Pacific West Coast. Other areas containing such reservoirs are also found in other deep sedimentary basins elsewhere in the United States and around the world. The most intensely studied basin containing geopressured-geothermal energy is the northern Gulf of Mexico basin due to the intensive hydrocarbon exploration and production activities in this area. In the mid 1960's it was suggested (Hottman, 1966) that the geothermal heat and pressure of the saline fluids of these formations might be used for process heat or power generation, and the methane entrained in these fluids could be produced as a third energy source. Various estimates have been made regarding the recoverable natural gas from the geopressured-geothermal resources of the northern Gulf of Mexico basin and Dorfman (1988) states that on an average approximately 250Tcf, equivalent to about 137% of known conventional methane reserves in the United States can be potentially extracted from this resource. The DOE objective in undertaking the geopressured-geothermal research program was to gather and provide sufficient reliable information for defining the resource and to provide answers to economic concerns regarding the scientific, engineering, resource recoverability, and environmental issues by well drilling and testing (Wallace, 1982).

The structure and geologic history of the northern Gulf of Mexico basin is well documented in the geologic literature as a result of this area being a prolific producer of oil and gas. In this area the sediment depocenters have shifted laterally and vertically in space and time and rapid sedimentation was accompanied by subsidence and growth faulting (Ocamb, 1961). The oldest growth faulted and geopressured sediments were deposited seaward of the lower Cretaceous shelf margin (Bebout, 1982). The abnormally pressured Cenozoic sedimentary formations in this area

occurring over 10,000 feet below the surface and having temperatures above 225°F contain the largest potential for the geopressured-geothermal energy resources.

Resource Characterization

During the course of the U.S. DOE geopressured-geothermal research program sixteen wells were tested (Figure 1) under two testing programs to provide data on reservoir and fluid properties for assessing the resource magnitude, and potential, its direct and indirect uses, environmental impacts and the commercial viability of developing this resources: (a) Wells of opportunity - those drilled by industry that have penetrated through geopressured reservoirs in the search for oil and gas that were made available to DOE for testing, and (b) Design wells - those drilled on sites in potentially favorable geopressured-geothermal prospects as determined by the best available geological and geophysical data. Initial investigations delineated the geopressured-geothermal corridors in South Louisiana and the Texas Gulf Coast and provided information on the subsurface structure, regional sandstone distribution, porosity, permeability, temperature, formation pressures and salinity. Detailed information on the well test results are provided in the main body of this compilation (volume IIA & IIB). A summary of the important test results available in shown herein (Table 1).

The well tested for the longest period of time (4 years) was the Gladys McCall #1 well located in a marsh area in Cameron Parish, Louisiana. It was drilled under the "design well" program. In this well, eleven potential production zones (Figure 2) were defined before testing but only zones 8 and 9 were flow tested. After zone 9 was plugged, zone 8 was tested for four years beginning in December 1983, before being shut in to observe pressure buildup at the end of 1987. During this period the well produced over 27 million barrels of brine and 676 million scf of gas from the brine,

