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WEST TEXAS GEOTHERMAL RESOURCE ASSESSMENT^{3#}

PART II^{2#}

PRELIMINARY UTILIZATION ASSESSMENT OF THE
TRANS-PECOS GEOTHERMAL RESOURCE^{3#}

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FINAL REPORT

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EXECUTIVE SUMMARY

The objective of the research was to assess the utilization potential of geothermal resources in Trans-Pecos, Texas. The potential for both direct use and electric power generation were examined. As with the resource assessment work, the focus was on the Hueco Tanks area in northeastern El Paso County and the Presidio Bolson area in Presidio County. Suitable users of the Hueco Tanks and Presidio Bolson resource areas were identified by matching postulated temperature characteristics of the geothermal resource to the need characteristics of existing users in each resource area. The amount of geothermal energy required and the amount of fossil fuel that geothermal energy would replace were calculated for each of the users identified as suitable. Although there is uncertainty about the temperature of both resources and about the flow rates that might be sustained, current data indicate that temperatures in the Hueco Tanks resource area are not high enough for electric power generation, but in at least part of the Presidio Bolson resource area, they may be high enough for electric power generation.

Using a variety of quantitative and qualitative assessment criteria, space heating and cooling applications and all industries in El Paso which use process heat were assessed for their suitability to utilize geothermal energy. Five industries were identified as most suitable: (1) the meat packing industry in which geothermal energy could supply refrigeration energy; (2) the dairy industry in which geothermal energy could supply process heat for pasteurization; (3) the soft drink bottling industry in which geothermal energy could supply heat for bottle washing and sterilization; (4) the canning

industry in which geothermal energy could supply heat for sterilization, washing, and blanching; and (5) the apparel industry in which geothermal energy could supply heat for pressing.

For each application, the quantity of geothermal energy required per unit of product output was determined along with the approximate total output in El Paso. For example, about 340 Btu's of geothermal energy per pound of meat would be required to provide refrigeration energy in the meat packing industry. For typical size manufacturing plants, flow rates of 3 to 65 million gallons of geothermal water per year are required with peak capacities ranging from 22 to 1,000 gallons per minute. The geothermal energy would substitute for 2 to 100 billion Btu's of fossil fuel per year.

The Hueco Tanks resource could also be used to heat and/or cool office complexes, schools, apartment complexes, single-family residences, and large installations such as Ft. Bliss. In order to heat and cool 1,000 ft² of space in El Paso, 165 to 248 thousand gallons per year of geothermal water are required depending on the building type. A peak flow capacity of 0.6 to 1.1 gallons per minute is needed and the geothermal energy substitutes for 70 to 170 million Btu's per year of fossil fuel.

The applications considered suitable and subsequently analyzed for the Presidio Bolson resource area were electric power generation and direct use of the resource for space heating and cooling in conjunction with water supply. Based on five assessment criteria, the electric power generation application emerged as the most favorable because of the sparsity of population in the area and the flexibility of electric power. Approximately 100 million kilowatt hours per year

of electric power are consumed by the towns within a 60 mile radius of the hottest area in the Presidio Bolson. This amount of electricity could be supplied by a 15 megawatt electric power plant operating with an annual average load factor of 75%. A total geothermal well capacity of 1,900 gallons per minute would be required to generate 100 million kwh/year and would displace 1,050 billion Btu's of fossil fuel (the equivalent of 180,000 barrels of oil). Additionally, these waters may provide benefits to this water short and economically depressed area.

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5. The fifth part of the document provides a conclusion and summarizes the key points of the study. It reiterates the importance of the research and the need for continued efforts in this field.

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Chapter 1

INTRODUCTION

The objective of this research was to assess the utilization potential of geothermal resources in the Trans-Pecos of Texas. The potential for electric power generation as well as for direct use of the resource was examined. The focus is on two resource areas: the Hueco Tanks area in northeastern El Paso County and the Presidio-Bolson area along the Rio Grande River in Presidio County. These are located on Fig. 1. Suitable users of the Hueco Tanks and Presidio-Bolson Resource Areas were identified by matching the temperature characteristics of the geothermal resource to the need characteristics of existing users in each resource area. The amount of geothermal energy required and the amount of fossil fuel that geothermal energy would replace were calculated for each of the users identified as suitable.

