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OPERATIONS RESEARCH AND SYSTEMS ANALYSIS
OF GEOPRESSURED/GEOTHERMAL RESOURCES
IN LOUISIANA

Final Report for Initiation Project

By
Bert Wilkins, Jr.

February 1978

MASTER

Work Performed Under Contract No. EG-77-S-05-5442

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Office of Advanced Studies and Research
Louisiana State University
Baton Rouge, Louisiana

U. S. DEPARTMENT OF ENERGY
Geothermal Energy

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OFFICE OF ADVANCED STUDIES & RESEARCH
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I. INTRODUCTION

Geothermal energy is essentially a regional resource, and to a large extent the problems that confront its development are local or regional in nature. Any program designed to expeditiously develop this resource in the United States to help meet national energy goals must recognize the individual regional needs. The United States Energy Research and Development Administration (ERDA) through its Division of Geothermal Energy (DGE) has the responsibility for planning the national geothermal energy program, and DGE is currently instituting a system of regional operations research and systems analysis activities to assess the regional needs and to develop time-phased plans with priorities, both regional and national, for cost effective development of the nation's geothermal energy resources.

In considering the Gulf Coast geopressured/geothermal (GP/GT) resource, it seems logical to group the states of Texas and Louisiana for regional analysis and planning. In addition to the fact that almost all of the potential Gulf Coast GP/GT resources are found in these two states, other geographical and economic similarities point to significant benefits to Texas and Louisiana as well as to ERDA's national energy program for a regionally coordinated GP/GT resource development planning activity.

Nevertheless, significant differences exist in the political, legal, and socio-economic organization of Texas and Louisiana as well as the nature of the resource itself. Moreover, there existed

no base in either state, much less a focal point, for such a regional program.

For such a regional planning activity to have the maximum impact on the development of the GP/GT resource, the program must evolve in a logical step-by-step fashion. Intrastate credibility and support must be established to assure interstate cooperation for the fully evolved plan.

As a logical first step in this procedure ERDA funded sub-regional operations research and systems analysis projects in both Texas and Louisiana which were coordinated in project milestones and basic planning methodology but which allowed for differences in the intrastate organization of each project. Coordination was insured by joint meetings and reviews.

One goal of this first step was the formulation of a plan for a regional operations research and systems analysis activity involving both Texas and Louisiana. In addition to producing a number of alternate time-phased plans for the GP/GT resource development in each state, each project would establish the intrastate framework and support for a regional program.

The purpose of this report is to review the status of the Louisiana initiation project conducted by Louisiana State University.

II. STATUS OF OBJECTIVES

The overall objective of this project was to develop a plan for Louisiana's participation in a Gulf Coast regional operations research and systems analysis activity. To achieve this overall objective, the following subobjectives were proposed:

1. A set of preliminary planning scenarios for GP/GT resource development in Louisiana will be prepared and analyzed.
2. Key decision makers and "stake holders" with respect to GP/GT energy policy in the state of Louisiana will be identified.
3. A state-wide advisory group for GP/GT resource development in Louisiana will be established.
4. Operations research activities will be coordinated with a parallel project in the state of Texas.
5. Specific recommendations for a regional operations research activity in support of GP/GT resource development in the Texas-Louisiana region will be formulated.

The following discussion gives a status of these subobjectives:

Preliminary Planning Scenarios

In developing the preliminary planning scenarios heavy emphasis has been placed on data describing the resource base. This analysis has included:

- a. Location and properties of potential GP/GT resource areas in Louisiana.
- b. An assessment of the state of knowledge concerning the amount and locations of potential GP/GT resources in Louisiana.
- c. Status of exploration, resource assessment and resource development.

In seeking a definition of the amount and location of Gulf Coast geopressed resources, an investigation of existing estimates were made. A summary of these estimates and the assumption upon which they are based are given in Tables 1, 2, and 3.

There is wide variance in these estimates, as evidenced by the following ranges:

Resource Base	
Thermal	19.5 - 176,000 quads
Mechanical	1.2 - 693 quads
Gas	13.6 - 111,500 quads
Recoverable Energy	
Thermal	19.5 - 2,058 quads
Gas	0.0001 - 52,000 quads
Electricity	0.1 - 110,000 MW-centuries

The reasons for these differences are demonstrated by comparing the various assumptions in Table 3. The ranges are as follows:

Area	29,000 - 154,000 sq. miles
Productive Area	1 - 50%
Thickness	8,000 - 19,680 feet
Sandstone	5.4 - 60%
Porosity	15 - 35%
Dissolved Natural Gas	1 - 164 scf/bbl
Recovery	.1 - 100%

In addition to the assumption variations illustrated in Table 3, implicit factors are significant in the resource assessment process. For example, resource assessment is closely linked to the development concept that is envisioned in making the resource assessment. If one perceives that development means the production of direct electrical energy as well as the production of methane, then one probably restricts his assessment to the amount of resource that is likely to have a fluid temperature in excess of 300°F. However, if one envisions that the geopressured resource will be developed primarily as a producer of methane, then a restriction to an assessment of resources having temperatures in excess of 300°F is not likely. This interaction between resource assessment and resource use is largely unstated but highly significant in understanding and describing the development process.

This variance has made the selection of assumptions for development scenarios very difficult. Two resource estimates were chosen as the basis for the Louisiana scenarios: Hawkins - LSU for the Louisiana conservative, Papadopulos - USGS for the Louisiana optimistic. These studies were chosen because extensive documentation of their assessments were broken down into various blocks, and sub-areas which were then used as the basis for the prospect scenarios.

The conservative estimates for production in Louisiana are 2,791 MW (electrical) and 454 Bcf/year (gas). The optimistic estimates are 56,440 MW (electrical) and 11 Tcf/year (gas).

TABLE 1

ESTIMATES OF TOTAL GEOPRESSURED RESOURCE
(Louisiana-Texas Gulf Coast, Onshore and Offshore, in Quads)

<u>Source</u>	<u>Thermal</u>	<u>Mechanical</u>	<u>Gas</u>	<u>Total</u>
Brown - Hudson ¹			60,000-105,000	
Dorfman - Texas ³			5,735	
Hawkins - LSU ⁷ (Louisiana only)	19.5	1.2	13.6	34.3
Hise - LSU ⁸			3,000	
House - Livermore			221.7	
Jones - LSU ¹¹ (sands & shales)			100,000	
(sands only)			49,000	
Karkalits - McNeese ¹²	60,000		12,000-30,000	
Myers - Livermore ¹³			0.1-2,650	
Papadopoulos - U.S.G.S. ¹⁴ (assessed onshore only)	43,331	198	23,927	67,456
(unassessed only)	1 1/2 to 2 1/2 times assessed			
Schnadelbach - de Laureal ¹⁵			111,500	
U.S. ERDA - MOPPS ¹⁸			3,000-40,000	
U.S. ERDA - Definition Report ¹⁷	44,000-176,000			

TABLE 2
ESTIMATES OF RECOVERABLE GEOPRESSURED ENERGY
(Louisiana - Texas Gulf Coast, Onshore and Offshore)

<u>Source</u>	<u>Thermal Quads</u>	<u>Gas Quads</u>	<u>Electricity (MW-centuries)</u>
Brown - Hudson ¹		2,400-52,000	
Dorfman - Texas ² (Texas only)			20,000
Dorfman - Texas ³		256	
Elmer - Tracor ⁵	529-2,058	2,000	
Gould - Intercomp ⁶ (onshore Texas only)		150	33,000
Hawkins - LSU ⁷ (Louisiana only)	<19.5	<13.6	
Hise - LSU ⁸		125	
House - Livermore ^{9&10}		222	5,990
Jones - LSU ¹¹		> 1,146	
Myers - Livermore ¹³		.0001-1,000	0.1-100,000
Papadopoulos - U.S.G.S. ¹⁴ (Plan 2)	1424	768	38,140
(Plan 3 - lower bounds)	- - - 77.38 - - -		2,880
Trehan - Mitre ¹⁶			100,000
U.S. ERDA - Definition Report ¹⁷		500-2,000	33,400-110,000
U.S. ERDA - MOPPS ¹⁸		150-2,000	
Wilson - Dow ^{19&20} (Texas only)		45.6	8,000

TABLE 3
ASSUMPTIONS FOR VARIOUS RESOURCE ASSESSMENTS

	Dorfman	Gould	Hawkins	Hise	House	Jones	Myers	Papadopoulos	Schnadelbach
Area (sq. mi.)	100,000	60,000	42,000	100,000	30,600	154,000	29,000	55,970	
Area Productive (X)		22.5			5		1-50		
Thickness (feet)	10,000	10,000	8,000	10,000	15,000	13,120- 19,680	15,000	9,482- 13,715	
Sandstone (X)	15	7.5	5.4	10	56	50	10-60	12-49	
Porosity (X)	22	20	20	20	20	25	15-35	18-22	
Dissolved Natural Gas (scf/bbl)	35	30-40	20.3	30	19-44	18.8- 164	1-30	28.2- 46.3	107
Water in Place (x 10 ¹² bbl)	164	10	.67	100	10.9	1,492	.126- 88.2	657	1,042
Gas in Place (Tcf)	5,735	>300	13.6	3,000	221.7	100,000	.126- 2,646	23,636	111,500
Recovery (X)	5	50		5	2-100	>1.1	.1-70	.12- 3.3	
Recoverable Water (x 10 ¹² bbl)	8.2	5.0		5.0		>17.1	.000126 -61.7	.79- 21.7	
Recoverable Gas Content (scf/bbl)	30	30		25		30			
Recoverable Gas (Tcf)	256	150		125		>1,146	.0001 -1,000	768	

Scenarios for developing the Louisiana GP/GT energy resources are affected by several factors. Among these are geological properties, energy production methods, legal and regulatory factors, and economic considerations. The preliminary development scenarios discussed in this paper are produced using a computer-oriented planning program that is code-named GEODEV. This program was developed by the parallel project team in Texas and was used in the Louisiana scenario development work to place the evaluation on a comparable basis. This program contains an algorithm for estimating resource capacity and reservoir performance based upon information obtained from geologic reports and reservoir simulation studies. GEODEV uses estimates of the following parameters to compute the total amount of recoverable energy from each fairway:

1. Fluid temperature
2. Thickness of formation
3. Porosity of formation
4. Permeability
5. Recoverability
6. Gas content of the fluid
7. Fairway area
8. Fraction of fairway producible

This information is then combined with other information obtained from drilling experts and from similar projects in developing California's hydrothermal resources to obtain a time-line for development.

The lifetime over which the resource is to be produced is specified in order to balance well spacing with total regional flow-rate. The time to drill a producing well, the time to drill a dry well, and the success ratio combine to yield the total average time needed to establish a producing well. The number of drilling rigs available can be combined with this information to indicate the number of production wells that are possible per year.

The number of allowable simultaneous construction projects and the amount of time delay from decision to actual start, resulting from sociological, technical, and/or administrative problems, combine with the plant construction time to detail the time-line of production. For the present, permitting and leasing process times have been absorbed into the plant construction time.

The development scenarios for Louisiana are based on the reservoir data given in the LSU-Hawkins report. The eight prospect areas are located in four different blocks: West Lockport and Newton in Calcasieu, Big Mouth Bayou and West Lake Arthur in Cameron, Southeast Pecan Island and South White Lake in Vermilion, South Midland and West Maurice in Acadia. The assumptions for the optimistic scenarios are based on the most favorable reservoir data; the assumptions for the conservative scenarios are based on the least favorable reservoir data. The fluid recovery fraction of fairway producing, and gas content were varied using the GEODEV program until the total electric power

generation and gas production calculations matched the LSU-Hawkins calculations (for conservative scenarios), and matched the USGS-Papadopoulos calculations (for optimistic scenarios). The GEODEV program gives a very conservative estimate of recoverable thermal energy for low temperature reservoirs such as those examined in Louisiana.

In Louisiana, four areas were chosen for development because reservoir data was available. These are the parishes of Vermilion, Cameron, Calcasieu, and Acadia. The results of these scenarios without deep reinjection are summarized as follows:

<u>Parish</u>	<u>Conservative</u>		<u>Optimistic</u>	
	Elec. MW	Gas Bcf/yr.	Elec. MW	Gas Bcf/year
Cameron	217	36	4527	520
Vermilion	193	33	4367	530
Acadia	100	18	3774	460
Calcasieu	100	18	2020	250

Examples of development scenarios for the four fairways in Louisiana, are attached in the Appendix. Results are given for two energy production strategies. One case assumes that the spent fluids are disposed of by reinjection into shallow formations with energy produced in the form of electricity and gas. The second case assumes that the spent fluid is reinjected into the producing formation with energy produced in the form of gas and essentially no net electrical output. In this second case the total gas produced is increased and the reservoir life is

doubled.

Identification of Decision Makers

In order to develop lines of communication with the Louisiana legislature and the Louisiana Office of Conservation of the Department of Conservation the project staff assisted Commissioner R. T. Sutton in preparing his annual resume of activity in GP/GT energy in Louisiana to the Governor and the Joint Legislative Committee on Natural Resources. A copy of this report is attached in the Appendix. In addition, a list of contracts concerning GP/GT energy in Louisiana and outside is also included in the Appendix.

State-Wide Advisory Group

Discussions throughout the State indicated that no action should be taken on a State-Wide Advisory Group until a plan for a long-term operations research program could be developed with the Louisiana Department of Natural Resources as the lead agency.

Coordination of Activities With Texas

Routine meetings have been held with Drs. Myron Dorfman and Dale Zinn of the University of Texas, Center for Energy Study to coordinate the Louisiana project with the Texas project. In addition to using the same scenario generating program, GEODEV. The two groups have jointly published work at the Third Annual GP/GT Energy Conference, November 16 - 18, 1977 in Lafayette, Louisiana. A copy of this paper is attached in the Appendix.

Regional Operations Research Activity

Over the last year, the Louisiana State government has gone through a reorganization mandated by a new constitution. One of the resulting new departments, the Department of Natural Resources (DNR) has been designated by the Governor to be the lead agency for negotiating a Louisiana regional effort in a GP/GT operations research activity. The project staff is currently assisting the DNR by drafting a proposal for such activity. The Secretary, Mr. William Huls, has taken a personal interest in this project and is working with Texas officials and the new U.S. Department of Energy to get a plan developed. See Figure 1 on the following page for the DNR Organization Chart.

DEPARTMENT OF NATURAL RESOURCES

Figure 1 --
Department of Natural Resources Organization Chart

III. Conclusions and Recommendations

The conclusions concerning the long-term impact of the GP/GT resource in Louisiana are limited at this time. However it is apparent that Louisiana has a large potential GP/GT resource base. The LSU resource assessment project has ranked 20 top potential sites for a GP/GT test well. Cameron Parish has seven potential sites and Vermilion has five potential sites. No other parish has more than three. Hence, the area of Louisiana with the highest potential is the southwest part of the State.

The resource assessment work currently going on at LSU is directed toward the evaluation of four top candidates for a test well. While this is the primary objective, an overall resource assessment will be made. In addition, the USGS is up-dating their total resource assessment for the Gulf Coast. However, it seems unlikely that vastly improved total resource assessments will be available until a significant number of actual test wells are drilled. This is especially true with respect to actual recoverable energy.

However, evaluation of resource assessments to date seems to indicate that the range of uncertainty can be narrowed enough to construct useful scenarios for planning purposes.

For South Louisiana, the wide spread occurrence of geopressed aquifers with good resource properties and a lack of data to define the extent of individual aquifers implies that

the appropriate subdivisions for study should be socio-economic or political in nature rather than geological. Hence, it seems appropriate to consider parish-wide units for scenario development.

In discussing the preliminary development scenarios with people in the State it became obvious that the degree of development was not sufficient to raise more than passing interest. It was anticipated that the very fact that the level of sophistication of the scenarios was limited would evoke response. This was not the case. It seems that a better strategy would be to pick a parish (for example Cameron) in which there is high potential to develop a prototype in some detail. This model could then be used to identify potentially similar issues or, by comparison, to highlight differences for other parishes.

While the prototype development will be somewhat slow, the understanding gained will make up the time on the development of subsequent study areas. It seems clear that interested "stake holders" will not be identified without much more detail in the development scenarios.

Coordination with the Texas project has revealed a number of common problems and features of the resource in the two states, for example, surface technology is similar and certain legal problems associated with the vast expanse of the reservoirs are common. However, the effort has revealed some major differences. For example, much of Louisiana's resource is in marsh land; thus the vast amount of State-owned water bottoms may make the State a major GP/GT resource owner. This fact could significantly

affect the initial development of the resource. It also indicates why the Department of Natural Resources should take the lead in resource development.

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**Preliminary Development Scenarios
for Geopressured/Geothermal Resources
for Selected Fairways**

VERMILION CONSERVATIVE WITHOUT REINJECTION

These are the fairway characteristics

Thickness, in feet	350.00
Temperature, in degrees Fahrenheit	245.00
Porosity, as a fraction	0.20
Permeability, in millidarcies	100.00
Fluid recovery, as a fraction	0.08
Gas content, in scf/bbl	36.40
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	0.89
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	31994. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	7.43 megawatts
Gas flow capacity	.13E 10 scf per year
Lifetime	30.years

Fairway Parameters

Number of plants	26
Elec gen. capacity	193.27 megawatts
Gas flow capacity	.33E 11 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	7.	.13E 10	17.	24.
1983.	1.	7.	.13E 10	17.	24.
1984.	2.	15.	.26E 10	34.	49.
1985.	3.	22.	.38E 10	51.	73.
1986.	4.	30.	.52E 10	68.	98.
1987.	5.	37.	.65E 10	85.	122.
1988.	6.	45.	.77E 10	102.	147.
1989.	7.	52.	.91E 10	119.	171.
1990.	8.	59.	.10E 11	136.	196.
1991.	9.	67.	.11E 11	153.	220.
1992.	10.	74.	.13E 11	170.	245.
1993.	11.	82.	.14E 11	187.	269.
1994.	12.	89.	.15E 11	204.	293.
1995.	13.	97.	.16E 11	222.	318.
1996.	14.	104.	.18E 11	239.	342.
1997.	15.	111.	.19E 11	255.	367.
1998.	16.	119.	.21E 11	273.	391.
1999.	17.	126.	.22E 11	290.	416.
2000.	18.	134.	.23E 11	306.	440.
2001.	19.	141.	.24E 11	324.	465.
2002.	20.	149.	.26E 11	341.	489.
2003.	21.	156.	.27E 11	357.	514.
2004.	22.	163.	.29E 11	375.	538.
2005.	23.	171.	.30E 11	392.	563.
2006.	24.	178.	.31E 11	409.	587.
2007.	25.	186.	.33E 11	426.	612.
2008.	26.	193.	.33E 11	443.	636.
2009.	26.	193.	.33E 11	443.	636.
2010.	26.	193.	.33E 11	443.	636.
2011.	26.	193.	.33E 11	443.	636.
2012.	25.	186.	.33E 11	426.	612.
2013.	25.	186.	.33E 11	426.	612.
2014.	24.	178.	.31E 11	409.	587.
2015.	23.	171.	.30E 11	391.	562.
2016.	22.	163.	.29E 11	375.	538.
2017.	21.	156.	.27E 11	357.	514.
2018.	20.	149.	.26E 11	340.	489.
2019.	19.	141.	.24E 11	324.	465.
2020.	18.	134.	.23E 11	306.	440.

VERMILION OPTIMISTIC WITHOUT REINJECTION

These are the fairway characteristics

Thickness, in feet	825.00
Temperature, in degrees Fahrenheit	312.00
Porosity, as a fraction	0.26
Permeability, in millidarcies	1400.00
Fluid recovery, as a fraction	0.38
Gas content, in scf/bbl	36.17
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	0.98
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	116420. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. gen. capacity	150.59 megawatts
Gas flow capacity	.18E 11 scf per year
Lifetime	30.years

Fairway Parameters

Number of plants	29
Elec. gen. capacity	4366.99 megawatts
Gas flow capacity	.53E 12 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	151.	.18E 11	246.	397.
1983.	1.	151.	.18E 11	246.	397.
1984.	2.	301.	.36E 11	492.	794.
1985.	3.	452.	.55E 11	739.	1190.
1986.	4.	602.	.72E 11	984.	1587.
1987.	5.	753.	.90E 11	1231.	1984.
1988.	6.	904.	.11E 12	1477.	2381.
1989.	7.	1054.	.13E 12	1723.	2777.
1990.	8.	1205.	.14E 12	1969.	3174.
1991.	9.	1355.	.17E 12	2216.	3571.
1992.	10.	1506.	.18E 12	2462.	3968.
1993.	11.	1656.	.20E 12	2708.	4364.
1994.	12.	1807.	.22E 12	2954.	4761.
1995.	13.	1958.	.23E 12	3200.	5158.
1996.	14.	2108.	.25E 12	3446.	5555.
1997.	15.	2259.	.27E 12	3693.	5952.
1998.	16.	2409.	.29E 12	3939.	6348.
1999.	17.	2560.	.31E 12	4185.	6745.
2000.	18.	2711.	.33E 12	4431.	7142.
2001.	19.	2861.	.34E 12	4677.	7538.
2002.	20.	3012.	.36E 12	4923.	7935.
2003.	21.	3162.	.38E 12	5170.	8332.
2004.	22.	3313.	.40E 12	5416.	8729.
2005.	23.	3464.	.41E 12	5662.	9125.
2006.	24.	3614.	.43E 12	5908.	9523.
2007.	25.	3765.	.45E 12	6154.	9919.
2008.	26.	3915.	.47E 12	6400.	10315.
2009.	27.	4066.	.49E 12	6647.	10713.
2010.	28.	4217.	.52E 12	6893.	11109.
2011.	29.	4367.	.54E 12	7139.	11506.
2012.	28.	4217.	.52E 12	6893.	11109.
2013.	28.	4217.	.52E 12	6893.	11109.
2014.	27.	4066.	.49E 12	6647.	10713.
2015.	26.	3915.	.47E 12	6401.	10316.
2016.	25.	3765.	.45E 12	6154.	9919.
2017.	24.	3614.	.43E 12	5908.	9523.
2018.	23.	3463.	.41E 12	5662.	9126.
2019.	22.	3313.	.40E 12	5416.	8729.
2020.	21.	3162.	.38E 12	5170.	8332.