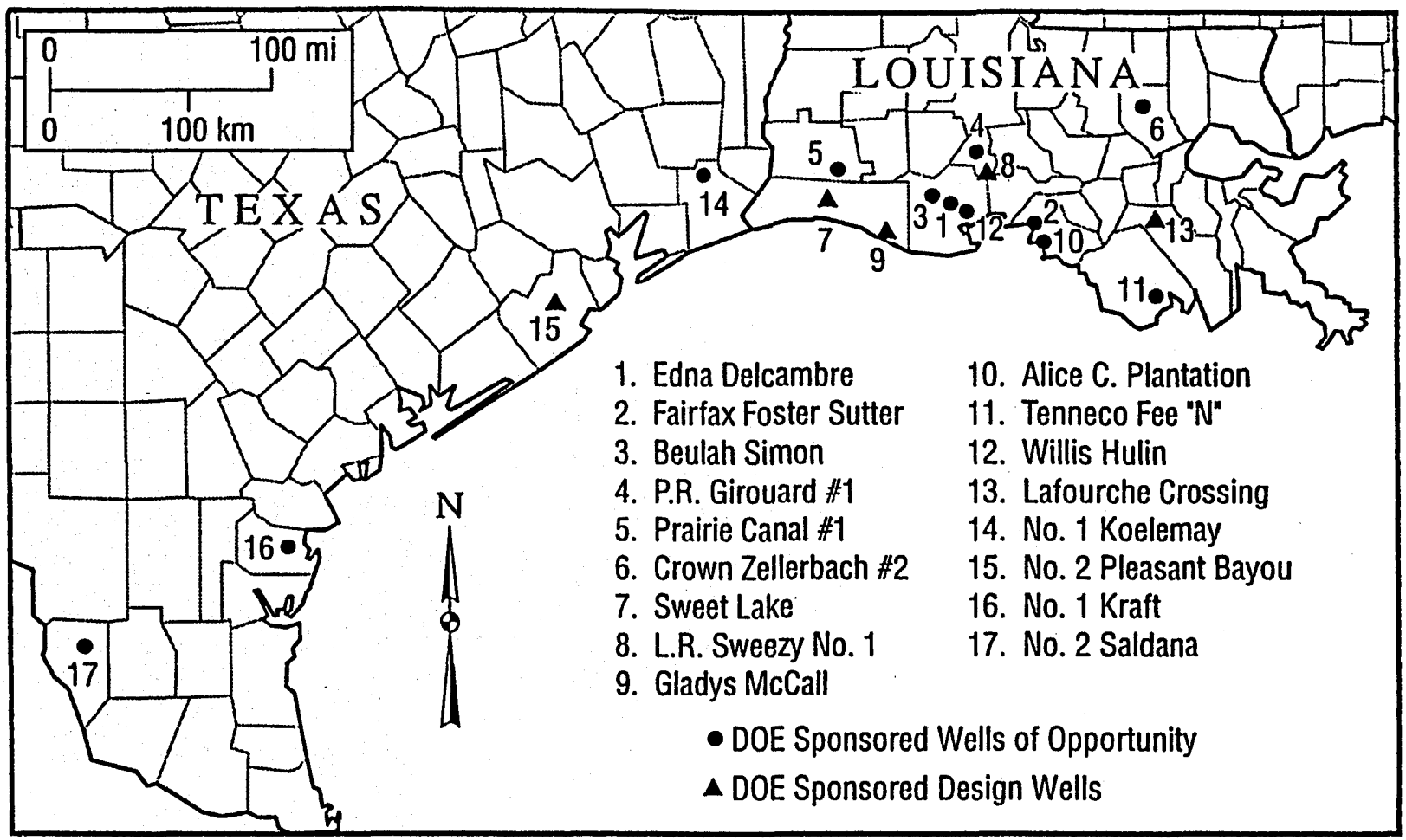

Figure 1. - - Location of wells investigated for the DOE geopressured - geothermal research program in the Gulf Coast.