This investigation has utilized a compilation of information from the literature, direct contact with knowledgeable individuals in key organizations, and evaluation calculations to produce documentation on geologic characteristics and potential applications of the Hueco Tanks and Presidio-Bolson resources, and technologies which are now developing to make use of geothermal energy.

Fig. 1. Index Map of the Trans-Pecos Texas Area.

The Geothermal Resource

The geothermal resources in the Trans-Pecos are generally thought to be associated with the Rio Grande rift which extends south from Leadville, Colorado. Data on the geothermal resource temperatures expected in the Hueco Tanks and Presidio-Bolson areas have been derived using silica geothermometry and heat flow measurements. For the Hueco Tanks resource area, these indicate temperatures of 45 to 151°C (geothermometry) and 152°C (heat flow).^a Temperatures of 100 to 177°C (geothermometry) and 23 to 396°C (heat flow)^a are indicated for the Presidio-Bolson area.

Potential Applications

Geothermal energy may be used as a steam or hot water source to generate electric power or as a heat source for direct applications in the residential, commercial, and industrial sectors. For electric power generation, the resource temperature must be above 250°C (482°F); above 300°C (572°F) is preferred. In contrast, a temperature of 30 to 80°C (86 to 176°F)^b is required for direct use to provide space and hot water heating. Direct use to provide space cooling requires a temperature of at least 110°C. The temperature requirements of process heat applications in the industrial sector vary greatly over a range of 100 to 250°C.

^a Extrapolation of temperature gradient measurements taken by Professor Rob Roy, of UTEP, to a depth of 5,000 feet.

^b Much of the literature on space heating applications of geothermal energy indicates that a minimum of 80°C is required; however, there is successful commercial use of 30°C geothermal water for space heating.

Utilization of The Hueco Tanks Resource

Introduction

The Hueco Tanks Geothermal Resource is located in the north-eastern corner of El Paso County, Texas (Fig. 1). El Paso County has a population of about 420,000 and encompasses about 160 square miles. Nearly all space heating is carried out with natural gas and nearly all space cooling is via evaporative coolers. Natural gas is the source of process heat for the industrial sector; the electric power plants are natural gas fired. The El Paso City limits begin about 17 miles west and southwest of the resource area with residential and commercial development extending to within 15 miles. Ft. Bliss and most industrial development are 20 to 25 miles from the resource.

Suitable Users

Although there is still some uncertainty about the temperature of the Hueco Tanks resource and substantial uncertainty about the flow rates that might be sustained, current data indicate that temperatures are not high enough for electric power generation.

Using a variety of quantitative and qualitative criteria, space heating and cooling applications and all industries in El Paso which use process heat were assessed for their suitability. Five industries were identified as most suitable: (i) the meat packing industry in which geothermal energy could supply refrigeration energy, (ii) the dairy industry in which geothermal energy could supply process heat for pasteurization, (iii) the soft drink bottling industry in which geothermal energy could supply heat for bottle washing and sterilization, (iv) the canning industry, and

(v) the apparel industry in which geothermal energy could supply heat for pressing. Our assessment also indicated that a system designed to provide both space heating and space cooling in the residential, commercial, or industrial sector represents a suitable use of the resource. In comparison to a system which provides either heating or cooling, a system which provides both operates double the amount of time during a year. Increased usage (a higher annual load factor) greatly reduces annual costs.

Geothermal Energy Demand of Suitable Users

Space heating and cooling demand patterns vary according to the manner in which a building is used. For example, apartment complexes, schools, and office complexes have a lower heating demand than single-family residences, but a similar cooling demand. Some demand patterns for heating and cooling are shown in Fig. 2 indicating that peak periods are similar for all building types.

The geothermal flow rates required to provide space heating and cooling were evaluated assuming a usable energy content of 417 Btu's per gallon of geothermal water in the heating mode^a and a coefficient of performance of 0.7 in the cooling mode.

Results are summarized in Table 1. In order to heat and cool 1,000 ft² of space, 165 to 248 thousand gallons per year of geothermal water are required, depending on the building type. A peak flow capacity of 0.6 to 1.1 gallons per minute is needed and the geothermal energy substitutes for 70 to 170 million Btu's per year of fossil fuel. The system would operate between 55% (school) and 74% (single-family residence) of the time.