CAMERON CONSERVATIVE WITHOUT REINJECTION

These are the fairway characteristics

Thickness, in feet	183.00
Temperature, in degrees Fahrenheit	185.00
Porosity, as a fraction	0.25
Permeability, in millidarcies	180.00
Fluid recovery, as a fraction	0.10
Gas content, in scf/bbl	22.80
Fairway extent, in sq. miles	2100.00
Fraction of fairway which produces	0.94
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	26138. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	3.94 megawatts
Gas flow capacity	.65E 09 scf per year
Lifetime	30.years

Fairway Parameters

Number of plants	55
Elec. gen. capacity	216.81 megawatts
Gas flow capacity	.36E 11 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	4.	.65E 09	9.	13.
1983.	1.	4.	.65E 09	9.	13.
1984.	2.	8.	.13E 10	17.	25.
1985.	3.	12.	.20E 10	26.	38.
1986.	4.	16.	.26E 10	35.	51.
1987.	5.	20.	.33E 10	43.	63.
1988.	6.	24.	.39E 10	52.	76.
1989.	7.	28.	.46E 10	61.	89.
1990.	8.	32.	.52E 10	69.	101.
1991.	9.	35.	.59E 10	78.	114.
1992.	10.	39.	.65E 10	87.	127.
1993.	11.	43.	.72E 10	95.	139.
1994.	12.	47.	.78E 10	105.	152.
1995.	13.	51.	.85E 10	113.	165.
1996.	14.	55.	.91E 10	121.	177.
1997.	15.	59.	.98E 10	131.	190.
1998.	16.	63.	.10E 11	139.	203.
1999.	17.	67.	.11E 11	147.	215.
2000.	18.	71.	.12E 11	157.	228.
2001.	19.	75.	.12E 11	165.	241.
2002.	20.	79.	.13E 11	173.	253.
2003.	21.	83.	.14E 11	183.	266.
2004.	22.	87.	.14E 11	191.	279.
2005.	23.	91.	.15E 11	199.	291.
2006.	24.	95.	.16E 11	209.	304.
2007.	25.	99.	.16E 11	217.	317.
2008.	26.	102.	.17E 11	225.	329.
2009.	27.	106.	.18E 11	235.	342.
2010.	28.	110.	.18E 11	243.	355.
2011.	29.	114.	.19E 11	251.	367.
2012.	30.	118.	.20E 11	261.	380.
2013.	30.	118.	.20E 11	261.	380.
2014.	30.	118.	.20E 11	261.	380.
2015.	30.	118.	.20E 11	261.	380.
2016.	30.	118.	.20E 11	261.	380.
2017.	30.	118.	.20E 11	261.	380.
2018.	30.	118.	.20E 11	261.	380.
2019.	30.	118.	.20E 11	261.	380.
2020.	30.	118.	.20E 11	261.	380.

CAMERON OPTIMISTIC WITHOUT REINJECTION

These are the fairway characteristics

Thickness, in feet	380.00
Temperature, in degrees Fahrenheit	270.00
Porosity, as a fraction	0.27
Permeability, in millidarcies	500.00
Fluid recovery, as a fraction	0.50
Gas content, in scf/bbl	27.90
Fairway extent, in sq. miles	2100.00
Fraction of fairway which produces	1.00
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	11
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	73271. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. Gen. capacity	78.05 megawatts
Gas flow capacity	.90E 10 scf per year
Lifetime	30.years

Fairway Parameters

Number of plants	58
Elec. gen. capacity	4526.87 megawatts
Gas flow capacity	.52E 12 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	78.	.90E 10	120.	198.
1983.	1.	78.	.90E 10	120.	198.
1984.	2.	156.	.18E 11	239.	395.
1985.	3.	234.	.27E 11	359.	593.
1986.	4.	312.	.36E 11	478.	790.
1987.	5.	390.	.45E 11	598.	988.
1988.	6.	468.	.54E 11	717.	1185.
1989.	7.	546.	.63E 11	837.	1383.
1990.	8.	624.	.72E 11	956.	1581.
1991.	9.	702.	.81E 11	1076.	1778.
1992.	10.	781.	.90E 11	1195.	1976.
1993.	11.	859.	.99E 11	1315.	2173.
1994.	12.	937.	.11E 12	1434.	2371.
1995.	13.	1015.	.12E 12	1554.	2568.
1996.	14.	1093.	.13E 12	1673.	2766.
1997.	15.	1171.	.14E 12	1793.	2963.
1998.	16.	1249.	.14E 12	1912.	3161.
1999.	17.	1327.	.15E 12	2032.	3359.
2000.	18.	1405.	.16E 12	2151.	3556.
2001.	19.	1483.	.17E 12	2271.	3754.
2002.	20.	1561.	.18E 12	2390.	3951.
2003.	21.	1639.	.19E 12	2510.	4149.
2004.	22.	1717.	.20E 12	2629.	4347.
2005.	23.	1795.	.21E 12	2749.	4544.
2006.	24.	1873.	.22E 12	2868.	4742.
2007.	25.	1951.	.23E 12	2988.	4939.
2008.	26.	2029.	.23E 12	3107.	5137.
2009.	27.	2107.	.24E 12	3227.	5334.
2010.	28.	2185.	.25E 12	3346.	5532.
2011.	29.	2263.	.26E 12	3466.	5730.
2012.	30.	2341.	.27E 12	3585.	5927.
2013.	30.	2341.	.27E 12	3585.	5927.
2014.	30.	2341.	.27E 12	3585.	5927.
2015.	30.	2341.	.27E 12	3585.	5927.
2016.	30.	2341.	.27E 12	3585.	5927.
2017.	30.	2341.	.27E 12	3585.	5927.
2018.	30.	2341.	.27E 12	3585.	5927.
2019.	30.	2341.	.27E 12	3585.	5927.
2020.	30.	2341.	.27E 12	3585.	5927.

ACADIA CONSERVATIVE WITHOUT REINJECTION

These are the fairway characteristics

Thickness, in feet	150.00
Temperature, in degrees Fahrenheit	202.00
Porosity, as a fraction	0.25
Permeability, in millidarcies	125.00
Fluid recovery, as a fraction	0.10
Gas content, in scf/bbl	27.92
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	0.92
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	.72
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	21424. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	3.73 megawatts
Gas flow capacity	.65E 09 scf per year
Lifetime	30.years

Fairway Parameters

Number of plants	27
Elec. gen. capacity	100.60 megawatts
Gas flow capacity	.18E 11 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	4.	.65E 09	9.	12.
1983.	1.	4.	.65E 09	9.	12.
1984.	2.	7.	.13E 10	17.	25.
1985.	3.	11.	.20E 10	26.	37.
1986.	4.	15.	.26E 10	35.	50.
1987.	5.	19.	.33E 10	44.	62.
1988.	6.	22.	.39E 10	52.	75.
1989.	7.	26.	.46E 10	61.	87.
1990.	8.	30.	.52E 10	70.	100.
1991.	9.	34.	.59E 10	79.	112.
1992.	10.	37.	.65E 10	87.	125.
1993.	11.	41.	.72E 10	96.	137.
1994.	12.	45.	.79E 10	105.	150.
1995.	13.	48.	.85E 10	114.	162.
1996.	14.	52.	.91E 10	122.	175.
1997.	15.	56.	.98E 10	131.	187.
1998.	16.	60.	.10E 11	140.	200.
1999.	17.	63.	.11E 11	149.	212.
2000.	18.	67.	.12E 11	157.	224.
2001.	19.	71.	.12E 11	166.	237.
2002.	20.	75.	.13E 11	175.	250.
2003.	21.	78.	.14E 11	184.	262.
2004.	22.	82.	.14E 11	192.	275.
2005.	23.	86.	.14E 11	201.	287.
2006.	24.	89.	.16E 11	210.	299.
2007.	25.	93.	.16E 11	219.	312.
2008.	26.	97.	.17E 11	227.	324.
2009.	27.	101.	.18E 11	236.	337.
2010.	27.	101.	.18E 11	236.	337.
2011.	27.	101.	.18E 11	236.	337.
2012.	26.	97.	.17E 11	227.	324.
2013.	26.	97.	.17E 11	227.	324.
2014.	25.	93.	.16E 11	219.	312.
2015.	24.	89.	.16E 11	210.	299.
2016.	23.	86.	.15E 11	201.	287.
2017.	22.	82.	.14E 11	192.	275.
2018.	21.	78.	.14E 11	184.	262.
2019.	20.	75.	.13E 11	175.	250.
2020.	19.	71.	.12E 11	166.	237.

ACADIA OPTIMISTIC WITHOUT REINJECTION

These are the fairway characteristics

Thickness, in feet	315.00
Temperature, in degrees Fahrenheit	306.00
Porosity, as a fraction	0.31
Permeability, in millidarcies	413.00
Fluid recovery, as a fraction	0.74
Gas content, in scf/bbl	35.21
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	1.00
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	103209. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. gen. capacity	130.13 megawatts
Gas flow capacity	.16E 11 scf per year
Lifetime	30.years

Fairway Parameters

Number of plants	29
Elec. gen. capacity	3773.87 megawatts
Gas flow capacity	.46E 12 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	130.	.16E 11	212.	343.
1983.	1.	130.	.16E 11	212.	343.
1984.	2.	260.	.32E 11	425.	685.
1985.	3.	390.	.48E 11	637.	1028.
1986.	4.	521.	.64E 11	850.	1370.
1987.	5.	651.	.80E 11	1062.	1713.
1988.	6.	781.	.96E 11	1275.	2056.
1989.	7.	911.	.11E 12	1487.	2398.
1990.	8.	1041.	.13E 12	1700.	2741.
1991.	9.	1171.	.14E 12	1912.	3083.
1992.	10.	1301.	.16E 12	2125.	3426.
1993.	11	1431.	.18E 12	2337.	3768.
1994.	12.	1562.	.19E 12	2550.	4111.
1995.	13.	1692.	.21E 12	2762.	4454.
1996.	14.	1822.	.22E 12	2974.	4796.
1997.	15.	1952.	.24E 12	3187.	5139.
1998.	16.	2082.	.26E 12	3399.	5481.
1999.	17.	2212.	.27E 12	3612.	5824.
2000.	18.	2342.	.29E 12	3824.	6167.
2001.	19.	2472.	.30E 12	4037.	6509.
2002.	20.	2603.	.32E 12	4249.	6852.
2003.	21.	2733.	.33E 12	4462.	7194.
2004.	22.	2863.	.35E 12	4674.	7537.
2005.	23.	2993.	.37E 12	4886.	7880.
2006.	24.	3123.	.38E 12	5099.	8222.
2007.	25.	3253.	.40E 12	5311.	8565.
2008.	26.	3383.	.42E 12	5524.	8907.
2009.	27.	3514.	.43E 12	5736.	9250.
2010.	28.	3643.	.45E 12	5949.	9593.
2011.	29.	3774.	.46E 12	6161.	9935.
2012.	28.	3643.	.45E 12	5949.	9593.
2013.	28.	3643.	.45E 12	5949.	9593.
2014.	27.	3514.	.43E 12	5736.	9250.
2015.	26.	3383.	.42E 12	5524.	8907.
2016.	25.	3253.	.40E 12	5311.	8565.
2017.	24.	3123.	.38E 12	5099.	8222.
2018.	23.	2993.	.37E 12	4887.	7880.
2019.	22.	2863.	.35E 12	4674.	7537.
2020.	21.	2733.	.33E 12	4462.	7194.

CALCASIEU CONSERVATIVE WITH REINJECTION

These are the fairway characteristics

Thickness, in feet	100.00
Temperature, in degrees Fahrenheit	183.00
Porosity, as a fraction	0.30
Permeability, in millidarcies	100.00
Fluid recovery, as a fraction	0.28
Gas content in scf/bbl	23.80
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	0.96
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	23995. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	3.55 megawatts
Gas flow capacity	.63E 09 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	28
Elec. gen. capacity	99.50 megawatts
Gas flow capacity	.18E 11 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.63E 09	8.
1983.	1.	.63E 09	8.
1984.	2.	.13E 10	17.
1985.	3.	.19E 10	25.
1986.	4.	.25E 10	33.
1987.	5.	.32E 10	42.
1988.	6.	.38E 10	50.
1989.	7.	.44E 10	58.
1990.	8.	.50E 10	67.
1991.	9.	.56E 10	75.
1992.	10.	.63E 10	83.
1993.	11.	.69E 10	92.
1994.	12.	.75E 10	100.
1995.	13.	.82E 10	108.
1996.	14.	.88E 10	117.
1997.	15.	.94E 10	125.
1998.	16.	.10E 11	133.
1999.	17.	.11E 11	142.
2000.	18.	.11E 11	150.
2001.	19.	.12E 11	158.
2002.	20.	.13E 11	167.
2003.	21.	.13E 11	175.
2004.	22.	.14E 11	183.
2005.	23.	.14E 11	192.
2006.	24.	.15E 11	200.
2007.	25.	.16E 11	208.
2008.	26.	.16E 11	217.
2009.	27.	.17E 11	225.
2010.	28.	.18E 11	234.
2011.	28.	.18E 11	234.
2012.	28.	.18E 11	234.
2013.	28.	.18E 11	234.
2014.	28.	.18E 11	234.
2015.	28.	.18E 11	234.
2016.	28.	.18E 11	234.
2017.	28.	.18E 11	234.
2018.	28.	.18E 11	234.
2019.	28.	.18E 11	234.
2020.	28.	.18E 11	234.

CAMERON CONSERVATIVE WITH REINJECTION

These are the fairway characteristics

Thickness, in feet	183.00
Temperature, in degrees Fahrenheit	185.00
Porosity, as a fraction	0.25
Permeability, in millidarcies	180.00
Fluid recovery, as a fraction	0.20
Gas content, in scf/bbl	22.80
Fairway extent, in sq. miles	2100.00
Fraction of fairway which produces	0.94
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	26138. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	3.94 megawatts
Gas flow capacity	.65E 09 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	55
Elec. gen. capacity	216.81 megawatts
Gas flow capacity	.36E 11 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.65E 09	90.
1983.	1.	.65E 09	90.
1984.	2.	.13E 10	17.
1985.	3.	.20E 10	26.
1986.	4.	.26E 10	35.
1987.	5.	.33E 10	43.
1988.	6.	.39E 10	52.
1989.	7.	.46E 10	61.
1990.	8.	.52E 10	69.
1991.	9.	.59E 10	78.
1992.	10.	.65E 10	87.
1993.	11.	.72E 10	95.
1994.	12.	.78E 10	105.
1995.	13.	.85E 10	113.
1996.	14.	.91E 10	121.
1997.	15.	.98E 10	131.
1998.	16.	.10E 11	139.
1999.	17.	.11E 11	147.
2000.	18.	.12E 11	157.
2001.	19.	.12E 11	165.
2002.	20.	.13E 11	173.
2003.	21.	.14E 11	183.
2004.	22.	.14E 11	191.
2005.	23.	.15E 11	199.
2006.	24.	.16E 11	209.
2007.	25.	.16E 11	217.
2008.	26.	.17E 11	225.
2009.	27.	.18E 11	235.
2010.	28.	.18E 11	243.
2011.	29.	.19E 11	251.
2012.	30.	.20E 11	261.
2013.	31.	.20E 11	270.
2014.	32.	.21E 11	278.
2015.	33.	.22E 11	287.
2016.	34.	.22E 11	296.
2017.	35.	.23E 11	305.
2018.	36.	.23E 11	314.
2019.	37.	.24E 11	322.
2020.	38.	.25E 11	331.

CAMERON OPTIMISTIC WITH REINJECTION

These are the fairway characteristics

Thickness, in feet	380.00
Temperature, in degrees Fahrenheit	270.00
Porosity, as a fraction	0.20
Permeability, in millidarcies	500.00
Fluid recovery, as a fraction	1.00
Gas content, in scf/bbl	27.90
Fairway extent, in sq. miles	2100.00
Fraction of fairway which produces	1.00
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	75771. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. gen. capacity	78.05 megawatts
Gas flow capacity	.90E 10 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	58
Elec gen. capacity	4526.86 megawatts
Gas flow capacity	.52E 12 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.90E 10	120.
1983.	1.	.90E 10	120.
1984.	2.	.18E 11	239.
1985.	3.	.27E 11	359.
1986.	4.	.36E 11	478.
1987.	5.	.45E 11	598.
1988.	6.	.54E 11	717.
1989.	7.	.63E 11	837.
1990.	8.	.72E 11	956.
1991.	9.	.81E 11	1076.
1992.	10.	.90E 11	1195.
1993.	11.	.99E 11	1315.
1994.	12.	.11E 12	1434.
1995.	13.	.12E 12	1554.
1996.	14.	.13E 12	1673.
1997.	15.	.14E 12	1793.
1998.	16.	.14E 12	1912.
1999.	17.	.15E 12	2032.
2000.	18.	.16E 12	2151.
2001.	19.	.17E 12	2271.
2002.	20.	.18E 12	2391.
2003.	21.	.19E 12	2510.
2004.	22.	.20E 12	2630.
2005.	23.	.21E 12	2749.
2006.	24.	.22E 12	2868.
2007.	25.	.23E 12	2988.
2008.	26.	.23E 12	3108.
2009.	27.	.24E 12	3227.
2010.	28.	.25E 12	3347.
2011.	29.	.26E 12	3466.
2012.	30.	.27E 12	3585.
2013.	31.	.28E 12	3705.
2014.	32.	.29E 12	3825.
2015.	33.	.30E 12	3944.
2016.	34.	.31E 12	4064.
2017.	35.	.32E 12	4184.
2018.	36.	.32E 12	4303.
2019.	37.	.33E 12	4423.
2020	38.	.34E 12	4542.

ACADIA CONSERVATIVE WITH REINJECTION

These are the fairway characteristics

Thickness, in feet	150.00
Temperature, in degrees Fahrenheit	202.00
Porosity, as a fraction	0.20
Permeability, in millidarcies	125.00
Fluid recovery, as a fraction	0.20
Gas content, in scf/bbl	27.90
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	0.90
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	0.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	21424. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	3.73 megawatts
Gas flow capacity	.65E 09 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	27
Elec. gen. capacity	100.60 megawatts
Gas flow capacity	.18E 11 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.65E 09	9.
1983.	1.	.65E 09	9.
1984.	2.	.13E 10	17.
1985.	3.	.20E 10	26.
1986.	4.	.26E 10	35.
1987.	5.	.33E 10	44.
1988.	6.	.39E 10	52.
1989.	7.	.46E 10	61.
1990.	8.	.52E 10	70.
1991.	9.	.59E 10	79.
1992.	10.	.65E 10	87.
1993.	11.	.72E 10	96.
1994.	12.	.79E 10	105.
1995.	13.	.85E 10	114.
1996.	14.	.91E 10	122.
1997.	15.	.98E 10	131.
1998.	16.	.10E 11	140.
1999.	17.	.11E 11	149.
2000.	18.	.12E 11	157.
2001.	19.	.12E 11	166.
2002.	20.	.13E 11	175.
2003.	21.	.14E 11	184.
2004.	22.	.14E 11	192.
2005.	23.	.15E 11	201.
2006.	24.	.16E 11	210.
2007.	25.	.16E 11	219.
2008.	26.	.17E 11	227.
2009.	27.	.18E 11	236.
2010.	27.	.18E 11	236.
2011.	27.	.18E 11	236.
2012.	27.	.18E 11	236.
2013.	27.	.18E 11	236.
2014.	27.	.18E 11	236.
2015.	27.	.18E 11	236.
2016.	27.	.18E 11	236.
2017.	27.	.18E 11	236.
2018.	27.	.18E 11	236.
2019.	27.	.18E 11	236.
2020.	27.	.18E 11	236.

ACADIA OPTIMISTIC WITH REINJECTION

These are the fairway characteristics

Thickness, in feet	315.00
Temperature, in degrees Fahrenheit	306.00
Porosity, as a fraction	0.30
Permeability, in millidarcies	413.00
Fluid recovery, as a fraction	1.00
Gas content, in scf/bbl	35.20
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	1.00
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	69736. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. gen. capacity	87.93 megawatts
Gas flow capacity	.11E 11 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	29
Elec. gen. capacity	2549.91 megawatts
Gas flow capacity	.31E 12 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.11E 11	144.
1983.	1.	.11E 11	144.
1984.	2.	.21E 11	287.
1985.	3.	.32E 11	431.
1986.	4.	.43E 11	574.
1987.	5.	.54E 11	718.
1988.	6.	.65E 11	861.
1989.	7.	.75E 11	1005.
1990.	8.	.86E 11	1148.
1991.	9.	.97E 11	1292.
1992.	10.	.11E 12	1436.
1993.	11.	.12E 12	1579.
1994.	12.	.13E 12	1723.
1995.	13.	.14E 12	1866.
1996.	14.	.15E 12	2010.
1997.	15.	.16E 12	2153.
1998.	16.	.17E 12	2297.
1999.	17.	.18E 12	2440.
2000.	18.	.19E 12	2584.
2001.	19.	.20E 12	2727.
2002.	20.	.21E 12	2871.
2003.	21.	.23E 12	3015.
2004.	22.	.24E 12	3158.
2005.	23.	.25E 12	3302.
2006.	24.	.26E 12	3445.
2007.	25.	.27E 12	3589.
2008.	26.	.28E 12	3732.
2009.	27.	.29E 12	3876.
2010.	28.	.30E 12	4019.
2011.	29.	.31E 12	4163.
2012.	29.	.31E 12	4163.
2013.	29.	.31E 12	4163.
2014.	29.	.31E 12	4163.
2015.	29.	.31E 12	4163.
2016.	29.	.31E 12	4163.
2017.	29.	.31E 12	4163.
2018.	29.	.31E 12	4163.
2019.	29.	.31E 12	4163.
2020.	29.	.31E 12	4163.

VERMILION OPTIMISTIC WITH REINJECTION

These are the fairway characteristics

Thickness, in feet	825.00
Temperature, in degrees Fahrenheit	312.00
Porosity, as a fraction	0.20
Permeability, in millidarcies	1400.00
Fluid recovery, as a fraction	1.00
Gas content, in scf/bbl	36.10
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	1.00
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	0.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	153233. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. gen. capacity	198.14 megawatts
Gas flow capacity	.24E 11 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	29
Elec. gen. capacity	5746.04 megawatts
Gas flow capacity	.70E 12 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.24E 11	324.
1983.	1.	.24E 11	324.
1984.	2.	.48E 11	648.
1985.	3.	.73E 11	972.
1986.	4.	.96E 11	1296.
1987.	5.	.12E 12	1620.
1988.	6.	.14E 12	1944.
1989.	7.	.17E 12	2268.
1990.	8.	.19E 12	2591.
1991.	9.	.22E 12	2915.
1992.	10.	.24E 12	3239.
1993.	11.	.26E 12	3563.
1994.	12.	.29E 12	3887.
1995.	13.	.31E 12	4211.
1996.	14.	.34E 12	4535.
1997.	15.	.36E 12	4859.
1998.	16.	.38E 12	5183.
1999.	17.	.41E 12	5507.
2000.	18.	.44E 12	5831.
2001.	19.	.46E 12	6155.
2002.	20.	.48E 12	6479.
2003.	21.	.51E 12	6803.
2004.	22.	.53E 12	7126.
2005.	23.	.55E 12	7450.
2006.	24.	.58E 12	7774.
2007.	25.	.60E 12	8098.
2008.	26.	.62E 12	8422.
2009.	27.	.65E 12	8746.
2010.	28.	.67E 12	9070.
2011.	29.	.70E 12	9394.
2012.	29.	.70E 12	9394.
2013.	29.	.70E 12	9394.
2014.	29.	.70E 12	9394.
2015.	29.	.70E 12	9394.
2016.	29.	.70E 12	9394.
2017.	29.	.70E 12	9394.
2018.	29.	.70E 12	9394.
2019.	29.	.70E 12	9394.
2020.	29.	.70E 12	9394.