TABLE 1
Summary of test results from the geopressured - geothermal test wells

Well Name	Depth (ft)	Pressure (psi)	Temp. (°F)	Salinity (ppm TDS)	Gas/Brine Ratio (SCF/STB)	Flow Rate (BPD)	Methane (mol%)	CO_2 (mol%)	Other Gases (mol%)	Porosity (%)	Permea-bility (mD)
Delcambre 3sd	-12,869	11,012	238	133,300	24.0	10,333	92.8	1.1	6.1	26.0	44.0
Delcambre 1sd	-12,573	10,858	234	113,000	24.0	12,653	95.4	2.0	2.6	29.0	364.0
F.F.Sutter	-15,781	12,220	270	190,904	24.9	7,747	89.6	7.9	2.5	19.3	14.3
Buelah Simon	-14,722	13,015	266	103,925	24.0	11,000	88.9	7.7	3.4	17.4	11.6
P.R. Giroud	-14,744	13,203	274	23,500	44.5	15,000	91.3	6.0	2.7	26.0	220.0
P. Canal	-14,976	12,942	294	43,400	47.0	7,100	88.4	8.4	3.2	22.5	90.0
C. Zellerbach	-16,720	10,144	330	31,700	55.7	3,887	71.0	23.5	5.5	17.0	14.1
Amoco Fee - Sweet Lake A	-15,387	11,974	298	160,000	34.0	34,000	88.7	8.6	2.6	20.0	400.0
Parcperdue - L. R. Sweezy No. 1	-13,395	11,410	237	99,700	30.0	10,000	94.0	2.5	3.5	29.4	500.0
Gladys McCall A	-15,508	12,936	298	95,500	30.4	36,500	86.9	9.5	3.6	24.0	90.0
Gladys McCall B	-15,158	12,821	288	94,000	30.4	36,000	85.9	10.6	3.5	22.0	130.0
Pleasant Bayou Well No. 2	-16,465	9,800	302	127,000	24.0	25,000	85.0	10.0	5.0	19.0	200.0
Hulin No. 1	-21,546	18,500	360	195,000	34.0	15,000	93	4.0	3.0	–	13.0
Riddle Saldana No. 2	-9,745	6,627	300	12,800	41.0	1,950	75.0	21.4	3.75	20.0	7.0
Lear Koelemay No. 1	-11,590	9,450	260	15,000	35.0	3,200	81.4	13.4	5.2	26.0	85.0
Ross Kraft No. 1	-12,750	10,986	263	23,000	45.0	–	–	–	–	23.0	39.0

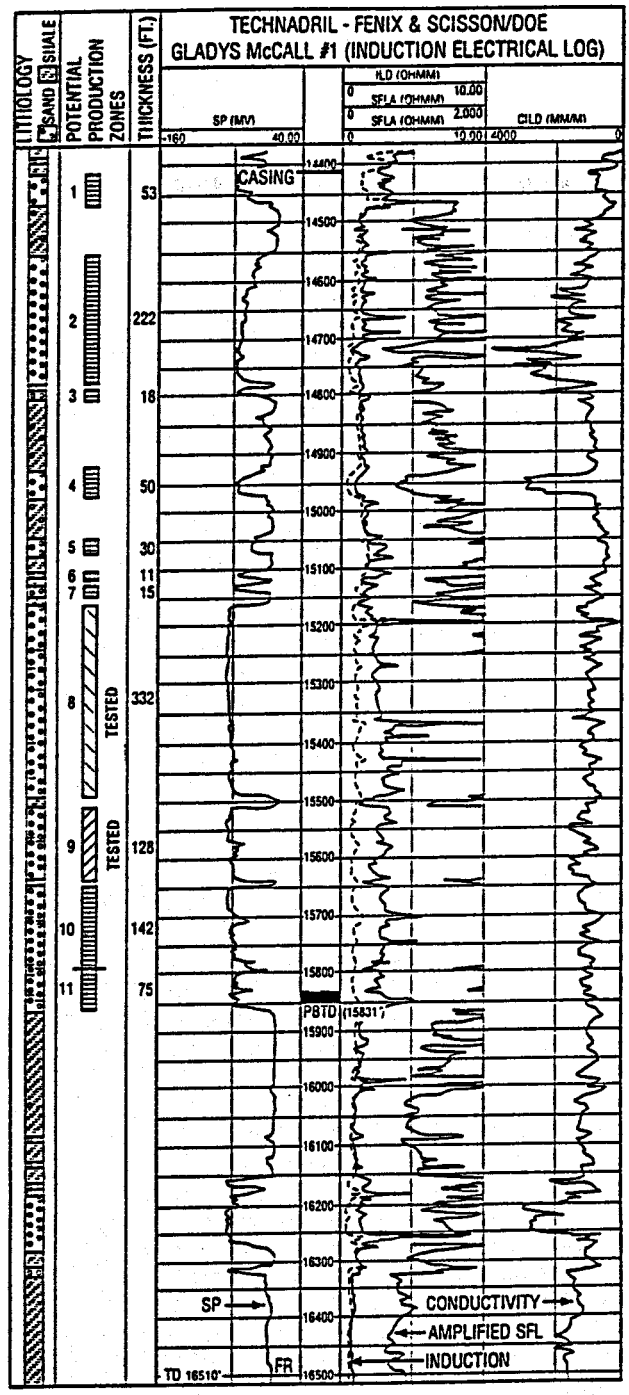

Figure 2. - - Electrical logs, potential production zones and lithology of the Gladys McCall test well (from, John, 1988).