There are about 72,700 single-family residences in El Paso, 30,300 units of a multi-family type and many schools, office complexes,

^a This represents a 50°F usable ΔT .

Legend:

- School
- - - Apartment complex
- Residence

Fig. 2. Fuel Consumption for Space Heating and Cooling, El Paso, Texas.

Table 1: Geothermal Energy Demand for Space Heating and Cooling in El Paso
(per 1000 ft²)

	Load Factor (%)	Fuel Offset (million Btu's/yr)	Geothermal Flow Rate	
			thousand gal/yr	gal/min.
Office Complex	71	105.6	244	0.8
School	55	69.8	165	0.6
Apt. Complex	57	70.3	170	0.6
Residence	74	107.2	248	1.1

and industries. In addition, Ft. Bliss heats about 17 million square feet of space. Thus, demand exists for almost any quantity of geothermal energy for space conditioning. Based on the data in Table 1, a typical well producing 400 gallons of geothermal water per minute could heat and cool about 400,000 ft² of space.^a

Table 2 summarizes the geothermal energy requirements of each industrial application identified as suitable. For each application, the quantity of geothermal energy required per unit of product output is given along with the approximate total output in El Paso. For example, about 340 Btu's of geothermal energy per pound of meat would be required to provide refrigeration energy in the meat packing industry. For typical size manufacturing plants, flow rates of 3 to 65 million gallons of geothermal water per year are required with peak capacities ranging from 22 to 1,000 gallons per minute (Table 3). The geothermal energy would substitute for 2 to 100 billion Btu's per year of fossil fuel.

Utilization of the Presidio-Bolson Resource

Introduction

The Presidio-Bolson resource extends for 70-75 miles along the Rio Grande River in Presidio County, Texas (Fig. 1). Four Counties are in or near the resource; Presidio, Hudspeth, Jeff Davis, and Culberson. On the U.S. side of the River, two small towns and four settlements occur within the resource area and on the Mexican side fifteen settlements are within the area. Two larger towns, Presidio

^a Assuming the 400 gpm represents peak capacity.

**Table 2: A Summary of Geothermal Energy Requirements
by Industry in El Paso**

Industry	Energy Application	Product Unit	Geothermal Energy Consumption (Btu's/unit)	Product Output in El Paso County (million units per yr)
Meat Packing	Refrigeration	Pound	340	300
Soft Drink Bottlg.	Bottle Washing & Sterilization	Ounce	14.2	600
Dairy	Pasteurization	Gallon	600	16
Apparel	Pressing	Pair	3,000	60
Canning	Cooking	Case	27,000	6

Table 3: Geothermal Energy Demand for Hypothetical Plants in El Paso

Hypothetical Plant	Product Output	Geothermal Energy Demand		Fuel Offset (billion Btu/yr)
		million gal/yr	gpm	
Meat Packing	100 mill. lbs/yr	45.0	375	100
Soft Drink Bottling	100 mill. oz/yr	3.4	28	1.9
Dairy	15 thou. gal/day	2.7	22	3.0
Apparel	100 mill. pr/yr	35.9	300	40
Canning	2 mill. cases/year	64.7	1000	72

gpm = gallons per minute

(population 1,160) and Valentine (population 314) are located just outside the resource area; eight additional towns occur within 60 miles of the hottest portion of the resource. The resource area is characterized by dispersed, relatively small towns with little or no industry. Ranching, agriculture and retail trade predominate. Space heating is largely with butane, and cooling (where present) is with evaporative coolers.

Most towns have had constant populations or experienced a small decline over the past ten years. An exception is Valentine which is presently in a growth cycle due to greatly expanded agricultural development introduced by two out-of-state companies. Population and economic declines in the towns along the River north of Presidio are due to a decline in the quantity and quality of the River water and its associated alluvial aquifers.

Suitable Users

As with the Hueco Tanks geothermal resource, some uncertainty about the temperature of the Presidio-Bolson resource still exists and the flow rates which might be sustained are largely unknown. Nevertheless, temperatures high enough for electric power generation are indicated; power generation was assessed along with direct use of the resource for space and hot water heating, space heating and cooling, and space heating and cooling in conjunction with water supply. These potential applications were compared qualitatively on five assessment criteria: location, load factor, market, fossil fuel offset potential, and environmental impact factors. The electric power generation application emerged as the most favorable,

primarily because electric power generation compared with direct uses offers flexibility for a rural area. Among the direct use applications considered, the space and hot water heating alternative appears most favorable and Presidio appears to be the best location.