VERMILION CONSERVATIVE WITH REINJECTION

These are the fairway characteristics

Thickness, in feet	350.00
Temperature, in degrees Fahrenheit	245.00
Porosity, as a fraction	0.20
Permeability, in millidarcies	100.00
Fluid recovery, as a fraction	0.10
Gas content, in scf/bbl	36.40
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	0.80
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	31994. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	7.43 megawatts
Gas flow capacity	.13E 10 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	26
Elec. gen. capacity	193.27 megawatts
Gas flow capacity	.33E 11 scf per year

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.13E 10	17.
1983.	1.	.13E 10	17.
1984.	2.	.26E 10	34.
1985.	3.	.38E 10	51.
1986.	4.	.52E 10	68.
1987.	5.	.65E 10	85.
1988.	6.	.77E 10	102.
1989.	7.	.91E 10	119.
1990.	8.	.10E 11	136.
1991.	9.	.11E 11	153.
1992.	10.	.13E 11	170.
1993.	11.	.14E 11	187.
1994.	12.	.15E 11	204.
1995.	13.	.17E 11	222.
1996.	14.	.18E 11	239.
1997.	15.	.19E 11	255.
1998.	16.	.21E 11	273.
1999.	17.	.22E 11	290.
2000.	18.	.23E 11	306.
2001.	19.	.25E 11	324.
2002.	20.	.26E 11	341.
2003.	21.	.27E 11	357.
2004.	22.	.29E 11	375.
2005.	23.	.30E 11	392.
2006.	24.	.31E 11	409.
2007.	25.	.32E 11	426.
2008.	26.	.33E 11	443.
2009.	26.	.33E 11	443.
2010.	26.	.33E 11	443.
2011.	26.	.33E 11	443.
2012.	26.	.33E 11	443.
2013.	26.	.33E 11	443.
2014.	26.	.33E 11	443.
2015.	26.	.33E 11	443.
2016.	26.	.33E 11	443.
2017.	26.	.33E 11	443.
2018.	26.	.33E 11	443.
2019.	26.	.33E 11	443.
2020.	26.	.33E 11	443.

1. INTRODUCTION

The purpose of this report is to provide a summary of the results of the investigation conducted by the Joint Committee on the Assassination of President John F. Kennedy. The report is based on the information received from the various sources mentioned in the report.

Communications to Identify "Decision Makers"

The following is a summary of the results of the investigation conducted by the Joint Committee on the Assassination of President John F. Kennedy. The report is based on the information received from the various sources mentioned in the report.

COMMUNICATIONS

Ad Hoc Committee to Draft Proposed Rules & Regulations
California
ERDA Projects
Geopressure Subcommittee
Louisiana State Government
Louisiana State University (Baton Rouge)
Louisiana (Miscellaneous)
Texas
United States Government
Others

These lists represent parties we have contacted concerning geothermal energy. Many of these individuals have supplied us with useful information. It is hoped that we have opened the lines of communication needed to develop the geopressured resources in Louisiana.

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Report to Governor
& Legislature on
STATUS OF GP/GT ENERGY IN LOUISIANA

Prepared by
this project for
LOUISIANA OFFICE OF CONSERVATION

LOUISIANA
GEOTHERMAL/GEOPRESSURED
ENERGY RESOURCES
June 1977

Resume of Activity

By

Louisiana Office of Conservation
R. T. Sutton, Commissioner

**LOUISIANA
GEOTHERMAL/GEOPRESSURED
ENERGY RESOURCES**

June 1977

Resume of Activity

By

**Louisiana Office of Conservation
R. T. Sutton, Commissioner**

**In Compliance With
Act 735 of 1975
Progress Report of Geothermal/Geopressured Programs
are herewith submitted to the Governor and the
Joint Legislative Committee on Natural Resources**

Summary

Louisiana may have a vast store of energy in its geothermal/geopressured resources. Present estimates range from 34 to 105,000 quads of energy (the United States uses 70 quads of energy per year). Much work remains to be done to better define and develop this resource.

The Energy Research and Development Administration (ERDA) has been funding research on geothermal/geopressured development and has budgeted 7.4 million for FY-78. The ERDA research program is designed to answer questions concerning the amount of contained natural gas, number and locations of reservoirs, reservoir deliverability, fluid disposal, economics, legal aspects, and institutional requirements. ERDA has funded projects in Louisiana covering research and development planning, legal aspects, well testing, resource assessment, environmental assessment, and non-electric uses of geothermal/geopressured energy. At least eight prime sites for a potential test well have been identified in Southwest Louisiana, and data on the fluid properties of a geopressured reservoir are now being obtained from an existing well.

Due to economic uncertainties, there is little public commitment by industry to geothermal/geopressured resource utilization. However, interest is growing. A new federal loan guaranty program may provide some additional incentive.

Pursuant to Act 134 of 1976 of the Louisiana Legislature, the Office of Conservation has formed an ad hoc committee to draft proposed rules and regulations relating to Louisiana's geothermal/geopressured resources.

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La. Representative Clyde Bel, Jr.
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The Office also wishes to recognize Bert Wilkins, Jr. and

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The typing and manuscript preparation were done by Ann Rice Parker, Mary F. McDaniel, and Frances W. Norwood.

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I. BACKGROUND

Introduction

Louisiana may be blessed with a resource whose development could rival that of oil and gas production. This resource is known as geothermal/geopressured energy. Estimates as to the energy content of this resource have ranged from 34 to 105,000 quads (one quadrillion BTUs). By comparison, the State of Louisiana consumes about 3 quads per year; the United States consumes about 70 quads per year.

Several articles have been written in our state newspapers concerning this resource. Special reports have appeared in Fortune (Oct. 1976) and Science (Feb. 13, 1976). The April 27 and May 20, 1977, editorials in the Wall Street Journal discuss geopressured methane, but there is still a lack of public awareness of this resource.

Since there is no general consensus as to the potential of this resource or the costs associated with its development, much work remains to be done before this resource can contribute to the energy needs of Louisiana. It is the purpose of this report to review the present and planned activities in Louisiana which are intended to define and develop this potential resource.

Nature of the Resource

In general, the term, "geothermal", refers to heat from the earth. However, geothermal resources have been classified into three categories. One type is the vapor-dominated or dry-steam reservoir which yields superheated steam and other gases with little or no water. This type of reservoir exists in the Geysers Field in California. It is interesting

to note that geothermal energy accounts for 502 megawatts (MW) of electric generating capacity in California. California utility companies have announced plans for increasing their geothermal capacity to 3356 MW by 1995. This dry-steam type of reservoir is the only geothermal resource in the United States that is presently used to generate electricity.

A second category of geothermal resources is the dry rock type. To extract energy from these deposits, two well bores are drilled and connected by underground fissures. Water is then pumped down one well, through the fissures, and back to the surface through the other well. The heat is transferred from the deposits to the surface via the heated water. The technology in this area seems to be several years away.

The third category of geothermal resources is found along the northern rim of the Gulf of Mexico. Louisiana is thought to be a prime area for this category. These deposits differ from the others in that they are dominated by hot water under extreme pressure. These deposits are thought to have resulted from water being trapped under compacted formations. The interstitial water is forced to bear much of the weight of the over-burden, resulting in the extreme pressure. These geo-pressured deposits are hotter than would normally be expected because the upward loss of water has been stopped for millions of years by the presence of impermeable shales overlying the deposits. It is this category which is described in this report. The terminology used in reference to this resource will be to denote it as the geothermal/geo-pressured (GT/GP) energy resource.

The GT/GP resources occur at depths of 8,000 to 18,000 feet. Pressures range from 4,000 to 15,000 pounds per square inch and temperatures range from 200° to 400°F. The waters are thought to be

saturated with dissolved methane at about 30 standard cubic feet per barrel of water. This may exceed 100 standard cubic feet per barrel of water at the higher temperatures and pressures, as measured in a recent Chevron gas well. These waters also vary in salinity from 2,000 parts per million (ppm) to 200,000 ppm, with total dissolved solids as high as 300,000 ppm. By comparison, the salinity of seawater is approximately 35,000 ppm. The reservoir permeabilities, which affect the rate at which a well will flow, range from 0.1 to 1,000 millidarcies.

Utilization of the Energy

There are three sources of energy recoverable from geopressured reservoirs: geohydraulic energy from the high pressure waters, geothermal energy from the water's heat, and dissolved natural gas. Since there is significant hydraulic and heat energy lost by transporting the resource any appreciable distance before utilization, use of these two sources of energy must be made at or near the site of extraction. Since the sites of geopressured reservoirs are restricted to the coastal areas in Louisiana, the place of utilization is similarly restricted.

Because the geopressured resource cannot be transported without significant energy loss, the generation of electricity from geopressured brines has received much attention. A typical operation is shown in the attached schematic. As noted earlier, electricity is currently being generated by Pacific Gas and Electric in Northern California using geothermal dry steam as "fuel". This electricity is then sold to Pacific's customers, the electricity being transported on Pacific's existing grid system.

SCHEMATIC DIAGRAM OF GEOPRESSURED ENERGY RECOVERY

The geopressured resources of Louisiana have very different physical properties from those in California. These differences present special problems in the generation of electricity. One recent study by the Dow Chemical Company of the use of geopressured brine postulated a model 25 megawatt (MW) electric generating plant. (By comparison, the proposed nuclear generating plant at River Bend near St. Francisville, La. will have two units rated at 934 MW each.) The production facilities for the model plant would consist of ten production and nineteen reinjection wells spaced in a model reservoir postulated to have a surface area of about 40 square miles.

To make electric generation feasible, the study indicates that each of the following must be present: 1) a well flow of about 40,000 BBL/day of geopressured brine per well or a total of 400,000 BBL/day; 2) temperature of about 325°F; 3) pressure of 2,000 lbs. per square inch at the well head; and 4) a methane content of 40 cubic feet per barrel. It should be noted that best estimates currently indicate that about one-half of the revenues of the generating plant are derived from the direct sale of the natural gas. The useful economic life of the plant is thirty years. The literature presently in existence is unclear in projecting the economic life of the reservoir.

Much depends on available technology. Using existing technology in turbine and generator design, high maintenance costs can be expected because of the impurities in the brine. Low pressure turbines presently in use are not very efficient. Conversion efficiency of the heat content of the water may be as low as 5.5%.

Present technology and the need for heat, pressure, gas content, and flow rate to be available at near optimum conditions make generation projects marginally economic. Hence, until more work is done to define the resource, prospects for large scale investment must be considered slim. This is especially the case where the profits of the public utility are so closely regulated.

In addition to providing energy for conversion into electricity, geothermal resources can be directly used for process heat. This has been done for some time in Iceland, and, in this country, at Klamath Falls, Oregon. Basically, these uses have been confined to providing residential heating, although industrial needs have also been studied.

In Louisiana, maximum use of low-grade process heat could probably be utilized by a number of industries, including the pulp/paper, the sugar, and the food processing industries. A preliminary examination of the requirements of these industries indicate that present technology is capable of utilizing the energy found in geopressured reservoirs and that major plant modification would not be necessary. Geopressured energy is competitive with present sources, provided the natural gas is separated and the geohydraulic energy is utilized for electricity generation.

The problem in using geopressured energy in the pulp/paper and sugar industries is the highly capital intensive nature of the project. Cost is especially restrictive in the sugar industry where operations are seasonal.

It is possible that geopressured resources could be utilized in the food processing or petrochemical industries. Given the cut-backs in natural gas supplies this winter, more companies can be expected

to explore the possibility of using geopressed resources as supplying at least part of their energy needs. To make utilization feasible, the methane would have to be extracted from the water to allow cut-backs in natural gas purchases, electricity would have to be generated, and the thermal energy would have to be passed through heat exchangers to utilize the heat energy.

The economics for either electricity generation or process heat applications are not well defined, but work is underway to supply the necessary information. It must always be remembered that the type of resource with which we are dealing in Louisiana is very different from the resource found at the Geysers Field in California. A change in the comparative economic picture, especially the price of natural gas, may make utilization much more attractive. In fact, the dissolved natural gas could prove to be the most valuable aspect of the resource. Advances in technology allowing a decrease in maintenance costs and an increase in conversion efficiency would also have an impact on the total picture.

ERDA's Research and Development Program

The United States Energy Research and Development Administration (ERDA) plans to fund GT/GP development at the level of \$7.4 million for 1978. One of the goals of the Division of Geothermal Energy (DGE) is to encourage establishment of a viable GT/GP industry beginning in the mid-1980's. Its research effort is designed to answer questions concerning the following topics:

- Amount of Contained Natural Gas
- Number and Locations of Reservoirs
- Reservoir Deliverability
- Fluid Disposal

- Economics
- Legal Aspects
- Institutional Requirements

This work is proceeding in two phases. Phase I will involve the location of fairways and selection of sites. Phase II will involve well testing in existing and new wells.

The next step in ERDA's program is to drill one well in each of the best of the prime areas defined by detailed resource assessment studies. In 1978, one well is planned for Brazoria County, Texas, one for southwestern Louisiana, and a well possibly in one of the three remaining promising areas in Texas. Three additional wells will be drilled in the area where the first well shows production in the volume required to make further development possible. The four-well field can deliver the large volume flow required to make feasible the construction of a 10 megawatt electrical generating plant which should be constructed and operating in 1982. In addition, existing well tests will contribute to the statistical data base of the resource to help establish its validity and to assist in determining locations for other wells to be drilled. Approximately ten wells will be drilled to determine resource development feasibility by 1982. After success is shown, industry is expected to continue resource development.

The second plant, which could be built in Louisiana, will be 25 MW and will incorporate improved heat conversion and generating equipment. This installation should be finished by 1986 and will be built on a cost-shared basis with industry.

ERDA has identified a number of potential problems involved in the production of energy from these resources. Natural gas may not be

present in the saturation levels estimated. Reservoirs may be limited in extent and have less permeability (ability to pass fluids) than needed. Adequate statistical data on the resource must be developed to stimulate industrial development. Environmental problems such as subsidence may be formidable. Disposal of large quantities of processed brines could be a problem. Natural gas prices are regulated at levels too low to justify full-scale development by the oil and gas industry. More efficient and economical methods of heat conversion need to be developed for electric power generation.

Lack of legal definition for the resource results in an inadequate legal basis for large drainage of large volume fluids. Action may be needed to resolve ownership rights of the gas dissolved in the geopressured water. Lease holders of prime areas in Texas and Louisiana are not known, and without legal definition of the resource, difficulties in negotiation can be foreseen.

ERDA has begun to address these problems in the research projects which are discussed in the following section.

II. RESEARCH AND DEVELOPMENT ACTIVITIES IN LOUISIANA

ERDA Projects

Five research and development projects are being funded in Louisiana by ERDA. Detailed description of each of these projects is contained in Appendix A. Brief summaries follow in this section:

Operations Research and Systems Analysis of Geothermal/Geopressured Energy Resources in Louisiana (See Appendix A-1)
Principal Investigator: Bert Wilkins, Jr.
Office of Advanced Studies and Research, Louisiana State University,
Baton Rouge, Louisiana
Funding: \$49,998
Starting Date: April 1, 1977
Duration of Project: 7 months

The overall objective of this project is to develop a long range plan for the development of Louisiana's geothermal/geopressured resources, and a system for monitoring the year by year accomplishment of the plan. A set of planning scenarios which will project GT/GP development is being prepared. Key decision-makers and "stake holders" are being identified. A state-wide advisory group will be established. Activities are being coordinated with a parallel project in Texas. Recommendations for a regional activity will be formulated. This project is being conducted in cooperation with the Office of Conservation.

Legal Problems Inherent in the Development of Geothermal/Geopressured Resources in Louisiana (See Appendix A-2)
Principal Investigator: Thomas A. Harrell
Law Center
Louisiana State University, Baton Rouge, La.
Funding: \$104,741
Starting Date: October 1, 1976
Duration of Project: 1 year

The objectives of this project are the identification of the legal, environmental and economic problems inherent in the development of Louisiana's geothermal/geopressured resource. It will evaluate whether,

to what extent, and how effectively existing legal institutions can resolve such problems. A determination will be made of the extent to which new legislation or regulation may be necessary or appropriate to encourage the exploration and development of the resource in an economically feasible and environmentally sound manner. The legitimate economic interests of the private property owners, as well as those of the public, in the benefits of such development will be taken into account.

Investigation on the Geopressured Resources of Southern Louisiana (See Appendix A-3)

Principal Investigator: Murray F. Hawkins, Jr.

Petroleum Engineering Department

Louisiana State University, Baton Rouge, La.

Funding: \$178,400

Starting Date: May 1975

Duration of Project: 22 months

The primary aims of the investigations are three-fold: (1) to estimate the total energy in the geopressured sandstone strata of southern Louisiana; (2) to locate one or more geopressured aquifers with bulk sandstone volumes of the order of one trillion cubic feet; and (3) to test the validity of the research methods in achieving these aims. A report on these investigations has been completed and submitted to ERDA, and a proposal to continue this work has been discussed with ERDA. Based on current results, the total energy in the sandstone geopressured aquifers underlying this area is estimated at 34.3 quadrillion BTUs or quads, of which 1.2 quads is geohydraulic energy, 19.5 geothermal and 13.6 natural gas. Eight large geopressured aquifers have been located and mapped. In addition, 55 prospective areas have been identified from the sand count and pressure maps which warrant detailed geologic study to ascer-

tain the limits and volumes of geopressured aquifers in these areas.

**Investigation and Definition of Parameters Associated
with Testing Geopressured Water (See Appendix A-4)**

Principal Investigator: O. Carroll Karkalits

School of Engineering and Technology

McNeese State University, Lake Charles, La.

Funding: \$1,400,000

Starting Date: August 1, 1976

Duration of Project: 1 year

This project consists of testing an abandoned gas well to produce geothermal/geopressured water from a sand separate from the gas source. The well utilized is in the Tigre Lagoon field in south Vermilion Parish.

The objectives of the project are to produce geologic maps of the reservoir; to collect and analyze samples of water from each sand bed aquifer; to determine reservoir flow rates; to investigate sand stability problem; to determine Kh value of the sand (Kh is the product of the permeability times the net sand thickness); and to develop methods for additional dynamic tests on geopressured reservoirs.

The first well tests began at the end of May 1977. The initial flow data indicates the bottom-hole pressure at 9,000 psi, surface pressure of 1,700 psi, and surface temperature of 210°F. Water and gas tests are underway.

**Engineering and Economic Studies of Non-Electric Applications of
Geothermal Heat (See Appendix A-5)**

Principal Investigator: DeLaureal Engineers, Inc., New Orleans, La.

Project Manager: T. W. Schnadelbach, Jr.

Starting Date: November 29, 1976

Duration of Project: 1 year

Funding:

The objectives of this project with respect to non-electric use of the GT/GP resource are to establish a quick reference source for potential and specific industrial use of geothermal energy; to establish economic

criteria for conversion, transmission, or relocation of each industry type; and to identify industries for case studies for near-term conversion.

All of the available data pertaining to the location, general features, composition, and reservoir specifics have been collected from known sources. State-wide maps have been prepared that illustrate the areas of activity.

The inventory of all food and kindred products in Louisiana has been completed. A listing of all the industries is available, including firm name, address, employment, activity location, and area of product distribution.

Future ERDA Activities

ERDA has plans for a number of GT/GP projects in Louisiana. The following list describes these projects:

- Drilling and Testing Geopressured-Geothermal Aquifers in South Louisiana.

The primary goals of this project will be to obtain information concerning aquifer fluid properties, the characteristics of GT/GP reservoirs, and the behavior of reservoirs under conditions of moderate to high rates of fluid production. Other goals include the evaluation of completion techniques and production strategies, the determination of possible environmental, legal, and social impacts of future GT/GP commercial development, and the study of the variability of the GT/GP formation characteristics between widely separated parts of the U. S. Gulf Coast.

Several proposals have been submitted to ERDA for this project, but no contract has been awarded.

- Investigation and Evaluation of Geothermal/Geopressured Formations in Existing Wells.

More information is needed on the Gulf Coast geopressured formations and their contained fluids to effectively stimulate industry in the development and recovery of the energy associated with this potentially valuable resource. One of the quickest and most economical means for obtaining this information is to contract with a qualified industry-management group to subcontract and supervise well testing of geopressured formations in existing wells in geographic areas of interest. This industry-management group will act as a "brokerage" firm to quickly subcontract oil and gas company operators to test wells-of-opportunity to gain the needed resource information.

ERDA intends to select one qualified oil-and-gas consulting organization to test fluid and reservoir properties in GT/GP formations in up to six oil and gas wells which are being drilled and completed or are being plugged and abandoned. Oil and gas wells not drilled but in the planning stage will also be considered. These tests are to be completed in one year, but extension of the contract for one year may be possible to test additional wells.

The prime area for well testing in Texas is the Brazoria-Galveston Counties area. Areas of high interest in Louisiana are in the parishes of Calcasieu, Cameron, and Acadia which have mapped GT/GP reservoir prospects. ERDA will identify other areas in Louisiana when studies now being conducted jointly by Louisiana State University and the Office of Conservation are completed. The attached map indicates the areas of current interest in Louisiana.

• Generic Environmental Assessment for Testing Geothermal/Geopressured Formations in Existing Wells

In the program described above to test existing wells, time is critical in gaining access to and subcontracting well tests in wells that are available for only a few days prior to their being cemented and abandoned. Accordingly, subcontracts must be negotiated and consummated quickly with well operators, and inadequate time is available for completion and approval of elaborate environmental assessment plans for individual wells. The objective of this program is to implement background studies needed to establish a generic environmental assessment for the Gulf Coast area adequate to cover a quick response geopressured well test program.

LOUISIANA

To accomplish this program, ERDA has recently awarded a contract to Coastal Environments, Inc. of Baton Rouge who will analyze the potential effects of the well-testing program for the specified areas of interest. On the basis of the environmental setting, subsurface characteristics, and the proposed actions, potential environmental impacts will be determined. These impacts will be evaluated together with potential conflicts with federal, state, and local programs.

● A Preliminary Environmental Analysis of Geothermal/Geopressured Prospect Areas on the Louisiana Gulf Coast.

A number of high potential GT/GP reservoir areas have been mapped in southwestern Louisiana (See discussion of Investigation on the Geopressured Resources of Southern Louisiana). The Louisiana State University Institute for Environmental Studies has recently submitted a proposal to ERDA to perform a preliminary analysis of these sites and to determine the ranking according to environmental impact. The proposed research will determine whether the drilling and operation of test wells in selected sites will result in significant detrimental environmental effects. This preliminary environmental analysis will include the compilation of environmental baseline data derived from existing sources and the identification of areas that require further research. The selected sites will receive a preliminary rank according to their environmental acceptability. Ranks will be assigned on the basis of the expected resource requirements and technological options to be used at the site, possible sources of environmental problems, and selected environmental indices.

- The Definition of Technical and Field Testing Requirements for Engineering and Economic Evaluation of the Producibility and Potential Recovery of Natural Gas from Geopressured Aquifers

The Gulf Universities Research Consortium (GURC) is assisting ERDA in developing a technical program plan relating to the evaluation of the recovery of dissolved natural gas from geopressured aquifers as a potential new supply of natural gas. The objective of the proposed program is to develop a comprehensive definition of the requirements for a sound engineering and economic assessment of the potential of natural gas recovery from geopressured aquifers in the Gulf Coast Region as a major domestic energy source, and to develop a technical program design for satisfying these requirements.

GURC staff will accomplish the acquisition, integration and documentation functions. Subcontracts, grants, and consulting agreements with five institutions and five selected individuals from universities or consulting firms are contemplated. Because the formations of most immediate interest are in the Texas/Louisiana/Mississippi area, and because at least an adequate sample of existing data, knowledge, and experience regarding these aquifers is resident in the Texas/Louisiana area, it is planned that such subcontracts, grants, and consulting will be limited geographically to this area.

- Geopressured Geothermal Energy Conference

The Center for Energy Studies at the University of Southwestern Louisiana is organizing the Third Geopressured Geothermal Energy Conference to be held in March, 1978. This conference will be sponsored by ERDA, as were the first two conferences, held in Austin, Texas.

U.S.L. has also proposed research to ERDA, concerning well tests and geologic studies.

United States Geological Survey Activities

The United States Geological Survey is assessing the onshore geothermal/geopressured resources in the Northern Gulf of Mexico Basin. This assessment was last reported in Circular 726, "Assessment of Geothermal Resources of the United States - 1975". The authors of the Gulf of Mexico report are S. S. Papadopoulos, R. H. Wallace, Jr., J. B. Wesselman, and R. E. Taylor. Research in the Louisiana resources is presently being conducted under the direction of R. H. Wallace, Jr. at the Gulf Coast Hydrosience Center near Bay St. Louis, Mississippi.