which was disposed by subsurface injection through a brine disposal well in the vicinity of the test well. During the test period the well was flowed at various rates with an average flow rate of 20,000 bbls/day, almost continuously. Scaling problems encountered during initial production were solved by injection of phosphonate pills. This well test and others proved that long term high volume brine production was feasible and that gas-extracted brine could be successfully disposed by subsurface injection.

Another design well test, the Pleasant Bayou #2 well in Brazoria County, Texas, was significant in that a direct use application of the geopressured - geothermal energy resource was successfully tested. This was the site for the installation and successful operation of a binary cycle hybrid power electrical generation system (HPS) which was operated for several months at the site.; The system utilized the geothermal energy of heat and gas from the well fluids, as well as using exhaust heat from the gas engine generators utilizing the produced gas as a fuel. This system successfully demonstrated that the geopressured - geothermal resource could be used for electrical generation. The Frio (Oligocene) age sandstone reservoirs tested at Pleasant Bayou had a temperature of 300°F and well testing was performed from April 1988 through August 1990. The reservoir was perforated from 14,644 to 14,700 ft. and the well produced a total of approximately 12 million barrels of brine and 231,600 MCF of gas.

Environmental Issues

The main environmental concerns associated with production testing and development are land subsidence growth fault activation and water quality impacts. Environmental monitoring consisting of microseismic, subsidence and water quality monitoring. Continuous microseismic

monitoring was carried out by a network of recording stations set up near and around the design well test sites, and no microseismic activity attributable to well testing was recorded at these sites. To determine subsidence, networks of closely spaced first order elevation benchmarks were installed around the design well sites which were surveyed and tied in with the National Geodetic Survey (NGS) regional control networks. Again, no subsidence related to well testing was observed. Water quality was also monitored at the test sites to determine contamination resulting from any well testing activities. Surface and groundwater samples were analyzed quarterly but these analyses did not show any problems arising due to well testing activities.

Direct and Indirect Uses

Geopressured-geothermal energy has been successfully used to generate electricity using a hybrid binary power system at the Pleasant Bayou No. 2 design well site located in Brazoria County, Texas. Thermal enhanced oil recovery (TEOR) is another potentially near term applicable use, especially in the case of heavy oil in areas where the two occur in close proximity. The hot geopressured-geothermal fluids under high pressure could be moved to shallower oil reservoirs through suitable piping thus providing a self propelled method of heat transfer to the target reservoir. As in the case of conventional TEOR, the heat from the brine will reduce the residual oil saturation and lower its viscosity leading to better recovery of oil. A summary of the potential direct and indirect applications of the geopressured-geothermal resource is shown in Figure 3.

Potential industrial uses suggested for the geopressured - geothermal resource using the heat for direct uses require temperatures ranging from 35°F to 350°F. These include direct heating of