University Research

There have been three graduate research projects completed at LSU since 1969, pertaining to geothermal resources. John M. Parmigiano's thesis, entitled "Geohydraulic Energy from Geopressured Aquifers", dealt with methods for calculating the surface pressure and flow rate history of several geothermal/geopressured reservoir systems. Rufus O. Elemo's thesis, entitled "Possible Use of Geopressured Aquifers for the Short-Term Storage of Energy", studied the off-peak storage of electrical energy in geopressured aquifers. Part of this research was made possible by a grant from Gulf States Utilities Company. Both of these studies were conducted in the LSU Department of Petroleum Engineering.

"Hydrology of Neogene Deposits in the Northern Gulf of Mexico Basin," a dissertation by Paul H. Jones in the LSU Department of Geology, has been the basis for many of the geologic studies of geothermal energy in Louisiana. Dr. Jones has built upon this work for many of his papers. In addition, there are several graduate research projects being conducted at the LSU Department of Geology, under the direction of Dr. Jones. The topics of these projects follow:

- a. Dissolved methane gas reserves in southern Louisiana.
- b. Distribution of pressure, temperature and salinity and their relationships with stratigraphic and structural controls on oil accumulation from dip profiles across Southwest Louisiana.
- c. Authigenic cements and their relation to the geopressured zone.
- d. Use of the environment of deposition of certain faunal assemblages of Order Foraminifera to predict the top of the geopressured zone.
- e. Analysis and interpretation of geologic and hydrologic controls on occurrence of methane in formation waters of the Gulf Coast, primarily in Oligocene and Miocene deposits.

III. INDUSTRY

Resource Development

One company that has shown considerable interest in developing the geothermal resources of Louisiana is Magma Gulf Company, headquartered in Baton Rouge. Founded in October 1976, this Texas corporation is the outgrowth of a joint venture in leasing between Magma Power Company, a Nevada corporation, and Gulf Geothermal Corporation, a Louisiana corporation. The Magma group of companies owns 25% of the California Geysers project and has holdings in many other geothermal areas.

Gulf Geothermal Corporation was not organized until May 1973, but two of its principals, Dr. C. O. Durham, Jr. and Mr. W. A. Romans, had attempted to raise funds for a proprietary investigation of Gulf Coast geothermal resources beginning in 1970. Gulf Geothermal Corporation conducted a five-fold investigation of the following facets:

- (1) Resource evaluation
- (2) Technology for development of resource
- (3) Ownership and regulation of resource
- (4) Economics
- (5) Environmental considerations

This investigation was largely completed by middle 1974. A leasing program was inaugurated in December, 1974.

Magma Gulf tried to obtain private funding to drill three test wells in a \$10 million program. From October, 1975 to February, 1976, large firms in the energy, manufacturing, and utility fields were solicited and several became interested. However, increasing publicity occurred in Texas newspapers regarding the ERDA plan to drill, and private enterprise money adopted the attitude of "wait and see". This is still the current situation.

The projects by L.S.U. and DeLaureal have begun to identify companies that are interested in geothermal development. Middle South Services, Inc. is studying the possibility of using the resource for electric power generation. Several oil and gas companies have collected data on the resource while drilling. It is this data that has been the basis for most of the resource assessment in the Gulf Coast.

ERDA Geothermal Loan Guaranty Program

The Geothermal Loan Guaranty Program Regulations were signed on May 25, 1976, published in the Federal Register, May 26, 1976, and became effective June 25, 1976. The key points in the Regulations are summarized in the following Fact Sheet:

Legal Basis: Geothermal Energy Research Development and Demonstration Act of 1974 (P.L. 93-410).

Purpose: Accelerate commercial development of geothermal energy by private sector through minimizing financial risk to lending agencies.

Dollar Limit: Single Project - \$25 Million; Single Borrower - \$50 Million; Also - 75% of aggregate cost of project but may be 100% of loan.

Interest: Not to exceed Administrator's determination (with Secretary of Treasury) of "reasonable" and "prevailing".

Terms: Up to 30 years or expected life of physical assets, whichever is less.

Location: Project in U.S., territories, or possessions

Termination: September 3, 1984, but guaranty agreements and interest assistance contracts in effect at that time will remain in effect.

Guaranty Fee: It is expected that no more than 1 per cent annually on average outstanding loan value may be passed to borrower; however, a firm fee will be determined at a later date.

Controls and

Restrictions: Detailed in Federal Register, May 26, 1976, pp.21433-21440.

- (1) Information concerning the lender and the borrower.
- (2) Information on project.
- (3) Interest assistance by ERDA.
- (4) Default authority by ERDA.
- (5) Permissible costs defined - criteria (financial considerations).
- (6) Expenses not allowable.
- (7) Environmental considerations.
- (8) Reports required and access to reports to other agencies.
- (9) Servicing the loan.
- (10) Visit access.
- (11) Withdrawal of guaranty.
- (12) Security (borrower's assets).
- (13) Patents and proprietary rights.
- (14) Escrow and interest.

Who Administers: The Administrator of ERDA; however, the Manager of SAN has been delegated the responsibility of processing all applications for geothermal loan guarantees from throughout the United States. After review and analysis of the application, the Manager will recommend approval or disapproval to the Administrator. Additionally, SAN has the responsibility of monitoring all loan guarantees throughout the life of the guaranty.

**Where to Obtain
Information:**

San Francisco Operations Office (SAN) or ERDA.
ATTENTION: Mark N. Silverman, 1333 Broadway,
Oakland, Calif. 94612; Telephone: (415)273-7881.

IV. REGULATIONS AND LEGISLATION

Regulations

Pursuant to Act 134 of 1976, (See Appendix B) an Ad Hoc Committee was formed to draft proposed rules and regulations relating to Louisiana's geothermal/geopressured resources. A list of the members follows:

Chairman: William P. Schuler, Attorney
Chalmette, La.

Members: Charles Browning
Union Oil Company of California
Houston, Texas

Robert. J. Duplantis
Shell Oil Company
New Orleans, Louisiana

Clay Durham
Magma Gulf Company
Baton Rouge, Louisiana

Orde R. Evans
Oreco Directional Drilling, Inc.
Lafayette, La.

Frank S. Haines, Jr.
Texaco, Inc.
New Orleans, Louisiana

Bill R. Hise
Louisiana State University
Baton Rouge, La.

James R. Hodges
Osborne, Hodges, Roberts, and Wieland Engineering
Lafayette, La.

Guy H. Johnston
Stamm Schelle, Inc.
Rayne, La.

Paul H. Jones
Louisiana State University
Baton Rouge, La.

Henry Lastrapes, Jr.
La. State Mineral Board
Baton Rouge, La.

Proposed Legislation

Several bills have been introduced in the legislature this year that could have an effect on the development of geopressured/geothermal resources. The titles of these bills are listed below:

- HB 926: Appropriation of \$10 million to the Department of Natural Resources to be used for energy research and development
- HB 1331: Coastal energy impact program administered by the Dept. of Transportation and Development
- HB 1135: Exemption of salt water discharge produced through wells from R.S. 56: 1464-1464.4
- HB 709,
- HB 1249,
- HB 1671,
- SB 740,
- SB 425: Louisiana Coastal Zone Management Program

The overall philosophy of the legislature concerning energy development is seen in the following resolutions:

- HR 10: Legislative concern and recommendations to the U. S. President Energy Program
- HCR 14: Support for development of a national comprehensive environmentally stable energy development program
- HCR 46: Establishment of Louisiana energy policy by Dept. of Natural Resources
- HCR 143: Major federal energy proposals and perspective of Louisiana Legislature

Legislation

Act No. 134 of 1976, Geothermal Energy Resources, is found in Appendix B. A discussion of this act is found in Appendix A-2 (Legal Problems) and Appendix A-1 (Operations Research).

APPENDIX A

ERDA Sponsored Research and Development

on

Geothermal/Geopressured Resources in Louisiana

APPENDIX A-1

Operations Research and Systems Analysis of Geothermal/Geopressured
Energy Resources in Louisiana
Principal Investigator: Bert Wilkins, Jr.
Office of Advanced Studies and Research, Louisiana State University,
Baton Rouge, Louisiana
Funding: \$49,998
Starting Date: April 1, 1977
Duration of Project: 7 months

Objectives

The overall objective of this proposal is to develop a plan for Louisiana's participation in a Gulf Coast regional operations research and systems analysis activity for geothermal/geopressured (GT/GP) resource development. To achieve this overall objective, the following subobjectives will be accomplished:

1. A set of preliminary planning scenarios for GT/GP resource development in Louisiana will be prepared and analyzed.
2. Key decision makers and "stake holders" with respect to GT/GP energy policy in the state of Louisiana will be identified.
3. A state wide advisory group for GT/GP resource development in Louisiana will be established.
4. Operations research activities will be coordinated with a parallel project in the state of Texas.
5. Specific recommendations for a regional operations research activity in support of GT/GP resource development in the Texas-Louisiana region will be formulated.

Since the planning scenarios form the basis for successful completion of the project, they will receive the top priority in the work plan. As used here, the term scenario refers to a reasonable statement

of what can be achieved in bringing GT/GP energy to commercialization. A scenario is not a projection of what is likely to happen based on past or present conditions, rather, it is a mission-oriented feasibility plan for the development of the GT/GP resource which implies positive actions which must be taken by private and public sections in order for the scenario to materialize. Inherent in the concept of a scenario is the identification of time-phasing and critical path programming.

The scenarios will form the basis for identifying decision makers, "stake holders", and advisory groups, providing specific choices and issues associated with the GT/GP resource to which they can respond. Moreover, the scenarios will present these choices and issues in a total system context rather than as isolated entities. In addition, the scenarios will also provide a basis for comparing Louisiana and Texas for the purpose of arriving at a cooperative program in support of regional GT/GP planning which will best fit the needs of both states.

Scope of Work

The preliminary development scenarios will span the following range:

1. A high growth-rate time-line (power on line versus year) based on optimistic assumptions concerning the outcomes of technology developments, exploration activities, and legal and institutional barrier considerations.
2. A low growth-rate time-line based on pessimistic assumptions concerning outcomes in the above mentioned areas.

3. A nominal growth-rate time-line based on the assumption of the continuation of historical rates of development success and the continuation of current attitudes toward legal and institutional barriers.

Scenarios will extend to the year 2020, but primary emphasis will be placed on the time frame through the year 2000. In developing the above scenarios, the data assembled and analyzed in this project will include the following:

1. Data describing the resource base.
 - a. Location and properties of potential GT/GP resource areas in Louisiana.
 - b. An assessment of the state of knowledge concerning the amount and locations of potential GT/GP resources in Louisiana.
 - c. Land ownership of all potential resource areas.
 - d. Status of exploration, resource assessment, and resource development.
2. Data on resource utilization.
 - a. An analysis of potential uses and a listing of potential users and an estimate of their growth probabilities.
 - b. Present projections for growth in energy consumption in Louisiana through the year 2020.
 - c. Present projections of availability and cost of alternate energy sources.

3. Data on legal and institutional factors.
 - a. Existing laws which affect the development process.
 - b. Regulatory bodies and policies which impact GT/GP enterprises.
 - c. Delineate practices, policies, and relationships of industrial organizations which may affect the development of GT/GP resources.
 - d. Identify environmental issues and land-use policies.
4. Data on the economics of resource exploitation.
 - a. Major cost factors in exploration, field development, and utilization.
 - b. Tax policies (federal, state, and local).
 - c. Capital cost and amortization policies of industry.
5. Data related to technology development.
 - a. Ongoing federal and non-federal programs and target dates for technology readiness.

The scenarios will be developed in two cycles. In the first cycle, the project staff with selected consultations will gather the background data and produce rough scenarios. These scenarios will be used as planning tools to generate input from "stake holders" throughout the state. The input will come not only from individual contacts but through seminars and workshops sponsored through the Office of Conservation.

The second cycle will refine the scenarios using the input above. These refined scenarios will then be analyzed to delineate specific public actions, together with their scheduled implementations, which

must be accomplished if these scenarios are to materialize. These required actions then can be used as a basis for recommendations for public actions at the appropriate local, state, and federal levels.

Present Status

A detailed work plan has been prepared, showing paths required for accomplishment of the different sub-activities of this project.

During April, existing data pertinent to preliminary GT/GP development scenarios were reviewed. This included a literature review, as well as discussions with the investigators of the other GT/GP projects both in Louisiana and Texas. Some of the sources included in the literature review were the Center for Energy Studies at the University of Texas at Austin, the Jet Propulsion Laboratory at the California Institute of Technology, the United States Geological Survey, the United States Federal Energy Administration, the United States Energy Research and Development Administration, Dr. Paul H. Jones of LSU, and the Hudson Institute.

Concurrently, work has begun to identify organizations in Louisiana that have an interest in and/or responsibility for GT/GP resources. Act 134 of 1976 states: "Full regulatory authority over all geothermal exploration, drilling, development, and production as well as subsurface disposal of geothermal waters and/or waste is hereby vested in the state Department of Conservation. Any disposal of any kind or nature made pursuant to this chapter into any navigable or non-navigable streams or waters shall be done under the supervision of the Stream Control Commission of the state. The State Mineral Board is hereby vested with exclusive authority to lease for the exploration,

development, production, and distribution of geothermal resources and the byproducts thereof any lands belonging to the state, or the title to which is in the public domain."

Several interested groups and individuals have been identified. There seems to be a growing interest in these resources by the oil and gas companies, the utilities, and other energy-related companies. Several universities have interests in research efforts. The Federal government has budgeted \$68 million for geothermal energy research and development in the U.S. for the coming fiscal year. Our own conversations with ERDA representatives indicate a deep commitment to develop the resources in Louisiana.

The state Office of Conservation has a similar commitment. The Commissioner has endorsed this project and has agreed to support and coordinate this project at the state level. The project has assisted the Commissioner in preparing an annual report on GT/GP resource development to the Legislature.

Currently high, nominal, and low GT/GP energy development rates are being studied in order to formulate the initial GT/GP development scenarios. These initial scenarios will be reviewed with representatives of local and state governments, industry, and community groups. It is intended to encourage as much public input as possible. The initial scenarios will then be revised on the basis of this input.

A preliminary structure for a regional planning support activity is being coordinated with a similar project at the University of Texas at Austin. A plan for a regional operations research activity will be formulated by the end of the summer and will be submitted to ERDA for

funding. Indications are that this project would be funded by ERDA, provided the Louisiana and Texas state governments give their support.

APPENDIX A-2

Legal Problems Inherent in the Development of Geothermal/Geopressured Resources in Louisiana

Principal Investigator: Thomas A. Harrell
Law Center

Louisiana State University, Baton Rouge, Louisiana

Funding: \$104,741

Starting Date: October 1, 1976

Duration of Project: 1 year

General Objectives

The research project will have as its objectives the identification of the legal, environmental and economic problems inherent in the development of Louisiana's geopressured geothermal resource; the evaluation of whether and to what extent existing legal institutions are available to resolve such problems and how effectively they might be so resolved within the framework of such institutions, and a determination of the extent to which new legislation or regulation may be necessary or appropriate to encourage the exploration and development of the resource in an economically feasible and environmentally sound manner which takes into account the legitimate economic interests of the private property owners, as well as those of the public, in the benefits of such development.

The problems to be investigated and the project development will fall within the following lines:

Private Property and Contractual Aspects: This will involve an analysis of the rights of landowners, mineral owners and others, including the developer of the resource, associated with securing and maintaining the right to explore for, develop and utilize the resource; the nature and extent of private rights in the resources and minerals

dissolved in them; evaluating conflicts with other property rights which may presently be in existence or which may be created under existing regimes; consideration of the most appropriate legal device for securing the right to develop the resource, whether by leasing in the manner currently used for oil and gas development, or the licensing or purchasing of the rights to the resource, the possibilities of ownership or control by the public and so forth. It will also include an evaluation of the problems associated with the physical development of the project - the securing of rights of ways or easements, and plant sites; the effect of building or zoning regulations, and the extent to which the developers of the resource would have or should have available the right of eminent domain to obtain such rights.

Environmental and Ecological Problems: This will include an evaluation of the problems which will be created environmentally and ecologically as a result of the development and exploitation of the resource. Problems resulting from subsidence, possible tectonic disturbances, the disposition of quantities of salt water, thermal pollution, and the liability of the developer or exploiter for such activities, possible conflict with existing land use concepts, coastal zone management rules and regulations, and the applicability of present environmental regulations or restrictions to the development of the resource will be investigated.

The Public Interest in the Utilization of the Resource: This will include a consideration of the applicability of existing legal and regulatory provisions; jurisdiction of regulatory agencies; applicability of rate and regulatory structures to the utilization of the resource and the effect such matters might have upon the economic

feasibility of development projects. A consideration of problems created by conflicting jurisdictions, and the applicability of the existing Federal statutes regulating the use of the bed of the Gulf to the development and exploitation of such resources will be included, as will an evaluation of the desirability of special regulation of the resource and the appropriate division of jurisdictional authority to effect such regulation.

Plan to be Utilized

The research will basically be conducted in three phases, although some overlapping of such phases will occur:

Phase One: Although some of the more obvious problems which may be encountered in the location, development and exploitation of the resource have been recognized and some tentative suggestions made for their solution, there has been no systematic or deliberate attempt to resolve these problems or to consider whether such solutions are practical within the economic, technical and environmental parameters dictated by the technology being developed for the resource's utilization. Furthermore, no comprehensive effort has been made to completely identify all of the legal problems which the various modes of development might entail or to consider the desirability of additional legislation or regulation to encourage the efficient development of the resource and to insure that it is done without undue effect upon the environment or in a manner not inconsistent with the public interest. Accordingly, the first phase of the project will be devoted to isolating and identifying the various legal, environmental, ecological or regulatory problems which may be implicit in the development of the resource

and in evaluating the scope and magnitude of such problems. This will include an examination of the current state of geologic, engineering and economic knowledge to identify and evaluate the nature and direction which the development of the resource is likely to take. The magnitude of the problems envisioned by those currently working in other disciplines will be investigated. The economic parameters associated with the current proposals will be considered and a descriptive model or models of the type of development which is considered feasible within these parameters will be constructed from such parameters, insofar as they involve legally significant considerations, to identify the legal problems implicit in them.

Obviously, a single well for producing water from a great depth, developing energy for use by a sugar mill during its three-month grinding season, will present materially different legal problems than would an offshore structure with numerous wells generating electricity for commercial distribution into an existing utility network. The severity and likelihood of ecological or environmental disturbances, and their nature and extent will be investigated to determine which of these may be present to such a degree as to present significant legal problems and determine what solutions might be appropriate for them. An investigation, will also be made of the problems which have been encountered in unrelated, but perhaps similar, geothermal and geophysical developments elsewhere in the world to evaluate whether and to what extent similar problems might be likely to be encountered in the development of the Gulf Coast geothermal province, as well as a consideration of the techniques used elsewhere to solve such problems.

Phase Two will then be devoted to an examination of existing property regimes, environmental and utility regulations, public regulatory statutes and other existing legal institutions to determine the extent they may be applicable to the problems identified from the models constructed during the first phase. Whether and to what extent such problems can be satisfactorily resolved by existing legal institutions within the economic and engineering parameters envisioned by those working in other disciplines will be considered and an effort made to define the extent to which one interested in or proposing the development of the resource might have to comply with existing legal institutions. Some portions of the work envisioned in Phase Two can be commenced immediately since there are certain problems which will undoubtedly be present within any form the development of the resource may take and which have been generally recognized as requiring some investigation and resolution. Among these would be included a determination of the extent to which, under existing legal institutions, landowners (including the state and Federal Government) might be free to license, lease or otherwise control the development of the resource and whether or to what extent such control might conflict with existing rights of mineral lessees, mineral owners or others possessing the rights to produce hydrocarbons and other substances (such as salt) from properties underlain by the resource.

Phase Three will consist of an evaluation of the deficiencies in, or conflicts which might occur from existing regimes or institutions; the extent to which the development of the resource might be inappropriate or difficult under such institutions, and the development of

proposals as to the type of legislation or regulation which might be required to remedy such deficiencies.

Present Study

A committee of interested persons in energy-related industries was formed to provide advice and consultation on the project. Additionally, various members of the Louisiana State University Faculty have been utilized to provide background geological and engineering assistance.

The initial phase of the research was devoted to a background study of the general physical characteristics of Louisiana's geopressed resource, where the resource is located, how it is reduced to possession, and a very general look at the economics of the project. In connection with this phase, a bibliography was prepared which will be submitted with the final report. This bibliography will include articles and books pertaining not only to the legal questions involved, but also to engineering and geological data which bear on the economic status and viability of the eventual development of the resource.

A paper exploring the ownership rights to the resource has been prepared. This paper examines basic Louisiana ownership principles and discusses who owns the rights to produce geopressed resources in light of Louisiana ownership theory. It contains a physical description of the resource as it is thought to occur, and describes the theory of how the resource came to exist. The applicability of the Louisiana Mineral Code as it pertains to the development of the geopressed reservoir, the question of whether the resource belongs in the public or private domain, and the effect of ownership which is

imperfect because of lease or servitudes, are examined. Dismemberment of ownership into usufruct, habitation, and rights of use is also examined as it pertains to the development of the resource.

The next study undertaken was of Louisiana law as it pertains to liability for accidents which could occur in the development and the processing of the resource. The paper begins with a broad look at the Louisiana law of Torts, and goes on to liability based on nonnegligent damage, as for ultra-hazardous activities. The requirements of neighborhood imposed by Article 667 through Article 669 of the Louisiana Civil Code are also examined. Louisiana's concept of solidary liability as it applies to the development of the geopressured resource, and the reciprocal rights and duties of lessor-lessees, and landowners-servitude owners are also discussed.

In addition to these two papers, which are undergoing final revision, further papers on the regulatory aspects of the development of the resource and on unitization concepts are underway. Current leasing practices are being examined in light of the problems found in developing geopressured resources. It appears that a model lease form, styled specifically for the geopressured industry in Louisiana, will be prepared.

New legislation, or at least some amendments to the Mineral Code, may be needed. If so, this legislation and/or amendments will be included in the final report.

In order to identify existing legal problems in the utilization of the resource, two possible uses have been postulated. The first possible use is that of the geopressured resource as "fuel" to power

electric generating plants. Current best estimates indicate that approximately 400,000 barrels of hot geopressured salt water per day would be needed to fuel a generating plant of 25 megawatts capacity. It should be noted that a large portion (perhaps as much as one-half) of the revenues from this generating plant would be from the direct sale of the natural gas which is thought to be dissolved in the resource.

A second possible use of the geopressured resource would be the use of the hot salt water for process heat. Again, a significant portion of the energy recoverable from the resource is from the natural gas. Some Louisiana industries that have been suggested for possible utilization of the process heat are the pulp paper, sugar, petrochemical, and food processing industries. Since much energy is lost in transporting the resource any appreciable distance, utilization must be made at or near the sight of extraction. The amount of the geopressured fuel used in this type of utilization is much less than that used in the generation of electricity. Although basic questions are identical, the practical problems involved in the two utilizations are different because of the vast difference in the amount of the geopressured fuel which is needed.

In March 1977, Michael Hill, Research Associate for the project, addressed the 24th Louisiana Mineral Law Institute which was held at the Law Center, on the "Present Status of Geopressured Energy in Louisiana". This seminar was attended by over 200 lawyers, landmen, geologists, and other persons interested in mineral law in Louisiana. The address can be found in the Proceedings of the Institute. An excerpt on legal issues follows.

Legal Issues

Article 4 of the Mineral Code sets out the parameters of coverage, and provides that the Codal provisions are applicable "to all forms of minerals including oil and gas", and are also "applicable to the rights to explore for and mine ... subterranean water". Although the term "subterranean water" is not defined, at least one Louisiana court has treated the term as synonymous with underground waters and said that subterranean waters must be classified with oil and gas as fugitive substances. The analogy to oil and gas is made even more persuasive by the similar characteristics of the respective reservoirs.

It is important to remember that while Article 4 includes geopressed resources for purposes of coverage under the Mineral Code, it does not classify the resource as a "mineral". This is crucial when construing certain contracts which include the word "mineral". The Comments to Article 4 make it clear that the Codal scheme has no relation whatever to the problem of construing particular conveyances or reservations. These constructions must be made on the basis of the intention of the parties as evidenced by the instrument.

Article 6 of the Mineral Code codifies the "Law of Capture" rule in Louisiana. In this regard, no one has actual ownership of the geopressed resource in place. The landowner in full ownership has the right to reduce to possession all deposits that underlie his land. His ownership can of course, be divided as with a mineral lease or mineral servitude, which is commonly the case.

Where ownership has been divided, the instrument which creates the division is of primary importance. The customary lease forms currently in use, grant the lessee the right to produce all of the "oil, gas, and

other minerals", underlying the property. The question then centers on whether or not the geopressured resource is an "other mineral" under the terms of the contract.

It has long been the law in Louisiana that the intention of the parties control the interpretation of the instrument. This principle has been recently applied by the Second Circuit Court of Appeals in deciding that lignite deposits were outside the terms of a lease which granted the right to produce the "oil, gas, and all other minerals" on a certain tract. In reaching this decision the court noted that the lease terms provided for laying pipelines, building tanks, power stations, and other uses consistent with oil and gas production, but made no mention of any surface use consistent with strip mining. Secondly, the court pointed out that the royalty provided for in the lease was 2 1/2 times the royalty generally prevailing in the coal industry. The court said that knowledge of the existence of the coal deposits, when no one considered it economically possible to exploit them, was of no consequence.

Similar reasoning can be applied in determining whether the right to produce geopressured brine is covered by a grant of "all the other minerals". These deposits have been known to exist for some time and it is only recently that "hot salt water" has become "geopressured brine". Furthermore, these deposits have only recently become even marginally economical to produce. It does not seem then, that the rights to produce from a geopressured reservoir have been conveyed by a grant of production rights to the "oil, gas, and other minerals" under a given tract.

A contrary result has been reached elsewhere. In Geothermal Kinetics, Inc. v. Union Oil Company, a California trial court held that geothermal steam belonged to the owner of the separate mineral estate. The court specifically held that neither the intention of the parties nor the terms of the grant were crucial. Rather, the court pointed out that the separation of the tract into surface and mineral estates created two fee simple estates of equal dignity. The court said that basically what was at issue was energy, and that since the geothermal steam was not necessary to the surface estate owner's enjoyment it went to the mineral estate owner.

Much of the reasoning in the case is inapposite in Louisiana. Here, of course, a grant of "all the minerals" does not create a separate estate of equal dignity, but only a servitude imposed on the land which allows the servitude owner to enter onto the tract and produce those substances covered by the grant. As seen in the lignite and prior cases, the intention of the parties is the crucial element. That which is not granted is retained by the landowner. Given this same factual situation, it is submitted that a Louisiana court should reach the opposite result.

It presently appears, that in order for the geopressured resource to be developed in the near future, the developer must exploit all three energy forms found in the substance. Especially crucial, is the presence of natural gas. Even if the brine is not included in the grant, an argument can be made that the dissolved natural gas belongs, not to the landowner, but to the gas lessee. Again, although it was known that natural gas was dissolved in the brine, its presence has

been ignored. Certainly no one, even now, would term one of these deposits a "gas deposit". Furthermore, if the natural gas is denied to the producer of the geopressured resource, this would apparently destroy any chance of utilization. This result would violate a valid state interest in having the geopressured resource produced and exploited.

Once it is determined who owns the rights to the resource, the next step is to acquire those rights. It is generally conceded that this will be by obtaining leases. The geothermal lease forms currently in use are very similar to those used in the oil and gas industry. Most forms call for royalty payments of 10% of the gross proceeds from the sale of the brine. Obviously, if a utility or industry is planning on producing and then using the brine itself some other formula will have to be devised. Royalty payments could be based on the end product, such as the net electricity generated, on the cost of comparable fuels, or at set rate per barrel of the fluid.

Whatever the final solution, it may turn out that 10% of gross is too high to allow profitable production. A royalty figure more in line with the 5% figure used in the coal industry may well be mandated.

In 1976, the Louisiana Legislature passed Act No. 134, entitled the Geothermal Energy Resources Act, which can be found in the Revised Statutes at Title 30, Sections 800-809. After a declaration that it is the policy of Louisiana that there be rapid and orderly development of geothermal resources within the state, the Act defines "Geothermal Resources" as including steam, hot water, hot brines, geopressured waters, natural gas in solution, and any by-product derived from the resource.

The Act vests regulatory power in the Commissioner of Conservation, and extends coverage of the Conservation Act to Geothermal Resources. The State Mineral Board is vested with the exclusive authority to grant geothermal leases on state lands. The bidding procedure is the same as that used for oil and gas leases. Royalties are set at 10% of the price received for the sale of geothermal resources and 5% of the value of all by-products. The Act also states that the rights of oil and gas lessees and geothermal lessees are to be exercised with due regard for each other, however, if a conflict does occur no rights in existence at the time of passage of the Act are to be diminished.

To this point, the Commissioner of Conservation has issued no regulations dealing with production of the resource. A committee is presently being formed to study the problems, and public hearings are planned in the near future.

Until these regulations are promulgated by the Commissioner it is impossible to know how complex the permitting process will be. In California, where a very complex regulatory system exists, one recent project in the Geysers Field required forty-four months to obtain the requisite permits.

Long lag time requirements present a special problem in Louisiana. If a producer must secure leases over a large area to protect the production capabilities of the reservoir, as would be the case for a public utility interested in electric power generation, then wait 3-4 years for requisite permits, and allow for construction time, the entire period may approach 10 years. The Mineral Code states that no lease may provide for a term of more than ten years without production.

If long time lapses of this nature do occur, amendments to the Mineral Code may be required.

Because the present marginal economic status depends so critically on pressure and rate of production, it is universally conceded, that some form of field wide management is essential. As indicated earlier, the legislature has made the Conservation Act applicable to geopressured resource development. Articles 5 and 9 of the Conservation Act provide the basics of unitization, which serves this purpose for oil and gas fields. While reservoir management is crucial, present unitization concepts present problems.

These concepts provide that the owner of each tract of land included in the unit has an interest in the means of production. In traditional operations this is limited to the well itself. In a large scale operation such as a geopressured project which includes a generating station, this concept can cause problems. Will a landowner who is included in a unit be able to claim an interest in the generating plant? He should not be able to do so, but language in some cases would allow him to make the argument.

Since any large scale use is very capital intensive, it will be necessary to lease enough surface to protect the production capability of the reservoir. If even one landowner refuses, the entire project is in danger. Under present law, the landowner whose tract is included in a compulsory unit has the right to take his pro rata share of production in kind. Since the producer will apparently need all of the resource that he can produce, this would give tremendous leverage to the non-consenting landowner. In practice, it is doubtful that the project

would ever be attempted without the complete agreement of all landowners, which in itself could prove an insurmountable hurdle.

Finally, the non-consenting landowner who is made a part of a compulsory unit does not share any of the risk of exploration. He is required to pay his share of drilling costs only if production occurs. This sole undertaking of the risk by the operator is tolerable where the potential return is high. Here, because of the nature of the deposit, large returns are at best improbable. Under these circumstances it hardly seems fair to allow a non-consenting landowner to possibly profit without taking the risk. It should be noted that one study has postulated that one of every three wells will be a nonproducer.

Appendix A-3**Investigation on the Geopressured Resources of Southern Louisiana**

Principal Investigator: Murray F. Hawkins, Jr.
Petroleum Engineering Department
Louisiana State University, Baton Rouge, Louisiana
Funding: \$178,400
Starting Date: May 1975
Duration of Project: 22 months

History

Sometime during 1972 it came to the attention of the project manager of these investigations that there was some interest in the geopressured sandstone aquifers of coastal Texas as a possible source of energy and potable water. Prior to that time he had assigned John M. Parmigiano an M. S. thesis topic on the use of cluster wells, specifically with regard to production from the very shallow (500 feet) oil reservoir of the Emraude Field in Offshore Nigeria. As energy production from geopressured aquifers appeared to present another use for cluster wells, as indeed it does, Parmigiano's thesis was enlarged to include this application.

Parmigiano's thesis "Geohydraulic Energy from Geopressured Aquifers" was completed in May 1973. In addition to treating the cluster well topic, this thesis first presented the basic theory from which the flow rate and surface pressure could be calculated as a function of time for one or more wells tapping a common geopressured aquifer. The theory and equations presented were based on recognized reservoir engineering principles for petroleum reservoirs. From the flow rate and well head pressure it was simple to calculate the available hydraulic horsepower as a function of time; and from the flow rate, the rate of natural gas production and the geothermal production rate, from a knowledge of the dissolved natural gas content of the water and aquifer temperature, respectively. This body of knowledge was presented in an extended form by Dr. William J. Bernard of Louisiana State University's Petroleum Engineering Department at the First Geopressured Geothermal Energy Conference held in Austin, Texas, June 2-4, 1975, in a paper "Reservoir Mechanics of Geopressured Aquifers".

As the results of Parmigiano's thesis indicated energy production in the megawatt range per well, assuming conversion only of the geohydraulic energy into electricity, a group of engineering and geology faculty at LSU was formed to look further into this source of energy. Subsequently, in March, 1974, a preliminary research proposal was submitted to the RANN division of NSF and in December 1974 a modified modified form of the proposal was submitted. It was in this form that

ERDA awarded an 18-month contract for \$158,400 beginning May 1975, later extended to December 15, 1975, with no additional funding and still later extended to March 15, 1976, with an additional funding of \$20,000. The final report on these investigations has been completed and submitted to ERDA.

Objectives and Results

The primary aims of the investigations were three-fold: (a) to estimate the total energy in the geopressed sandstone strata of southern Louisiana, including state-owned offshore waters, with a breakdown of the separate contributions of geohydraulic energy, geothermal energy and natural gas; (b) to locate one or more geopressed aquifers with bulk sandstone volumes of the order of one trillion cubic feet; and (c) to test the validity of the research methods in achieving these aims. It is the happy conclusion of these investigations that all three objectives have been reached with what the investigators feel is at a very satisfactory level. The total energy in the sandstone geopressed aquifers underlying this area is estimated at 34.3 quadrillion BTU or quads, of which 1.2 quads is geohydraulic energy, 19.5 geothermal and 13.6 natural gas. These are "raw" energy figures, i.e., with no allowance for recovery efficiency, conversion or utilization. The total amounts to the equivalent of about 6 billion barrels of oil. The natural gas content of the geopressed water is estimated at 13.6 trillion cubic feet.

The reader is cautioned to realize that these figures tell only the estimated total energy in place and that at this point very little is known about (a) the rate at which geopressed energy could be produced and (b) the fraction of the total geopressed energy resource which occurs in aquifers which are large enough to warrant drilling even one well which would produce for say ten years at a sufficiently high volume rate to be of economic interest. Indeed, it is to be inferred from the general geology of southern Louisiana, that much of this geopressed water is contained in aquifers far too small to justify the drilling and completion of a single well, much less a cluster of wells. Other precautions on the validity and use of these figures are given in the discussion of the Task II work.

In these investigations eight large geopressed aquifers have been located and mapped. In addition, 55 prospective area have been identified from the sand count and pressure maps which warrant detailed geologic study to ascertain the limits and volumes of geopressed aquifers in these areas (See attached map and tables). It is a recommendation of these investigations that consideration be given to funding a study of some or all of these 55 areas.

From the preceding paragraphs it appears obvious that the methods used in these investigations have proved to be more than reasonably successful. Thus, all objectives of these studies are believed to be realized.

Organization and Management

The investigations were divided into four tasks, two of which were accomplished by personnel of the Louisiana Department of Conservation, employed on an extra compensation basis and the other two by personnel of the Petroleum Engineering and Geology Departments of Louisiana State University.

Task I-Data Acquisition was under the direction of the State Geologist, Mr. Leo W. Hough. Using several professional geologists of the Department of Conservation on nights, week-ends, and holidays, this task comprised the inspection of some 10,000 electrical well logs in the files of the Department of Conservation which were made available at no charge for these studies. Data on some 5,964 wells were taken.

Task II - Data Storage, Retrieval and Analysis was under the direction of Dr. William J. Bernard of the Petroleum Engineering Department. It was his concern to see that the data obtained in Task I was entered into the data base. This included card punching and verification and the preparation of tapes were also used by Dr. Bernard to provide several kinds of statistical analyses of the data.

Task III - Computer Mapping was under the direction of Dr. Donald W. Kupfer of the Geology Department. Using the tapes on the data base from Task II, this part of the investigations provided three kinds of computer maps.

Task IV - Detailed Geologic Studies was also under the direction of Mr. Leo W. Hough, again using professional geologists of the Conservation Department to make structure and isopachous maps and geologic cross sections of large geopressured aquifers located using the maps of Task III. In a final report, the detailed geology is presented on eight large aquifers and also a map showing the location of 55 other prospective areas which may contain one or more large aquifers.

A-99 LOUISIANA

FUTURE STUDY AREAS WITH
GEOPRESSURE WELL CONTROL

- 1 ● MAPPED PROSPECT
9 ● UNMAPPED PROSPECT

AREAS WHICH HAVE BEEN MAPPED AS GEOPRESSURED PROSPECTS

<u>Area Number</u>	<u>Parish</u>	<u>Approximate Location</u> <u>Twp. & Rge.</u>		<u>Size of Area with</u> <u>Geopressured well</u> <u>control (Sq. Mi.)</u>
1*	Calcasieu	10S	10W	27
2*	Vermilion	17S	1E	67
3*	Vermilion & Cameron	15S	2W	51
4*	Cameron	14S	5W	60
5*	Acadia	10S	1W	24
6*	Jefferson Davis	10S	5W	24
7*	Vermilion	11S	3E	42
8*	Calcasieu	8S	8W	11

AREAS FOR FUTURE STUDY WHICH HAVE GEOPRESSURED WELL CONTROL

9	Cameron	12S	7W	45
10	Cameron	Block 12		90
11	Cameron	Block 9		27
12	Cameron	Block 26		54
13	Cameron	12S	3W	30
14	Vermilion	12S	1E	96
15	Vermilion	14S	3E	48
16	Vermilion	14S	4E	72
17	Iberville	9S	13E	48
18	Lafayette	10S	5E	36
19	St. Martin	11S	6E	84
20	Iberia	13S	7E	60
21	Iberia & St. Mary	12S	9E	49
22	St. Martin & Assumption	13S	12E	42
23	St. Mary	14S	9E	60
24	Iberia & St. Mary	14S	6E	55
25	St. Mary	16S	8E	28
26	St. Mary	16S	10E	96
27	St. Martin	15S	13E	54
28	St. Mary	18S	12E	40
29	St. Mary	Block 16		54
30	Terrebonne	20S	12E	132
31	Iberia	Block 3		60
32	St. James & Assumption	13S	15E	72
33	St. James & St. John the Baptist	13S	18E	72
34	Lafourche	14S	17E	40
35	St. Charles	13S	21E	48
36	St. Charles & Jefferson	14S	22E	36
37	St. Charles & Jefferson	16S	22E	30
38	Lafourche	16S	19E	30
39	Terrebonne & Lafourche	16S	16E	84
40	Terrebonne	18S	15E	48

<u>Area Number</u>	<u>Parish</u>	<u>Approximate Location</u> <u>Twp. & Rge.</u>		<u>Size of Area with</u> <u>Geopressured well</u> <u>control (Sq. Mi.)</u>
41	Terrebonne	19S	17E	40
42	Lafourche	19S	20E	36
43	Jefferson	19S	24E	25
44	Lafourche	20S	21E	40
45	St. Bernard	14S	15E	180
46	St. Bernard	15S	14E	36
47	St. Bernard	15S	16E	36
48	St. Bernard	16S	15E	36
49	St. Bernard & Plaquemines	17S	25E	80
50	Plaquemines	19S	25E	42
51	Plaquemines	20S	27E	20
52	St. Bernard & Plaquemines	19S	17E	50
53	Plaquemines	21S	31E	36
54	Plaquemines	22S	21E	32
55	Terrebonne	Ship Shoal Block 46		54
56	Terrebonne	22S	16E	35
57	Terrebonne	18S	17E	30
58	Lafourche	20S	23E	24
59	Plaquemines	S. Pass Block 21		32
60	Plaquemines	Main Pass Block 66		21
61	Plaquemines	Main Pass Block 14		24
62	St. Bernard	Chandeleur Sound Block 56		36
63	Terrebonne	S. Timbalier Block 13		35

* Areas 1-8 have been mapped in detail. Maps prepared as part of ERDA Grant AT (40-1) 4889.

SUMMARY OF DATA FOR PROSPECTS

56	Name of Prospect	Area Sq. Mi.	Geopressure	Maximum	Average	Bulk	Porosity Percent	Permeability Md.	Interval Range of Temperature Degrees F*	Mud Weight Lb./Gal.
			Interval Ft.	Net Sand Thickness Ft.	Net Sand Thickness Ft.	Sand Volume 10 ⁹ Cu. Ft.				
	Newton	11	110- 430	325	165	49	30	Up to 1,000	183-205	12.4-15.9
	S. Midland	24	730	300	150	78	30.7	413	210-284	15.4-18.3
	W. Lake Arthur	24	1,930	380	190	140	25	500 av.	215-270	13.5-18.0
	W. Lockport	27	440- 650	430	100	128	NA	NA	211-219	15.9-17.8
	W. Maurice	42	800-1,390	315	200	262	25.5	125	202-306	15.5-18.3
	S. White Lake	51	2,100	700	350	368	26	100-300 E	245-312	10.5-17.7
	Big Mouth Bayou	60	850	365	183	429	25-27	180 E	185-220	12.0-17.6
	SE Pecan Island	67	800-1,420	825	400	856	20	Up to 1,400	245-292	17.2-18.1

• - Uncorrected

E - Estimate

NA - Not Available

Av - Average

Appendix A-4Investigation and Definition of Parameters Associated with Testing Geopressured Water

Principal Investigator: O. Carroll Karkalits
School of Engineering and Technology
McNeese State University, Lake Charles, Louisiana
Funding: \$1,400,000
Starting Date: August 1, 1976
Duration of Project: 1 year

History and Background of the Project

In June of 1975, McNeese began a cooperative research program with the Osborn-Hodges-Roberts-Wieland Engineering firm to perform a research project for ERDA which consisted of testing a shut-in gas well to produce geopressured geothermal water. ERDA had expressed interest in obtaining information concerning the dissolved methane content of geopressured waters and also to get some information concerning the chemical composition and the producibility of the reservoir in which the waters were contained. It was reasoned that a shut-in gas well or shut-in oil well which penetrated the geopressured zone would provide a less expensive method of obtaining this information than the on-purpose drilling of a geopressured well. The first portion of the project consisted of contacting a hundred and seventy-five oil and gas companies announcing the purpose of the project and soliciting their cooperation in obtaining a shut-in oil or gas well. About August 1st, the Coastal States Gas Producing Company offered to the project a shut-in gas well in the Tigre Lagoon field in south Vermilion Parish. A meeting of the project team was held and it was decided that this well would be suitable for the purposes of the project. Dr. Paul Jones of Louisiana State University worked with the team as a geological consultant. The division of labor was as follows: Osborn and his engineering firm would be responsible for all activities at the well site; Dr. Jones would be responsible for the geological work and advising concerning ground water hydrology at geopressured depths; McNeese University would furnish overall direction of the project in an administrative sense and also would provide the analytical team of chemists who would analyze the dissolved gas after it had been exsolved from the waters as well as the chemical composition of the waters.

Objectives of the Project

There were six primary objectives which we hoped to accomplish in the project. These are listed below.

1. Produce geologic maps of the reservoir. These would consist of structure-contour, depth to the top of each sand bed to be tested as well as cumulative net sand thickness and similar geological properties.

2. Collect and analyze samples of water from each sand bed aquifer to be tested.
3. Determine reservoir flow rates.
4. Investigation of sand stability problem.
5. Determination of the Kh value of the sand. We use the term Kh as the permeability times the net sand thickness.
6. Development of methods for additional dynamic tests on geo-pressured reservoirs.

It is interesting to observe that the original objective of the project was to do static tests on the well by simply obtaining wire line samples at reservoir depth in a pressure bomb sampler of the geo-pressured waters and not to flow the waters from the reservoirs. Upon examination of the well log it was decided that the well penetrated a fairly large reservoir of water and that it would be desirable to go ahead and get dynamic tests of the well if ERDA would approve. A conference was held in September, 1975, in Houston, and it was decided by the Board of Advisors to proceed with the dynamic tests. The above objectives then are consistent with the decision to do dynamic testing on the well.

Summary of Work to Date

Shortly after the decision in Houston to do dynamic testing on the well, it was discovered that Coastal States Gas Producing Company had lost the lease on the well due to an error in bookkeeping. Because of this, it became necessary to negotiate for mineral rights and land leases with the owners of the land and those who had the mineral interest options. The legal negotiations took from October 1st to November 15th. The next few weeks were spent in negotiating a new contract with ERDA for the work. A final contract was not approved until the 1st of August, 1976. After the contract had been negotiated with ERDA, it was necessary to develop a large group of sub-contracts with potential well service companies who would supply various services at the well site. It was planned for operations at the well site to begin on January 3, 1977. However, the work over rig we had planned to use was not available until January 26th.

After the work-over rig was brought to the well site, the first two weeks were spent in developing and drilling a disposal well to dispose of the salt water that would be produced from the test well. The test well in question should be identified as the EDNA DELCAMBRE ETAL NO. 1 in Tigre Lagoon field. It is located about 8 or 10 miles due south of the city of Delcambre and about 25 miles south of Lafayette, Louisiana. It is located in a marsh which meant that all operations at the well site had to be done using barges. The only approach to the well site was by boat or barge. After the disposal well had been drilled, completed, and tested, the rig was skidded over to the Edna Delcambre No. 1 to begin

work-over operations. This occurred approximately February 15th. Work continued on the well, reconditioning it, so it could be used for testing. This meant pulling out the old drilling mud which had caked up and dried, also pulling out the old production string and replacing it with a new production string of somewhat larger diameter and higher quality tubing. This work has been completed. The plan is to perforate the No. 3 sand at a depth of 12,900 feet. After we have successfully flowed water from this sand, testing it both at bottom hole conditions with a wire line sampling tool and at the surface after the waters and vapors have been separated, then we will have a conference with ERDA and consider testing a No. 1 sand at 12,600 feet. Water has been successfully flowed from the well at this time and testing has begun. It is hoped that these operations will be completed by mid-summer.