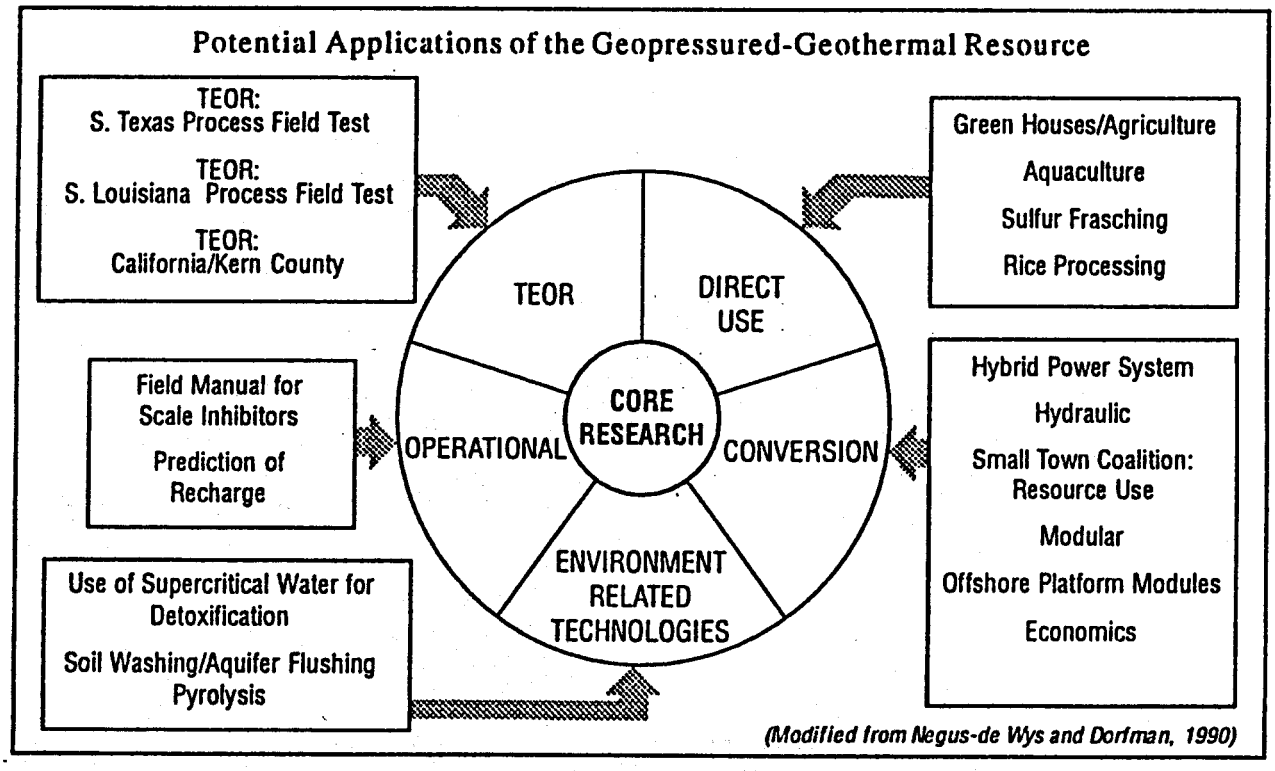

Figure 3. - - Schematic illustration of the multiple uses for the geopressured - geothermal energy resource.

houses, sulphur extraction, coal desulfurization, chemical processing, extraction of chemicals from brine, water desalination, fish rearing, greenhouse heating, cane sugar processing, lumber drying etc.

Conclusions

The significant accomplishments of this program included (1) identification of the geopressured-geothermal onshore fairways in Louisiana and Texas, (2) determination that high brine flow rates of 20,000 - 40,000 barrels a day can be obtained for long periods of time, (3) brine, after gas extraction can be successfully reinjected into shallow aquifers without affecting the surface waters or the fresh water aquifers, (4) no observable subsidence or microseismic activity was induced due to the subsurface injection of brine, and no detrimental environmental effects attributable to geopressured - geothermal well testing were noticed, (5) sanding can be controlled by reducing flow rates, (6) corrosion controlled with inhibitors, (7) scaling controlled by phosphonate scale inhibitors, (8) demonstrated that production of gas from saturated brine under pressure was viable and (9) a hybrid power system can be successfully used for conversion of the thermal and chemical energy contained in the geopressured-geothermal resource for generation of electricity.

The U.S. Department of Energy's geopressured-geothermal research program in the Gulf Coast achieved many significant findings and disproved and clarified many historical perceptions that had previously limited industry's interest in developing this resource. Though in today's economic market it may not be commercially profitable to exploit this resource, the rapid advance of technology in all its different aspects could potentially make this resource attractive in the not too distant future. The ideal situation would involve the development of a total energy system in which all three associated forms of energy - chemical, thermal and mechanical are utilized. The extraction of gas

from brine combined with the large number of potential direct and indirect uses of this resource will add to its economic profitability. This U.S. DOE's visionary research program has essentially laid the foundations for characterization of this resource and all aspects connected with its development.

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