Outlook for the Future

Assuming that both of the sands will be tested successfully, it is expected that a final report will be written in the fall of 1977 and submitted to ERDA. The final report, of course, will be in the public domain and will be available to any group or person who sought to obtain a copy. It is expected that we will find the geopressured waters produced from this well will be at a temperature of about 280 degrees at the bottom hole conditions. It is expected that the surface pressure will be approximately 6,000 psig. The test barge which is located at the well site adjacent to the drilling rig is fitted with separating tanks and measuring devices which will enable us to measure flow rate, temperature, pressure, Ph, conductivity and similar properties. Samples will be sent to the McNeese Laboratories for detailed chemical analysis of the water as well as a detailed component analysis of the gas. We expect to find that the waters are saturated with methane at the pressures and temperature of the reservoir.

It is universally agreed that geopressured waters in the geopressured zones of the northern Gulf Coast contain natural gas dissolved in these waters. It is not universally agreed that the waters are saturated with respect to natural gas. It is expected that this test will help to corroborate or bring negative evidence to bear on this subject. We also expect to be able to verify whether or not radioactive gas such as radon is present in this particular reservoir. It should be noted that radon in small amounts have been found in geopressured reservoirs in the western section of Calcasieu Parish. It is not known at this time how widely distributed are the radioactive gases in Southern Louisiana reservoirs. Also, we wish to determine how much sulfur there is in the gas. It is, of course, of considerable interest to all who might use geopressured-geothermal waters as to the nature of the noxious gases such as sulfur oxides or H_2S which might be contained therein. The presumption is that these are in minute traces if present at all but the analytical team is dedicated to discover the exact amounts.

This type of test is of extreme importance to the future developments of the geopressured geothermal resource. If the results are disappointing, it does not mean that the resource is not there and cannot be exploited. It would simply mean that we must make other well tests of this sort in different locations in Southern Louisiana to determine how geopressured waters are distributed and how the gas content varies with respect to the degree of saturation. Also, the chemical compositions of the waters are known to vary by electric log analysis, therefore, salinity ranges all the way from as low as maybe 8 or 10,000 parts per million to as high as 160,000 parts per million. The exact chemical composition of the waters would vary also from place to place. Much remains to be done, but we have at least made a beginning with the current research project.

APPENDIX A-5**Engineering and Economic Studies of Non-Electric Applications of Geothermal Heat****Principal Investigator: DeLaureal Engineers, Inc. New Orleans, Louisiana****Project Manager: T. W. Schnadelbach, Jr.****Starting Date: November 29, 1976****Duration of Project: 1 year****Funding:****Objectives**

- 1) Establish a quick reference source for potential and specific industrial use of Geothermal Energy
- 2) Establish economic criteria for conversion, transmission, or relocation of each industry type
- 3) Identify industries for case studies for near-term conversion
 - a) Identify specific equipment available for immediate use of the Geopressured Resource
 - b) Identify specific equipment requiring development or design to utilize the Geopressured Resource
 - c) Determine practical multiple-uses for the Geopressured Resource
 - d) Examine alternatives to injection/well disposal
 - e) Review practical financial and legal considerations

Task 1 - Inventory Geopressured Geothermal (GPGT) Resources

- a) Collect available information of each phase on:
 - 1) Existing GPGT resources in Louisiana
 - 2) Determine availability and utilization where possible
 - 3) Identify policy, control, legal constraints
- b) Classify known resources, where possible, as to:
 - 1) Depth, temperature, flow rate, and pressure
 - 2) Chemical composition
 - 3) Geographic location
 - 4) Reservoir life
 - 5) Methane content
 - 6) Recovery or production costs
 - 7) Utilization factor

c) Documentation

- 1) Catalog all known information at each phase for quick reference
- 2) Map specific data
- 3) Rank resources for importance to study

Task 2 - Inventory Louisiana Industry (Phase 1 - Food and Kindred Products)

a) Identify all industries (where available) by:

- 1) SIC Code (Standard Industrial Classification, Department of Commerce)
- 2) Size (production, quantity, value of physical plant)
- 3) Employment
- 4) Purchased energy or fuel consumption, amount, and source
- 5) Capitalization

b) Locate each industry inventoried by:

- 1) Geographic location
- 2) Distance to known GPGT resource
- 3) Identify concentrations and classifications

c) Documentation

- 1) Catalog all inventoried industry for quick reference
- 2) Map and chart industries inventoried
- 3) Rank industries as to commonality of:
 - Identification factors
 - Classification, purchased energy sources and consumption, concentration and distance to known GPGT resource
- 4) Plot geographic distribution of existing industry BTU's by present energy source

Task 3 - Determine Industry Potential for Geothermal Utilization

a) Analyze and evaluate GPGT resource with industries for importance, commonality, and compatibility as to:

- 1) Temperature and pressure vs. industry process
- 2) Salinity and chemical composition vs. industry process
- 3) Industry finance, energy consumption vs. geopressure potential

b) Determine feasibility of geopressured geothermal applications to process of each industry

c) Rank and list remaining industries that are potential geothermal participants and identify by:

- 1) SIC code
- 2) Number of industries
- 3) Total energy consumption
- 4) Employment and production
- 5) Capital investment
- 6) Low heat processes

- 7) Energy intensiveness
- 8) Growth potential and reservoir life
- d) Select industries for specific geopressured applications and list them in order of:
 - 1) Highest potential for substitution or reduction of current fuel
 - 2) Highest potential for substitution or reduction of electrical energy
 - 3) Highest potential for immediate or near term conversion to Geopressured Resource

Task 4 - Relocation of Industry to Geothermal

- a) Select candidate specific industries from Task 3 evaluation and obtain ERDA approval for initial attention
- b) Determine basic hardware and technology required
- c) Define geothermal resource limitations
- d) Determine and evaluate total energy available for daily and long term utilization
- e) Estimate preliminary economic factors (gain vs losses)
- f) List benefits and disadvantages
- g) Document results

Task 5 - Transmission of Resource to Industry

- a) Determine basic technology required
- b) Estimate cost of resource transmission
- c) Define transmission and conversion losses per distance interval and flow rate
- d) Determine practical transmission distances for classes of Geothermal Resources
- e) Determine and evaluate nature of total energy available for daily and long term utilization
- g) List benefits and disadvantages
- h) Document results

Task 6 - Prepare Recommendations for ERDA Approval of Specific Case Studies

Task 7 - Examine Typical Existing Plant Designs

Task 8 - Examine Multi-Product Use of Plant**Task 9 - Hardware Conversion****Task 10 - Multiple Use of GPGT**

- 1) Methane extraction
- 2) Processing and cooking
- 3) Heating and Air Conditioning
- 4) Refrigeration
- 5) Freezing
- 6) Mechanical (hydraulic) Drivers
- 7) Process Cooling
- 8) Increase Seafood Production
 - a) Increase survival probability of infant shrimp in estuaries
 - b) Crawfish farming
 - c) Catfish farming
 - d) Frog farming
- 9) Alternative disposal methods
 - a) injection well
 - b) membrane osmotic desalinization
 - c) irrigation

Task 11 - Financial Review**Task 12 - Legal/Regulatory Review****Present Status**

During the first quarter of the project, efforts have been primarily devoted to the goals and objectives of accomplishing Tasks #1 and 2, Inventory of the Geopressed Geothermal Resources and Inventory of Louisiana Industry. Task #3, Determining Industry Potential for Geothermal Utilization, has been initiated and work towards completing some of the subtasks are underway. The following is a reporting of the accomplishments that have been made thus far.

All of the available data pertaining to the location, general features, composition and reservoir specifics have been collected from known sources. Statewide maps have been prepared that illustrate the areas of activity.

The U. S. G. S. assessed the GPGT resources in 1975 by means of defining sub-areas of distinction. The defined sub-areas provide average depth, pressure, temperature, and areal extent. Each area's average has been determined from samples of oil and gas exploration in the Gulf Coast area. Table 1.1 illustrates the sub-area averages and the number of samples taken in each area.

It should be pointed out that since the 1975 study, more data pertaining to deep oil and gas explorations have developed in the northern Louisiana sub-areas. The Chevron discovery in Point Coupee Parish has been noted as a GPGT well in which the production specifics greatly exceed the sub-area averages. The Alma Plantation well, 20 miles west of Baton Rouge, Louisiana flowed methane-saturated superheated water from a water sand at a depth of 20,600 feet. The Chevron test well flowed 5,000 barrels of water through a gas separator for a period of two days, after which Chevron sealed the well approximately 2,000 feet above the aquifer and is presently extracting the gas from a shale formation immediately above the GPGT. The water temperature of the GPGT was 425°F; its salinity was 12,000mg/l ; and the closed-in formation pressure was 16,000 psi. The dissolved gas content was 107 standard cubic feet per barrel, at saturation according to the curves of Russian geologists (1972). The details of this well have been reported by Chevron to Mr. James C. Bresee, Director of ERDA's Division of Geothermal Energy.

Table 1.1.

**AREAL EXTENT & AVERAGE PRESSURE, TEMPERATURE
AND SALINITY CONDITIONS IN EACH SUB-AREA**

Sub-Area	Areal Extent Sq Miles (Km ²)	Average depths to top of geopressure Feet (Km)	Average depths to midpoint Feet (Km)	Average Pressure PSI (MN/m)	Average Temperature ° F (°C)	Average Salinity	
						No. of Samples	TDS g/l
AtL ₁	8095 (20,965)	8104 (2.47)	13878 (4.23)	11385 (78.5)	281 (156)	-	20*
BT ₂	2160 (5,595)	7612 (2.32)	13648 (4.16)	11806 (81.4)	270 (150)	50	38
DTL ₄	1970 (5,102)	8596 (2.62)	14140 (4.31)	12096 (83.4)	254 (141)	18	46
DL ₅	2708 (7,015)	9875 (3.01)	16437 (5.01)	14794 (102.0)	295 (164)	222	65**
DL ₆	1440 (3,729)	10007 (3.05)	16470 (5.02)	15084 (104.0)	288 (160)	14	55**
ETL ₄	1336 (3,461)	8629 (2.63)	14140 (4.31)	12662 (87.3)	252 (140)	14	52
EL ₅	3144 (8,144)	12008 (3.66)	17486 (5.33)	15505 (106.9)	297 (165)	39	90**
EL ₆	3417 (8,849)	10892 (3.32)	16929 (5.16)	15229 (105.0)	286 (159)	87	83
EL ₇	2413 (6,249)	9810 (2.99)	16404 (5.00)	14518 (100.1)	263 (146)	9	26
FL ₂	1817 (4,707)	12336 (3.76)	17651 (5.38)	15229 (105.0)	266 (148)	46	84**
FL ₃	2370 (6,139)	12730 (3.88)	17848 (5.44)	16070 (110.8)	272 (151)	11	45**

* Estimated samples not available.

** Only few samples from deep zones included.

++ No samples from deep zones are included.

Source: United States Geological Survey Circular 726

Table 1.2 is a supportive listing of the illustrated fields identifying the depth, temperature and pressures of each field. This approaches the objectives of Task #1 of the project; however, its major failing is that it identifies optimum oil and gas explorations that have known GPGT aquifers. It does not identify optimum methane content or more desirable pressures or temperatures.

The inventory of all Food and Kindred Products (SIC-20) in the State of Louisiana has been completed. A listing of all the industries is available, including firm name, address, employment, activity location and area of product distribution.

The overall statewide outlook of manufacturing industries is presented in Table 2.1. Industry #20, Food and Kindred Products, ranks as #2 in the State in number of establishments, #1 in employment, #4 in earned wages and #2 in value added by manufacture. Economically 15.8 percent of the total manufacturing employment earns 10.4 percent of the total manufacturing wages, to produce 13.5 percent of the total value of manufactured products. This indicates the importance of maintaining and increasing the economic production of this particular industry.

A further breakdown of the Food and Kindred products industry, Table 2.2 reveals that the most significant sub-industries are #201 Meat Products, #206 Sugar Confectionery Products, #208 Beverages and #2091 and 2092 Canned and Cured Seafoods and Fresh or Frozen Packaged Fish. Important to the location of the industry to the GPGT resources the #206 Sugar Confectionery Products and #2091 and 2092 Canned and Cured Seafoods and Fresh or Frozen Packaged Fish appear to be the most significant. Application of the resource for non-electric use is further enhanced by the relative proximity of one industry to the other.

TABLE 1.2

A-114

Geopressured aquifers in southern
areas of the Continental Shelf (partial extract of data
in Exhibit "H", Southern Louisiana Rate Case AR61-2, Gas
Supply Section, U. S. Federal Power Commission)

Depth (feet)	Field Name	Temperature (degrees F.)	Pressure (psi)*	Geostatic Ratio
1355-1430	Bay Marchand	91	680	.502
2674-?	Southeast Pass	106	1,390	.520
5405-5433	Ship Shoal	140	3,132	.570
6268-6311	West Cameron	163	3,205	.511
7080-7090	West Cameron	173	3,712	.524
7483-7507	West Cameron	179	3,993	.533
7996-8013	West Cameron	187	4,370	.546
8400-8413	Vermilion Bay	208	4,580	.545
8700-8831	Vermilion Bay	211	4,680	.538
9012-9047	Eugene Island	182	4,715	.523
9033-9061	South Pelto	219	4,938	.547
9401-9422	Church Point	201	6,417	.683
9464-9533	South Pelto	225	5,416	.572
9824-9877	East Cameron	213	6,025	.613
9879-9906	East Cameron	213	6,001	.607
10005-10047	Iowa	246	7,169	.717
10025-10039	Jefferson Island	194	5,379	.537
10410-10418	High Island	209	7,802	.749
10500-10517	English Bayou	233	8,154	.777
10585-10630	West Cameron	223	6,325	.598
10790-10816	Raceland	208	6,792	.629
10800-10906	Mud Lake	231	5,724	.530
10950-10974	Churchpoint	243	7,686	.702
11200-11389	Mud Lake	246	6,272	.560
11330-11356	Rayne	217	6,900	.609
11650-11679	Chalkley	233	9,345	.802
11933-11943	Erath	231	6,602	.553
11950-11995	Bayou Penchant	230	9,031	.756
12200-12246	Lake Arthur	262	10,100	.828
12295-12328	Thornwell	303	11,800	.960
12450-12493	Belle Isle	231	6,690	.537
12550-12562	Grand Isle	263	8,745	.697
12693-12757	Vermilion	235	8,276	.652
12900-12935	Bastian Bay	224	8,859	.687
12942-12949	Bayou Chevrui	246	11,067	.855
13200-13228	Lake Chicot	232	11,522	.873
13265-13275	West Cameron	280	11,664	.879
13617-13640	Thibodaux	237	10,418	.765
13700-13735	Thornwell	272	12,282	.896
13708-13761	West Delta	239	10,782	.787
13753-?	Caillou Island	270	7,113	.517

TABLE 1.2

A-115

Geopressured aquifers in southern Louisiana and adjacent areas of the Continental Shelf (partial extract of data in Exhibit "H" Southern Louisiana Rate Case AR61-2, Gas Supply Section, U. S. Federal Power Commission)

Depth (feet)	Field Name	Temperature (degrees F.)	Pressure (psi)*	Geostatic Ratio
13937-13950	Rousseau	241	10,635	.763
14145-14178	Ship Shoal	261	7,109	.503
14150-14225	Houma	253	10,790	.763
14300-14341	Lake Sand	263	10,975	.767
14344-14376	Garden City	259	12,096	.843
14594-14606	Garden City	263	12,295	.842
14602-14628	Constance Bayou	278	7,340	.503
14600-14650	Lapeyrouse	264	9,075	.622
14700-14731	Lapeyrouse	266	10,020	.682
14900-14940	Lake Washington	266	10,180	.683
15050-15084	Garden City	260	14,210	.944
15150-15160	Deep Lake	332	9,390	.620
15249-15289	Lake Pagie	268	10,819	.709
15318-15375	Thornwell	315	11,376	.743
15336-15407	Lake Arthur	329	13,933	.909
15580-15595	Leleux	277	13,570	.871
15600-15800	Deep Lake	366	9,885	.634
15871-15880	Lake Sand	296	12,505	.788
16000-16018	Lacassine	275	14,625	.914
16450-16495	Hollywood	280	14,540	.884
16570-16585	Weeks Island	266	9,495	.573
17300-17340	Belle Isle	316	11,420	.660
17395-17429	Lake Sand	318	13,477	.775

*A pressure of 1 psi is equivalent to 2.31 feet of fresh-water head.

TABLE 2.1

STATE OF LOUISIANA - DISTRIBUTION OF ESTABLISHMENTS, EMPLOYMENT,
WAGES & PRODUCTION VALUE BY INDUSTRY

Indus- try Code	Industry	# Estab- lishments	% of Total	# All Em- ployees (1000)	% of Total	# Production Workers (1000)	% of Total	Wages (\$ mil- lion)	% of Total	Value Added by Manufacturer (\$ million)	% of Total
20	Food & Kindred Products	556	15.5	28.1	15.8	18.7	13.9	111.2	10.4	579.3	13.5
22	Textile Mill Products	12	0.3	1.3	0.7	1.1	0.8	5.7	0.5	14.1	0.3
23	Apparel, Other Textile Products	91	2.5	9.0	5.1	7.9	5.9	30.6	2.9	67.3	1.6
24	Lumber & Wood Products	930	25.9	14.7	8.3	13.0	9.7	71.9	6.7	208.9	4.9
25	Furniture & Fixtures	65	1.8	1.5	0.8	1.3	1.0	6.0	0.6	15.5	0.4
26	Paper & Allied Products	62	1.7	15.5	8.7	12.8	9.5	126.8	11.8	396.9	9.3
27	Printing & Publishing	467	13.0	7.4	4.2	4.7	3.5	32.7	3.1	125.3	2.9
28	Chemical & Allied Products	212	5.9	24.4	13.7	16.9	12.6	192.9	18.1	1349.6	31.5
29	Petroleum & Coal Products	58	1.6	9.5	5.3	6.1	4.5	71.2	6.6	442.6	10.3
30	Rubber, Misc. Plastic Products	37	1.0	0.7	0.4	0.6	0.4	3.2	0.3	11.3	0.3
31	Leather & Leather Products	9	0.3	2.21	1.2	0.2	0.1	0.9	0.1	3.0	0.01
32	Stone, Clay, Glass Products	221	6.2	6.7	3.8	5.3	3.9	39.4	3.7	127.6	3.0
33	Primary Metal Indstrs.	28	0.8	7.3	4.1	5.9	4.4	58.0	5.4	145.0	3.4
34	Fabricated Metal Products	201	5.6	12.5	7.0	9.9	7.4	82.1	7.7	210.9	4.9
35	Machinery, Except Electrical	293	8.2	7.0	3.9	5.3	3.9	39.7	3.7	124.0	2.9
36	Electric, Electronic Equipment	45	1.3	7.0	3.9	5.8	4.3	44.3	4.1	145.0	3.4
37	Transportation Equipt.	171	4.8	21.9	12.3	17.5	13.0	146.9	13.7	289.4	6.8
38	Instruments Related Products	26	0.7	0.4	0.2	0.2	0.1	1.7	0.2	8.1	0.2
39	Miscell. Manufactur- ing Industries	95	2.7	1.5	0.8	1.2	0.9	6.5	0.6	18.6	0.4
TOTAL - All Manufactur- ing Industries		3660		179.6		134.4		1072.7		4282.4	

TABLE 2.2

SIC# - FOOD & KINDRED PRODUCTS IN STATE OF LOUISIANA

SIC#	Industry	# Estab- lishments	% Total	All Employees (1000)	# Production Workers (1000)	Wages (\$ million)	by Manufacturer (\$ million)	Expenditures (\$ million)
201	Meat Products	92	16.3	3.4	2.8	14.3	44.2	2.2
2011	Meat Packing Plants	64	11.3	1.0	0.8	4.6	11.4	0.9
2013	Sausages & Other Prepared Meats	17	3.0	0.6	0.4	2.6	10.6	0.5
0216	Poultry Dressing Plants	11	1.9	1.8	1.6	7.1	22.2	0.7
202	Dairy Products	58	10.2	2.9	1.1	6.8	58.8	4.5
2024	Ice Cream & Frozen Desserts	12	2.1	BB/0.4	D/0.2	D/1.0	D/4.4	D/0.1
2026	Fluid Milk	43	7.6	2.5	0.9	5.8	54.4	4.4
203	Preserved Fruit & Vegetables	28	4.9	2.5	2.1	8.3	31.4	1.6
2033	Canned Fruits & Vegetables	13	2.3	1.5	1.3	5.6	14.9	1.0
2035	Pickles, Sauces, Salad Dressings	7	1.2	CC	D	D	D	D
2037	Frozen Fruits & Vegetables	1	0.2	BB	D	D	D	D
204	Grain Mill Products	48	8.5	1.5	1.2	5.9	37.1	1.3
2044	Rice Milling	17	3.0	CC/0.9	D/0.8	D/3.6	D/26.0	D/0.7
2048	Prepared Feeds, NEC	28	4.9	0.6	0.4	2.3	11.1	0.6
205	Bakery Products	47	8.3	3.3	1.7	10.2	50.0	2.9
2051	Bread, Cake & Related Products	45	7.9	FF	D	D	D	D
206	Sugar Confectionery Products	60	10.6	5.1	4.2	33.7	114.8	14.4
2061	Raw Cane Sugar	44	7.8	EE	D	D	D	D
2062	Cane Sugar Refining	7	1.2	FF	D	D	D	D
2065	Confectionery Products	9	1.6	0.2	0.2	0.7	2.5	0.1

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Page 2 of 2 TABLE 2.2
SIC# - Food & Kindred Products in
State of Louisiana

SIC#	Industry	# Estab- lishments	% Total	All Employees (1000)	# Production Workers (1000)	Wages (\$ million)	by Manufacturer (\$ million)	Expenditures (\$ million)
207	Fats & Oils	23	4.1	1.1	0.9	6.0	22.7	4.0
2074	Cottonseed Oil Mills	6	1.1	AA	D	D	D	D
2077	Animal & Marine Fats & Oils	11	1.9	0.5	0.4	2.7	12.7	1.0
2079	Shortening & Cooking Oils	3	0.5	BB	D	D	D	D
208	Beverages	62	10.9	4.5	1.8	12.0	113.9	5.2
2082	Malt Beverages	4	0.7	CC	D	D	D	D
2086	Bottled & Canned Soft Drinks	50	8.8	3.1	1.0	5.0	47.7	4.5
2087	Flavoring Extracts, Syrups, NEC	7	1.2	BB	D	D	D	D
209	Misc. Foods, Kindred Products	148	26.1	3.7	3.0	14.1	106.4	4.0
2091	Canned & Cured Seafoods	24	4.2	CC	D	D	D	D
2092	Fresh or Frozen Pack- aged Fish	33	5.8	CC	D	D	D	D
2095	Roasted Coffee	13	2.3	CC	D	D	D	D
2097	Manufactured Ice	40	7.1	BB	D	D	D	D
2098	Macaroni & Spaghetti	4	0.7	AA	D	D	D	D
2099	Food Preparations, NEC	34	6.0	0.7	0.5	2.5	16.8	1.3
20	TOTAL - Food & Kindred Products	566		28.1	18.7	111.2	579.3	40.0

In addition to the collection of industry listings, a questionnaire survey was prepared and distributed to 370 Food and Kindred Products Industries through the State. The purpose of the questionnaire was to obtain individual information on each industry so that we can propose appropriate economic analysis of the industry.

The results of the survey can be evaluated as good, in that the information asked is highly confidential and many industries do not wish to disclose this data and/or view the effort as time consuming. Table 2.3 illustrates the response obtained from the survey questionnaires.

With the objective of selecting a few high priority establishments, considering their employment and energy demands, various maps listing by parishes the different kinds of establishments by four digits within the S.I.C. Code #20 were prepared. Further, a summary map showing the employment and energy consumed by parishes was prepared with a view to locate the concentration of the above two factors.

Although it was found that the major concentration of employment and energy was in Orleans and Jefferson Parishes, these two parishes were overlooked for further investigation for the following reason:

It was felt that in the event a pilot project was to be initiated to demonstrate the ability of a chosen establishment or a group of establishments to use efficiently the geothermal energy produced from an experimental geothermal well, it might be difficult to find within such area a suitable place to locate the geothermal well because of a high amount of concentration within the metropolitan area of New Orleans.

Other two concentrations of employment and energy, although lower in magnitude were located 1) in the five parish group of Vermillion, Acadia, Lafayette, St. Martin and Iberia and 2) the two parish group

TABLE 2.3
SUMMARY OF QUESTIONNAIRES RECEIVED

NAME OF ESTABLISHMENT	S. I. C. #	PARISH & CITY/TOWN	TYPE & QUANTITY OF ENERGY USED	AVERAGE ANNUAL EMPLOYMENT	TOTAL ANNUAL WAGES	TOTAL ANNUAL SALES
Amstar Corpn.	2062	St. Bernard Arabi	Natural Gas 130,000 M.C.F. Oil-427,500 Bbl.	700	\$ 10,000,000	\$ 233,000,000
Seacoast Products Inc.	2077	Vermilion Abbeville	Natural Gas (Dry) 292,00 M.C.F. Oil-9,000 Bbl. Electricity- 2,000,000 Kwh.	200	N.A.	N.A.
Bruce Foods Corp.	2033, 2035, 2099	Iberia New Iberia	Nat. Gas 60,160 M.C.F. Electricity- 980,000 Kwh.	145	1,131,000	12,000,000
L.A. Frey & Sons Inc.	2011	Orleans New Orleans	Nat. Gas 16,288 M.C.F. Electricity- 2,784,526 Kwh.	200-250	N.A.	N.A.
- DO -	2011	Lafayette Lafayette	Nat. Gas 59,797 M.C.F. Electricity- 7,792,018 Kwh.	200-250	N.A.	N.A.
Charlo Foods Inc.	2099	Caddo Shreveport	Nat. Gas 3,348 M.C.F.	12	70,468	N.A.
John A. Chauvin Inc.	2091, 2092	Jefferson Gretna	Nat. Gas (Dry) N.A. Electricity- N.A.	50	250,000	2,000,000

Questionnaires Received (page 2)

NAME OF ESTABLISHMENT	S. I. C. #	PARISH & CITY/TOWN	TYPE & QUANTITY OF ENERGY USED	AVERAGE ANNUAL EMPLOYMENT	TOTAL ANNUAL WAGES	TOTAL ANNUAL SALES
Elmer Candy Corp.	2065	Tangipahoa Ponchatoula	Nat. Gas N.A. Electricity N.A.	130	\$ 950,000	\$ 5,000,000
Martin's Sausage Inc.	2013	Ascension Prairieville	Electricity 311,340 Kwh.	11	129,000	801,000
Savoie Industries, Inc.	2061	Assumption Belle Rose	Nat. Gas 65,000 M.C.F. Electricity 75,000 Kwh.	105	850,000	5,002,500
Glenwood Cooperative, Inc.	2061	Assumption Napoleonville	Nat. Gas 247,950 M.C.F. Electricity- 1,128,000 Kwh.	71	653,000	5,038,000
Texada-Bailey Co.	2011	Rapides Alexandria	Nat. Gas N.A. Electricity N.A.	75	800,000	N.A.
Cora Texas Mfg. Co., Inc.	2061	Iberville White Castle	Nat. Gas 139,440 M.C.F. Electricity 1,612,340 Kwh.	50	467,352	4,410,000
Dr. Pepper Bottling Co., Inc.	2086	Rapides Alexandria	Nat. Gas 546 M.C.F. Electricity 56,786 Kwh.	22	212,233	1,570.374

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Questionnaires Received (page 3)

NAME OF ESTABLISHMENT	S. I. C. #	PARISH & CITY/TOWN	TYPE & QUANTITY OF ENERGY USED	AVERAGE ANNUAL EMPLOYMENT	TOTAL ANNUAL WAGES	TOTAL ANNUAL SALES
Meeker Sugar Cooperative, Inc.	2061	Rapides Lecompte	Nat. Gas 196,580 M.C.F. Electricity 2,004,340 Kwh.	64	\$ 650,000	\$ 6,321,240
National Fruit Flavor Co., Inc.	2087	Orleans New Orleans	Nat. Gas 215 M.C.F. Electricity 43,264 Kwh.	12	100,000	750,000
Gulf South Beverages, Inc.	2086	Jefferson Harahan	Nat. Gas 2923 M.C.F. Electricity 1,193,100 Kwh.	222	2,487,221	14,700,000
Caire & Graugnard	2061	St. John the Baptist Edgard	Nat. Gas 176,215 M.C.F. Electricity 965,000	102	897,079	N.A.
Howard Stark Co., Inc.	2065	Lafourche Thibodaux	Nat. Gas N.A. Electricity N.A.		270,000	1,500,000
Petrou Fisheries, Inc.		Plaquemines Empire	Nat. Gas 116,410 M.C.F. Electricity 2,677,900 Kwh.	65	634,000	5,373,000

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Questionnaires Received (page 4)

NAME OF ESTABLISHMENT	S.I.C. #	PARISH & CITY/TOWN	TYPE & QUANTITY OF ENERGY USED	AVERAGE ANNUAL EMPLOYMENT	TOTAL ANNUAL WAGES	TOTAL ANNUAL SALES
			Nat. Gas N.A. Electricity N.A.	80	\$ 685,620	\$ 9,867,000
			Nat. Gas 75,000 M.C.F.	40	467,352	4,410,000

of Terrebonne and Lafourche. Both of these parish groups were further analyzed with respect to employment and energy use in each of the cities/town within these parishes. The purpose was to pin down the cities/towns with a high amount of employment and/or energy demand.

An attempt was made to gather data from individual industries within the S.I.C. group #20 with respect to the type and quantity of energy use, the dollar amount spent on this energy, total average annual employment etc. Questionnaires were mailed to a total of 378 establishments. The response to this survey was about 6.5%.

Evaluating the responses received, an attempt was made to rank these establishments on the basis of their employment and energy demand. The first five establishments were as shown below:

1. Amstar Corp. Arabi, St. Bernard
(S.I.C. #2062) Average annual employment of 700 and a total energy demand of 811,547,758 kwh equivalent. (Natural gas 130,000 MCF and oil 427,500 Bbl.)
2. Seacoast Products Abbeville, Vermilion
(S.I.C. #3077) Average annual employment of over 200 and a total energy demand of 87,555,230 kwh equivalent. (Natural gas 292,000 MCF and electricity 2,000,000 kwh.)
3. Caire & Graugnard Edgard, St. John the Baptist
(S.I.C. #2061) Average annual employment of 102 and a total energy demand of 52,595,530 kwh equivalent. (Natural gas 176,215 MCF and electricity 965,000 kwh.)
4. L.A. Frey & Sons Lafayette, Lafayette
(S.I.C. #2011) Average annual employment between 200 to 250 and a total energy demand of 25,312,381 kwh equivalent. (Natural gas 59,797 MCF and electricity 965,000 kwh.)

5. Gulf South Beverages, Inc. Harahan, Jefferson

(S.I.C. #2086) Average annual employment of 222 and total energy demand of 2,928,523 kwh. equivalent. (Natural gas 5,923 MCF and electricity 965,000 kwh.)

APPENDIX B

**Geothermal Energy Resources
Act No. 134 of 1976**

ACT 134

A-127

Regular Session, 1976

HOUSE BILL NO. 663

BY MESSRS. TAUZIN, FREEMAN, BEL, MARTIN, AND SENATORS KIEFER, MOUTON,
J. BROWN, NUNEZ AND DOUCET

AN ACT

To amend and reenact Chapter 8 of Title 30 of the Louisiana Revised Statutes of 1950 to be comprised of R.S. 30:800 through R.S. 30:809 inclusive, relative to geothermal energy resources, to provide for policy and purpose; to provide for definitions; to provide for regulation of exploration, drilling, production and subsurface disposal; to provide for conservation and environmental protection; to provide for leasing procedures and terms, rentals and royalties on state-owned lands; to provide for regulatory control by the state mineral board and the department of conservation; to provide for records and funds; to preserve rights; and to provide for related matters.

Be it enacted by the Legislature of Louisiana:

Section 1. Chapter 8 of Title 30 of the Louisiana Revised Statutes of 1950, to be comprised of R.S. 30:800 through R.S. 30:809 inclusive, is hereby amended and reenacted to read as follows:

CHAPTER 8. GEOTHERMAL ENERGY RESOURCES

§800. Policy.

It is declared to be the policy of Louisiana that:

(1) The rapid and orderly development of geothermal resources within the state of Louisiana is in the interest of the people of the state of Louisiana;

(2) In developing the state's geothermal resources, the primary purpose is to provide a dependable supply of electrical

energy and process heat at reasonable rates for the people of the state of Louisiana;

(3) Maximum possible consideration shall be afforded to protection of the environment and to conservation of natural resources by all agencies and officials of the state of Louisiana involved in prescribing rules and regulations governing the development, production and distribution of geothermal energy in Louisiana.

§801. Definitions

(1) "Geothermal resources" means:

(a) All products of geothermal processes, embracing indigenous steam, hot water, hot brines and geopressured waters excepting, however, waters produced incidental to oil or gas exploration or production;

(b) Steam and other gases, hot water and hot brines resulting from water, gas or other fluids artificially introduced into geothermal and/or geopressured water formations;

(c) Heat, natural gas dissolved in formation water or which was dissolved in formation water and is produced at the geothermal and/or geopressured well bore, or other associated energy found in geothermal and/or geopressured water formations;

(d) Any byproduct derived therefrom.

(2) "Byproduct" means any mineral or minerals, excluding oil and natural gas, which are found in solution or in association with a geothermal resource and which have a value less than seventy-five percent of the value of the total geothermal resource if utilized or not, because of quantity, quality, or technical difficulties in extraction and production of sufficient value to warrant extraction and production by themselves or which production would waste or not fully utilize the geothermal resource.

(3) "Geothermal lease" is a contract by which the lessee is granted the right for exploration, drilling, development, production and distribution of geothermal resources and byproducts.

(4) "Geothermal operation" includes the exploration for, drilling for, development of, production of and distribution of geothermal resources as defined in this Chapter.

§802. Regulation of exploration, drilling, production and subsurface disposal

Full regulatory authority over all geothermal exploration, drilling, development, and production as well as subsurface disposal of geothermal waters and/or waste is hereby vested in the state Department of Conservation. The provisions of the Louisiana Conservation Act R.S. 30:1, et seq., including particularly, but without limitation, R.S. 30:5 and R.S. 30:9 thereof, are hereby extended to all geothermal operations. The commissioner of conservation is further authorized to promulgate such additional rules and regulations relating specifically to geothermal operations that are deemed by him to be needed in the interest of conservation if they are not inconsistent with the provisions of this Chapter. All geothermal operations shall be exempt from the provisions of R.S. 38:3091 et seq.

Any disposal of any kind or nature made pursuant to this chapter into any navigable or non-navigable streams or waters shall be done under the supervision of the Stream Control Commission of the state.

§803. Conservation and environmental protection

In all cases, a lessee under a geothermal lease or an owner shall conduct his exploration, drilling, development, production operations and disposal methods using all reasonable precautions to protect the environment and to prevent pollution of state waters, other environmental damages, or waste of geothermal resources.

§804. Jurisdiction over state geothermal resources and products

The State Mineral Board is hereby vested with exclusive authority to lease for the exploration, development, production and distribution of geothermal resources and the byproducts thereof any lands belonging to the state, or the title to which is in the public domain, including road beds, water bottoms, and lands adjudicated to the state at tax sale. To the extent applicable, the mineral board is also vested with the same powers of supervision and management of all geothermal leases granted by the state that are vested in the board under R.S. 30:129 with respect to leases granted for minerals, oil and gas.

§805. Leasing procedures

H. B. NO. 663

Except as otherwise specifically provided herein, applications for state geothermal leases, the inspection of the lands, the quantity of land to be obtained in a single lease, the advertisement for bids, the bidding procedures and the board's authority to accept or reject bids all shall be governed by the provisions of R.S. 30:125 through R.S. 30:129 both inclusive.

§806. Terms; rentals; royalties

A. All state geothermal leases shall be granted for a maximum primary term of ten years and so long thereafter as geothermal operations are being conducted or geothermal resources are being produced or utilized in commercial quantities.

B. Where a state geothermal lease provides for delay rentals, the annual rental shall be for not less than one dollar per acre or one-half the cash bonus, whichever is greater.

C. Royalties on production obtained from a state geothermal lease shall be not less than the following:

(1) A royalty of not less than ten percent of the price received for all geothermal resources produced and saved or utilized.

(2) A royalty of not less than five percent of the value of any byproduct produced and saved or utilized.

D. The term rental or royalty obtained by the state from a geothermal lease shall not affect or limit the compensation negotiated by the owners of adjoining or nearby property which may be affected or exploited by the lessee.

§807. Regulations of board

The mineral board is hereby authorized to incorporate such additional customary provisions in a state geothermal lease and to adopt such additional regulations governing the administration and management of such leases that are not inconsistent with the provisions of this Chapter.

§808. Records; execution of documents; disposition and appropriation of funds

A. The maintenance of records, the execution of division orders and other documents and the handling and distribution of all bonuses, rentals, royalties, shut-in payments or other sums payable to

the state under a geothermal lease shall be handled as provided for in R.S. 30:130 as now enacted or hereafter amended.

B. The allocations of all proceeds described in Subsection A of this Section shall be made as provided for in R.S. 30:136(B) as now enacted, or hereafter amended, and to the extent necessary, all remaining funds, after making appropriate deductions, are hereby dedicated and allocated in the same manner as provided by existing law for the dedication and allocation of oil and gas revenues.

§809. Preservation of rights

The respective rights of the lessees under oil, gas, and mineral leases and of the lessees under geothermal leases are intended to be compatible and to be exercised reasonably by one with due regard to the other. However, in the event of conflict, the rights of the lessee under any oil, gas, or mineral lease heretofore issued on lands as set forth in Section 804 hereof and in effect on the effective date of this Act, shall not be diminished or limited by virtue of this Act or any provisions hereof.

The provisions of this Chapter are not intended and should not be construed to deny the legal right or remedy of any owner for the protection of his property interests that is otherwise available to such owner under the law.

Section 2. If any provision or item of this Act or the application thereof is held invalid, such invalidity shall not affect other provisions, items or applications of this Act which can be given effect without the invalid provisions, items or applications, and to this end the provisions of this Act are hereby declared severable.

Section 3. All laws or parts of laws in conflict herewith are hereby repealed.

SPEAKER OF THE HOUSE OF REPRESENTATIVES

PRESIDENT OF THE SENATE

GOVERNOR OF THE STATE OF LOUISIANA

APPROVED:

Paper Presented Jointly
by Louisiana and Texas
Project Team at

Third Geopressured Geothermal
Energy Conference

University of Southwestern Louisiana
Lafayette, Louisiana

PRELIMINARY DEVELOPMENT SCENARIOS
FOR GEOPRESSURED - GEOTHERMAL ENERGY
RESOURCES IN LOUISIANA AND TEXAS*

C. Dale Zinn, University of Texas at Austin
Bert Wilkins, Jr. and Michael O. Waguespack
Louisiana State University (Baton Rouge)

Introduction

Geothermal energy is essentially a regional resource and to a large extent the problems that confront its development are local in nature. Any program designed to expeditiously develop this resource in the Gulf Coast to help meet national energy goals must recognize the individual regional needs. The United States Department of Energy (DOE) through its Division of Geothermal Energy (DGE) has the responsibility for planning the national geothermal energy program, and DGE is currently instituting a system of regional operations research and systems analysis activities to assess the regional needs and to develop time-phased plans with priorities, both regional and national, for cost effective development of the nation's geothermal energy resources.

In considering the Gulf Coast geopressured/geothermal (GP/GT) resource, it seems logical to group the states of Texas and Louisiana for regional analysis and planning. In addition to the fact that almost all of the potential Gulf Coast GP/GT resources are found in these two states, other geographical and economic similarities point to significant benefits to Texas and Louisiana as well as DOE's national

*Work supported by the United States Energy Research and Development Administration

energy program for a regionally coordinated GP/GT resource development planning activity.

The objective of this effort is to develop realistic scenarios for the development of commercial utilization of GP/GT energy resources in the Gulf Coast region of the United States, evaluating the potential regional contributions to the national energy goals, and identifying the type, magnitude and scheduling of public and private action needed to support the materialization of the scenarios.

As used here, the term scenario refers to a reasonable statement of what can be achieved in bringing GP/GT energy to commercialization. A scenario is not a projection of what is likely to happen based on past or present conditions, rather it is a mission-oriented feasibility plan for the development of the GP/GT resource which implies positive actions which must be taken by private and public sectors in order for the scenario to materialize. Inherent in the concept of a scenario is the identification of time-phasing and critical path programming.

The scenarios will form the basis for identifying decision makers, "stake holders," and advisory groups, providing specific choices and issues associated with the GP/GT resource to which they can respond. Moreover, the scenarios will present these choices and issues in a total system context rather than as isolated entities. In addition, the scenarios will also provide a basis for comparing Louisiana and Texas for the purpose of arriving at a cooperative program in support of regional GP/GT planning which will best fit the needs of both states.

For such a regional planning activity to have the maximum impact

on the development of the GP/GT resource, the program must evolve in a logical step-by-step fashion. Intrastate credibility and support must be established to assure interstate cooperation for the fully evolved plan.

As a logical first step in this procedure, DOE has funded sub-regional operations research and systems analysis projects at the University of Texas and Louisiana State University. Project milestones and basic planning methodology have been coordinated with allowances for differences in the intrastate organization of each project.

One of the goals of these projects has been to develop a set of planning scenarios to be used in formulating a regional planning strategy. The purpose of this paper is to present a set of preliminary planning scenarios, to illustrate issues involved in refining and integrating these scenarios, and to emphasize the need for a systems approach in resource evaluation and planning.

Preliminary Development Scenarios

The necessary components in producing development scenarios are the definition of the resource base, including location and amount, and the formulation of a development model. In the following sections these components will be described and preliminary scenarios for promising GP/GT reservoirs in Texas and Louisiana will be presented.

Definition of the Resource In seeking a definition of the amount and location of Gulf Coast geopressured resources, an investigation of existing estimates was made. A summary of these estimates and the

assumption upon which they are based are given in Tables 1, 2, and 3.

There is wide variance in these estimates, as evidenced by the following ranges:

Resource Base	
Thermal	19.5 - 176,000 quads
Mechanical	1.2 - 693 quads
Gas	13.6 - 111,500 quads

Recoverable Energy	
Thermal	19.5 - 2,058 quads
Gas	0.0001 - 52,000 quads
Electricity	0.1 - 110,000 MW-centuries

The reasons for these differences are demonstrated by comparing the various assumptions in Table 3. The ranges are as follows:

Area	29,000 - 154,000 sq. miles
Productive Area	1 - 50%
Thickness	8,000 - 19,680 feet
Sandstone	5.4 - 60%
Porosity	15 - 35%
Dissolved Natural Gas	1 - 164 scf/bbl
Recovery	.1 - 100%

In addition to the assumption variations illustrated in Table 3, implicit factors are significant in the resource assessment process. For example, resource assessment is closely linked to the development concept that is envisioned in making the resource assessment. If one perceives that development means the production of direct electrical energy as well as the production of methane, then one probably restricts his assessment to the amount of resource that is likely to have a fluid temperature in excess of 300°F. However, if one envisions that the geopressured resource will be developed primarily as a producer of methane, then a restriction to an assessment of resources having

TABLE 1

ESTIMATES OF TOTAL GEOPRESSURED RESOURCE
(Louisiana-Texas Gulf Coast, Onshore and Offshore, in Quads)

<u>Source</u>	<u>Thermal</u>	<u>Mechanical</u>	<u>Gas</u>	<u>Total</u>
Brown - Hudson ²			60,000-105,000	
Dorfman - Texas ⁴			5,735	
Hawkins - LSU ⁸ (Louisiana only)	19.5	1.2	13.6	34.3
Hise - LSU ⁹			3,000	
House - Livermore ^{10,11}			221.7	
Jones - LSU ¹² (sands & shales)			100,000	
(sands only)			49,000	
Karkalits - McNeese ¹³	60,000		12,000-30,000	
Myers - Livermore ¹⁵			0.1-2,650	
Papadopoulos - U.S.G.S. ¹⁶ (assessed onshore only)	43,331	198	23,927	67,456
(unassessed only)		1 1/2 to 2 1/2 times assessed		
Schnadelbach - de Laoreal ¹⁷			111,500	
U.S. ERDA - MOPPS ²⁰			3,000-40,000	
U.S. ERDA - Definition Report ¹⁹	44,000-176,000			

TABLE 2

ESTIMATES OF RECOVERABLE GEOPRESSURED ENERGY
(Louisiana - Texas Gulf Coast, Onshore and Offshore)

<u>Source</u>	<u>Thermal Quads</u>	<u>Gas Quads</u>	<u>Electricity (MW-centuries)</u>
Brown - Hudson ²		2,400-52,000	
Dorfman - Texas ³ (Texas only)			20,000
Dorfman - Texas ⁴		256	
Elmer - Tracor ^{5,6}	529-2,058	2,000	
Gould - Intercomp ⁷ (onshore Texas only)		150	33,000
Hawkins - LSU ⁸ (Louisiana only)	<19.5	<13.6	
Hise - LSU ⁹		125	
House - Livermore ^{10,11}		222	5,990
Jones - LSU ¹²		> 1,146	
Myers - Livermore ¹⁵		.0001-1,000	0.1-100,000
Papadopoulos - U.S.G.S. ¹⁶ (Plan 2)	1424	768	38,140
(Plan 3 - lower bounds)	- - - 77.38 - - -		2,880
Trehan - Mitre ¹⁸			100,000
U.S. ERDA - Definition Report ¹⁹		500-2,000	33,400-110,000
U.S. ERDA - MOPPS ²⁰		150-2,000	
Wilson - Dow ^{21,22} (Texas only)		45.6	8,000

TABLE 3
ASSUMPTIONS FOR VARIOUS RESOURCE ASSESSMENTS

	Dorfman	Gould	Hawkins	Hise	House	Jones	Myers	Papadopulos	Schnadelbach
Area (sq. mi.)	100,000	60,000	42,000	100,000	30,600	154,000	29,000	55,970	
Area Productive (%)		22.5			5		1-50		
Thickness (feet)	10,000	10,000	8,000	10,000	15,000	13,120- 19,680	15,000	9,482- 13,715	
Sandstone (%)	15	7.5	5.4	10	56	50	10-60	12-49	
Porosity (%)	22	20	20	20	20	25	15-35	18-22	
Dissolved Natural Gas (scf/bbl)	35	30-40	20.3	30	19-44	18.8- 164	1-30	28.2- 46.3	107
Water in Place (x 10 ¹² bbl)	164	10	.67	100	10.9	1,492	.126- 88.2	657	1,042
Gas in Place (Tcf)	5,735	>300	13.6	3,000	221.7	100,000	.126- 2,646	23,636	111,500
Recovery (%)	5	50		5	2-100	>1.1	.1-70	.12- 3.3	
Recoverable Water (x 10 ¹² bbl)	8.2	5.0		5.0		>17.1	.000126 -61.7	.79- 21.7	
Recoverable Gas Content (scf/bbl)	30	30		25		30			
Recoverable Gas (Tcf)	256	150		125		>1,146	.0001 -1,000	768	

temperatures in excess of 300°F is not likely. This interaction between resource assessment and resource use is largely unstated but highly significant in understanding and describing the development process.

This variance has made the selection of assumptions for development scenarios very difficult. Three studies were chosen as the basis for these scenarios: Hawkins - LSU for the Louisiana conservative, Papadopulos - USGS for the Louisiana optimistic, and Bebout - Bureau of Economic Geology for the Texas scenarios. These studies were chosen because extensive documentation of their assumptions and calculations was available. These resource assessments were broken down into various blocks, sub-areas, and fairways, which were then used as the basis for the prospect scenarios.

Development Model Scenarios for developing the Gulf Coast geopressured energy resources are affected by several factors. Among these are geological properties, energy production methods, legal and regulatory factors, and economic considerations. The preliminary development scenarios discussed in this paper are produced using a computer-oriented planning program that is code-named GEODEV. This program contains an algorithm for estimating resource capacity and reservoir performance based upon information obtained from geologic reports and reservoir simulation studies. GEODEV uses estimates of the following parameters to compute the total amount of recoverable energy from each fairway:

1. Fluid temperature

2. Thickness of formation
3. Porosity of formation
4. Permeability
5. Recoverability
6. Gas content of the fluid
7. Fairway area
8. Fraction of fairway producible

This information is then combined with other information obtained from drilling experts and from similar projects in developing California's hydrothermal resources to obtain a time-line for development.

The lifetime over which the resource is to be produced is specified in order to balance well spacing with total regional flow-rate. The time to drill a producing well, the time to drill a dry well, and the success ratio combine to yield the total average time needed to establish a producing well. The number of drilling rigs available can be combined with this information to indicate the number of production wells that are possible per year.

The number of allowable simultaneous construction projects and the amount of time delay from decision to actual start, resulting from sociological, technical, and/or administrative problems, combine with the plant construction time to detail the time-line of production. For the present, permitting and leasing process times have been absorbed into the plant construction time.

The Formulation of development scenarios for the Texas Gulf Coast geopressured resource begins with an estimate of how much resource is

available. In this case, we deal with the geopressured resources that are associated with the identified areas of the Frio Formation along the Texas Coast. These areas are identified by a resource assessment project conducted by the Bureau of Economic Geology, working under an ERDA contract. This project identified five fairways within the Frio Formation of the Texas Gulf Coast as having the potential for the production of useful energy from the geopressured resource.

In order to provide a starting point for proposed development, the operations research group used the information in the resource assessment reports, and held discussions with Dr. Don Bebout, head of the resource assessment team, with Dr. M. D. Dorfman, head of the geothermal research group at University of Texas at Austin, and with Dr. Roy Knapp, director of the reservoir simulation research group. The result of these investigations was to describe the geopressured resources in the Frio Formation of the Texas Gulf Coast by specifying a range of estimates of key parameters required by the GEODEV program. These values were used to establish the variation between conservative and optimistic scenarios.

The development scenarios for Louisiana are based on the reservoir data given in the LSU-Hawkins report. The eight prospect areas are located in four different blocks: West Lockport and Newton in Calcasieu, Big Mouth Bayou and West Lake Arthur in Cameron, Southeast Pecan Island and South White Lake in Vermilion, South Midland and West Maurice in Acadia. The assumptions for the optimistic scenarios are the highest values of the reservoir data; the assumptions for the conservative

scenarios are the lowest values of the reservoir data. The fluid recovery, fraction of fairway producing, and gas content were varied using the GEODEV program until the total electric power generation and gas production calculations matched the LSU-Hawkins calculations (for conservative scenarios), and matched the USGS-Papadopoulos calculations (for optimistic scenarios).

Scenarios for Promising Prospects Examples of development scenarios for two promising projects, the Brazoria County fairway in Texas and Calcasieu Parish fairway in Louisiana, are shown in Tables 4, 5, 6, 7, 8, and 9. Results are given for two energy production strategies. One case assumes that the spent fluids are disposed of by reinjection into shallow formations with energy produced in the form of electricity and gas. The second case assumes that the spent fluid is reinjected into the producing formation with energy produced in the form of gas and essentially no net electrical output. In this second case the total gas produced is increased and the reservoir life is doubled.

Gulf Coast Prospect Scenarios In Louisiana, four areas were chosen for development because reservoir data was available. These are the parishes of Vermilion, Cameron, Calcasieu, and Acadia. The results of these scenarios without deep reinjection are summarized as follows: (after Tables 4 - 9)

TABLE 4

BRAZORIA FAIRWAY OPTIMISTIC SCENARIO

Estimated Resource Characteristics

Formation Thickness	500 feet
Temperature	300°F
Porosity	22%
Permeability	50 millidarcies
Fluid Recovery	
a) Without Deep Reinjection	15%
b) With Deep Reinjection	45%
Gas Content	50 SCF/bbl
Fairway Extent	784 sq. miles
Fraction of Fairway Producing	.75
Life of Facilities	
a) Without Deep Reinjection	30 years
b) With Deep Reinjection	60 years

Optimistic Without Deep Reinjection

Well Parameters

Flow Rate	94267. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	35.35 megawatts
Gas flow capacity	5.16E+09 scf per year
Lifetime	30.years

Fairway Parameters

Number of Plants	16
Elec. gen. capacity	565.60 megawatts
Gas flow capacity	8.26E+10 scf per year

TABLE 4 continued
PROJECTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	0	0.	0.
1981	0.	0.	0	0.	0.
1982.	1.	35.	5.16E+09	69.	104.
1983.	1.	35.	5.16E+09	69.	104.
1984.	2.	71.	1.03E+10	138.	208.
1985.	3.	106.	1.55E+10	207.	313.
1986.	4.	141.	2.06E+10	276.	417.
1987.	5.	177.	2.58E+10	344.	521.
1988.	6.	212.	3.10E+10	413	625.
1989.	7.	247.	3.61E+10	482.	730.
1990.	8.	283.	4.13E+10	551.	834.
1991.	9.	318.	4.65E+10	620.	938.
1992.	10.	354.	5.16E+10	689.	1042.
1993.	11.	389.	5.68E+10	758.	1147.
1994.	12.	424.	6.19E+10	827.	1251.
1995.	13.	460.	6.71E+10	896.	1355.
1996.	14.	495.	7.23E+10	964.	1459.
1997.	15.	530.	7.74E+10	1033.	1564.
1998.	16.	566.	8.26E+10	1102.	1668.
1999.	16.	566.	8.26E+10	1102.	1668.
2000.	16.	566.	8.26E+10	1102.	1668.
2001.	16.	566.	8.26E+10	1102.	1668.
2002.	16.	566.	8.26E+10	1102.	1668.
2003.	16.	566.	8.26E+10	1102.	1668.
2004.	16.	566.	8.26E+10	1102.	1668.
2005.	16.	566.	8.26E+10	1102.	1668.
2006.	16.	566.	8.26E+10	1102.	1668.
2007.	16.	566.	8.26E+10	1102.	1668.
2008.	16.	566.	8.26E+10	1102.	1668.
2009.	16.	566.	8.26E+10	1102.	1668.
2010.	16.	566.	8.26E+10	1102.	1668.
2011.	16.	566.	8.26E+10	1102.	1668.
2012.	15.	530.	7.74E+10	1033.	1564.
2013.	15.	530.	7.74E+10	1033.	1564.
2014.	14.	495.	7.23E+10	964.	1459.
2015.	13.	460.	6.71E+10	896.	1355.
2016.	12.	424.	6.19E+10	827.	1251.
2017.	11.	389.	5.68E+10	758.	1147.
2018.	10.	354.	5.16E+10	689.	1042.
2019.	9.	318.	4.65E+10	620.	938.
2020	8.	283.	4.13E+10	551.	834.

TABLE 5

BRAZORIA FAIRWAY OPTIMISTIC WITH DEEP REINJECTION

Well Parameters	
Flow rate	128838. barrels per day
Support area	11.45 square miles
Plant Parameters	
Number of wells	3
Elec. gen. capacity	48.31 megawatts
Gas flow capacity	7.05E+09 scf per year
Lifetime	60. years
Fairway Parameters	
Number of plants	16
Elec. gen. capacity	773.03 megawatts
Gas flow capacity	1.13E+11 scf per year

Estimated Resource Characteristics are given in Table 4.

TABLE 5 continued

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	0	0.
1981.	0.	0	0.
1982.	1.	7.05E+09	94.
1983.	1.	7.05E+09	94.
1984.	2.	1.41E+10	188.
1985.	2.	1.41E+10	188.
1986.	3.	2.12E+10	282.
1987.	4.	2.82E+10	377.
1988.	5.	3.53E+10	471.
1989.	6.	4.23E+10	565.
1990.	7.	4.94E+10	659.
1991.	8.	5.64E+10	753.
1992.	9.	6.35E+10	847.
1993.	10.	7.05E+10	942.
1994.	11.	7.76E+10	1036.
1995.	12.	8.46E+10	1130.
1996.	13.	9.17E+10	1224.
1997.	14.	9.88E+10	1318.
1998.	15.	1.06E+11	1412.
1999.	16.	1.13E+11	1506.
2000.	16.	1.13E+11	1506.
2001.	16.	1.13E+11	1506.
2002.	16.	1.13E+11	1506.
2003.	16.	1.13E+11	1506.
2004.	16.	1.13E+11	1506.
2005.	16.	1.13E+11	1506.
2006.	16.	1.13E+11	1506.
2007.	16.	1.13E+11	1506.
2008.	16.	1.13E+11	1506.
2009.	16.	1.13E+11	1506.
2010.	16.	1.13E+11	1506.
2011.	16.	1.13E+11	1506.
2012.	16.	1.13E+11	1506.
2013.	16.	1.13E+11	1506.
2014.	16.	1.13E+11	1506.
2015.	16.	1.13E+11	1506.
2016.	16.	1.13E+11	1506.
2017.	16.	1.13E+11	1506.
2018.	16.	1.13E+11	1506.
2019.	16.	1.13E+11	1506.
2020.	16.	1.13E+11	1506.

TABLE 6

BRAZORIA FAIRWAY CONSERVATIVE WITHOUT DEEP REINJECTION

These are the fairway characteristics

Formation thickness	350 feet
Temperature	325°F
Porosity	20%
Permeability	35 millidarcies
Fluid recovery without reinjection	10%
Gas content	40 scf/bbl
Fairway extent	784 square miles
Fraction of fairway producible	.60
Life of facilities	30 years

Well Parameters

Flow rate	39992. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	13.64 megawatts
Gas flow capacity	1.75E+09 scf per year
Lifetime	30. years

Fairway Parameters

Number of plants	13
Elec. gen. capacity	177.30 megawatts
Gas flow capacity	2.28E+10 scf per year

TABLE 6 continued
 PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	0	0.	0.
1981.	0.	0.	0	0.	0.
1982.	0.	0.	0	0.	0.
1983.	0.	0.	0	0.	0.
1984.	0.	0.	0	0.	0.
1985.	1.	14.	1.75E+09	23.	37.
1986.	1.	14.	1.75E+09	23.	37.
1987.	1.	14.	1.75E+09	23.	37.
1988.	2.	27.	3.50E+09	47.	74.
1989.	2.	27.	3.50E+09	47.	74.
1990.	3.	41.	5.25E+09	70.	111.
1991.	3.	41.	5.25E+09	70.	111.
1992.	4.	55.	7.01E+09	94.	148.
1993.	4.	55.	7.01E+09	94.	148.
1994.	5.	68.	8.76E+09	117.	185.
1995.	5.	68.	8.76E+09	117.	185.
1996.	6.	82.	1.05E+10	140.	222.
1997.	6.	82.	1.05E+10	140.	222.
1998.	7.	95.	1.23E+10	164.	259.
1999.	7.	95.	1.23E+10	164.	259.
2000.	8.	109.	1.40E+10	187.	296.
2001.	8.	109.	1.40E+10	187.	296.
2002.	9.	123.	1.58E+10	210.	333.
2003.	9.	123.	1.58E+10	210.	333.
2004.	10.	136.	1.75E+10	234.	370.
2005.	10.	136.	1.75E+10	234.	370.
2006.	11.	150.	1.93E+10	257.	407.
2007.	11.	150.	1.93E+10	257.	407.
2008.	12.	164.	2.10E+10	281.	444.
2009.	12.	164.	2.10E+10	281.	444.
2010.	13.	177.	2.28E+10	304.	481.
2011.	13.	177.	2.28E+10	304.	481.
2012.	13.	177.	2.28E+10	304.	481.
2013.	13.	177.	2.28E+10	304.	481.
2014.	13.	177.	2.28E+10	304.	481.
2015.	12.	164.	2.10E+10	281.	444.
2016.	12.	164.	2.10E+10	281.	444.
2017.	12.	164.	2.10E+10	281.	444.
2018.	11.	150.	1.93E+10	257.	407.
2019.	11.	150.	1.93E+10	257.	407.
2020.	10.	136.	1.75E+10	234.	370.

TABLE 7

CALCASIEU CONSERVATIVE WITHOUT REINJECTION (DEEP)

These are the fairway characteristics

Thickness, in feet	100.00
Temperature, in degrees Fahrenheit	183.00
Porosity, as a fraction	0.30
Permeability, in millidarcies	100.00
Fluid recovery, as a fraction	0.14
Gas content, in scf/bbl	23.80
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	0.96
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	0.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	23995. barrels per day
Support area	12.57 square miles

Plant Parameters

Number of wells	3
Elec. gen. capacity	3.55 megawatts
Gas flow capacity	.63E 09 scf per year
Lifetime	30.years

Fairway parameters

Number of plants	28
Elec. gen. capacity	99.50 megawatts
Gas flow capacity	.18E 11 scf per year

TABLE 7 continued

PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	4.	.63E 09	8.	12.
1983.	1.	4.	.63E 09	8.	12.
1984.	2.	7.	.13E 10	17.	24.
1985.	3.	11.	.19E 10	25.	36.
1986.	4.	14.	.25E 10	33.	47.
1987.	5.	18.	.32E 10	42.	60.
1988.	6.	21.	.38E 10	50.	71.
1989.	7.	25.	.44E 10	58.	83.
1990.	8.	28.	.50E 10	67.	95.
1991.	9.	32.	.56E 10	75.	107.
1992.	10.	36.	.63E 10	83.	119.
1993.	11.	39.	.69E 10	92.	131.
1994.	12.	43.	.75E 10	100.	143.
1995.	13.	46.	.82E 10	108.	154.
1996.	14.	50.	.88E 10	117.	167.
1997.	15.	53.	.94E 10	125.	178.
1998.	16.	57.	.10E 11	133.	190.
1999.	17.	60.	.11E 11	142.	202.
2000.	18.	64.	.11E 11	150.	214.
2001.	19.	67.	.12E 11	158.	225.
2002.	20.	71.	.13E 11	167.	238.
2003.	21.	75.	.13E 11	175.	250.
2004.	22.	78.	.14E 11	183.	261.
2005.	23.	82.	.14E 11	192.	274.
2006.	24.	85.	.15E 11	200.	285.
2007.	25.	89.	.16E 11	208.	297.
2008.	26.	92.	.16E 11	217.	309.
2009.	27.	96.	.17E 11	225.	321.
2010.	28.	100.	.18E 11	234.	334.
2011.	28.	100.	.18E 11	234.	334.
2012.	27.	96.	.17E 11	225.	321.
2013.	27.	96.	.17E 11	225.	321.
2014.	26.	92.	.16E 11	217.	309.
2015.	25.	89.	.16E 11	209.	298.
2016.	24.	85.	.15E 11	200.	285.
2017.	23.	82.	.14E 11	192.	274.
2018.	22.	78.	.14E 11	184.	262.
2019.	21.	75.	.13E 11	175.	250.
2020	20.	71.	.13E 11	167.	238.

TABLE 8

CALCASIEU OPTIMISTIC WITHOUT REINJECTION (DEEP)

These are the fairway characteristics

Thickness, in feet	430.00
Temperature, in degrees Fahrenheit	216.00
Porosity, as a fraction	0.30
Permeability, in millidarcies	1000.00
Fluid recovery, as a fraction	0.49
Gas content, in scf/bbl	21.65
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	1.00
Life of facility, in years	30.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	90282. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. gen. capacity	69.67 megawatts
Gas flow capacity	.86E 10 scf per year
Lifetime	30.years

Fairway Parameters

Number of Plants	29
Elec. gen. capacity	2020.55 megawatts
Gas flow capacity	.25E 12 scf per year

TABLE 8 continued
 PRODUCTION SCHEDULE

YEAR	PLANTS	ELEC MW	GAS SCF	GAS MW	TOTAL MW
1980.	0.	0.	.00E 00	0.	0.
1981.	0.	0.	.00E 00	0.	0.
1982.	1.	70.	.86E 10	114.	184.
1983.	1.	70.	.86E 10	114.	184.
1984.	2.	139.	.17E 11	227	368
1985.	3.	209.	.26E 11	343.	552.
1986.	4.	279.	.34E 11	457.	736.
1987.	5.	348.	.43E 11	572.	920.
1988.	6.	418.	.51E 11	686.	1104.
1989.	7.	488.	.60E 11	800.	1288.
1990.	8.	557.	.69E 11	915.	1472.
1991.	9.	627.	.77E 11	1028	1656.
1992.	10.	697.	.86E 11	1143.	1840.
1993.	11.	766.	.95E 11	1258.	2024.
1994.	12.	836.	.10E 12	1371.	2207.
1995.	13.	905	.11E 12	1486.	2392.
1996.	14.	975.	.12E 12	1601.	2576.
1997.	15.	1045.	.13E 12	1714.	2759.
1998.	16.	1115.	.14E 12	1829.	2944.
1999.	17.	1184.	.15E 12	1944.	3128.
2000.	18.	1254.	.15E 12	2057.	3311.
2001.	19.	1324.	.16E 12	2172.	3496.
2002.	20.	1393.	.17E 12	2287.	3680.
2003.	21.	1463.	.18E 12	2400.	3863.
2004.	22.	1533.	.19E 12	2515.	4048.
2005.	23.	1602.	.20E 12	2630.	4232.
2006.	24.	1672.	.21E 12	2743.	4415.
2007.	25.	1742.	.22E 12	2858.	4600.
2008.	26.	1811.	.22E 12	2973.	4784.
2009.	27.	1881.	.23E 12	3085.	4967.
2010.	28.	1951.	.24E 12	3201.	5152.
2011.	29.	2021.	.25E 12	3314.	5334.
2012.	28.	1951.	.24E 12	3201.	5152.
2013.	28.	1951.	.24E 12	3201.	5152.
2014.	27.	1881.	.23E 12	3085.	4968.
2015.	26.	1812.	.22E 12	2971.	4783.
2016.	25.	1742.	.22E 12	2858.	4600.
2017.	24.	1672.	.21E 12	2743.	4416.
2018.	23.	1603.	.20E 12	2628.	4231.
2019.	22.	1533.	.19E 12	2515.	4048.
2020.	21.	1463.	.18E 12	2400.	3864.

TABLE 9

CALCASIEU OPTIMISTIC WITH REINJECTION (DEEP)

These are the fairway characteristics

Thickness, in feet	430.00
Temperature, in degrees Fahrenheit	216.00
Porosity, as a fraction	0.30
Permeability, in millidarcies	1000.00
Fluid recovery, as a fraction	1.00
Gas content, in scf/bbl	21.65
Fairway extent, in sq. miles	1050.00
Fraction of fairway which produces	1.00
Life of facility, in years	60.00

These are the drilling characteristics

Probability a well will produce	.75
Number of drilling rigs available	10
Time to drill a producing well, in days	120.00
Time to drill a dry well, in days	90.00
Facility construction time	3 years
Delays following construction	none
Maximum number of simultaneous projects	3
Beginning date for construction	1979

Well Parameters

Flow rate	92125. barrels per day
Support area	3.14 square miles

Plant Parameters

Number of wells	12
Elec. gen. capacity	71.10 megawatts
Gas flow capacity	.87E 10 scf per year
Lifetime	60.years

Fairway Parameters

Number of plants	29
Elec. gen. capacity	2061.78 megawatts
Gas flow capacity	.25E 12 scf per year

TABLE 9 continued

PRODUCTION SCHEDULE

YEAR	PLANTS	GAS SCF	GAS MW
1980.	0.	.00E 00	0.
1981.	0.	.00E 00	0.
1982.	1.	.87E 10	117.
1983.	1.	.87E 10	117.
1984.	2.	.17E 11	233.
1985.	3.	.26E 11	350.
1986.	4.	.35E 11	466.
1987.	5.	.44E 11	583.
1988.	6.	.52E 11	700.
1989.	7.	.61E 11	816.
1990.	8.	.70E 11	933.
1991.	9.	.79E 11	1049.
1992.	10.	.87E 11	1166.
1993.	11.	.96E 11	1283.
1994.	12.	.10E 12	1399.
1995.	13.	.11E 12	1516.
1996.	14.	.12E 12	1633.
1997.	15.	.13E 12	1749.
1998.	16.	.14E 12	1866.
1999.	17.	.15E 12	1983.
2000.	18.	.16E 12	2099.
2001.	19.	.17E 12	2216.
2002.	20.	.17E 12	2332.
2003.	21.	.18E 12	2449.
2004.	22.	.19E 12	2566.
2005.	23.	.20E 12	2682.
2006.	24.	.21E 12	2799.
2007.	25.	.22E 12	2916.
2008.	26.	.23E 12	3032.
2009.	27.	.24E 12	3148.
2010.	28.	.24E 12	3265.
2011.	29.	.25E 12	3382.
2012.	29.	.25E 12	3382.
2013.	29.	.25E 12	3382.
2014.	29.	.25E 12	3382.
2015.	29.	.25E 12	3382.
2016.	29.	.25E 12	3382.
2017.	29.	.25E 12	3382.
2018.	29.	.25E 12	3382.
2019.	29.	.25E 12	3382.
2020.	29.	.25E 12	3382.

<u>Parish</u>	<u>Conservative</u>		<u>Optimistic</u>	
	<u>Elec.</u>	<u>Gas</u>	<u>Elec.</u>	<u>Gas</u>
	<u>MW</u>	<u>Bcf/yr.</u>	<u>MW</u>	<u>Bcf/yr.</u>
Cameron	217	36	4527	520
Vermilion	193	33	4367	530
Acadia	100	18	3774	460
Calcasieu	100	18	2020	250

In Texas, five areas were chosen for development scenarios:

Brazoria, Matagorda, Corpus Christi, Armstrong, and Hidalgo. The results for these fairways are:

<u>Fairway</u>	<u>Conservative</u>		<u>Optimistic</u>	
	<u>Elec.</u>	<u>Gas</u>	<u>Elec.</u>	<u>Gas</u>
	<u>MW</u>	<u>Bcf/yr.</u>	<u>MW</u>	<u>Bcf/yr.</u>
Brazoria	177	23	566	83
Hidalgo	76	10	379	55
Corpus Christi	20	3	69	10
Matagorda	16	2	48	7
Armstrong	--	--	9	1

Systems Development Issues

The examples of the preliminary scenarios presented in this paper are a result of considering only a limited number of issues associated with the GP/GT resource. These issues exist in all fields ranging from strictly technological considerations to legal and social problems. For example, the resolution of the legal issues of ownership, leasing, and unitization could delay the resource development.

Many of these issues are completely unresolved, while others can

be characterized only by varying degrees of uncertainty. The issues that can affect the timely development of these scenarios need to be identified, so that problems arising from these issues can be resolved. Future research will include further discussion of these issues.

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