Geothermal Energy Demand of Suitable Users

Approximately 100 million kilowatt hours per year of electric power are consumed by the towns within a 60-mile radius of the hottest resource area. This amount of electricity could be supplied by a 15 megawatt-electric power plant operating with an annual load factor of 75%. Table 4 gives the quantity of geothermal water which would be required to generate 100 million kwh/year and the quantity of fossil fuel that geothermal energy would replace. A total geothermal well capacity of 1,900 gallons per minute would be required and 1,050 billion Btu's of fossil fuel (the equivalent of 180,000 barrels of oil) would be saved.

Geothermal energy demand for space heating and cooling in Presidio is shown in Table 5. If geothermal energy were used to provide both heating and cooling instead of heating only, the system would deliver 3.4 times as much energy but the peak capacity of the wells required would be equivalent. A well capacity of 260 gallons per minute could supply enough energy to heat and cool all residences in Presidio. Used in the heating mode only, the geothermal system saves 30 million Btu's per year of fuel. Whether or not fuel is saved in the cooling mode depends on whether the geothermal system is replacing a refrigerated air system or simply represents the addition of air conditioning to homes. If it is a

Table 4: Hypothetical 15 Mwe Geothermal Electric Power Plant in the Presidio-Bolson Resource Area (Presidio County)

	Unit	Quantity
Electric Power Generated	million kwh per yr ^a	100
Geothermal Water Requirement	million gallons per yr ^a	750
	gallons per minute ^b	1,900
Fuel Offset	billion Btu's/yr ^a	1,050

^a Assumes a 75% annual load factor.

^b At full capacity.

Table 5: Geothermal Flow Rates and Fuel Offset: Space Heating and Cooling: Presidio^a

	Flow Rate thousand gallons/yr gal/min.		Fuel Offset (million Btu's/yr)
Per 1000 ft ² of Space Heating ^c	80	0.8	30
Space Heating & Cooling ^b	270	0.8	100 ^b
400 homes ^d			
Space Heating ^c	25,600	260	9,600
Space Heating & Cooling ^b	87,100	260	32,800 ^b

^a Assumes system is sized for peak demand.

^b Fuel is not actually saved in the cooling mode unless the geothermal system is replacing a refrigerated air system.

^c Includes hot water heating.

^d Assuming 800 ft² per home.

replacement, fuel is saved; however, if it is an addition, fuel consumption may actually increase because of the added fuel needed to pump the geothermal water out of the ground.

If the geothermal water used for heating and cooling in Presidio was not reinjected into the aquifer, but used for crop irrigation, the 87.1 million gallons (267 acre-feet) could irrigate 50 acres of alfalfa (about 5 acre-feet per acre) or 100 acres of vegetables (2.5 acre-feet per acre). Similarly, the geothermal water supplying a 15 Mwe power plant represents 2,300 acre-feet, sufficient to irrigate 460 acres of alfalfa or 920 acres of vegetables.

Geothermal Utilization Technologies

A number of power generation technologies capable of using hot geothermal waters as an energy source are under development. The most promising appears to be the binary fluid system, in which the hot geothermal water is used to heat a second fluid. The second fluid, or working fluid, vaporizes and drives the turbine in the power plant. It is then cooled and cycled in a closed loop back to a heat exchanger where it picks up heat from more geothermal water. After leaving the heat exchanger, the geothermal water is reinjected into the aquifer.

Use of geothermal energy for space heating also requires a heat exchanger. For district space heating, heat is extracted from the geothermal fluid in a heat exchanger and transferred to a second fluid (usually distilled water). The secondary water is then distributed to buildings where it can easily be adapted to an existing forced air or hot water space heating system. For space cooling, an absorption refrigeration cycle is the most suitable

technology. Absorption refrigeration involves pressure, temperature, and phase changes in two or more chemicals. As one of the chemicals changes phase in the system, it essentially absorbs heat. For space cooling, the ammonia-water and lithium bromide systems are the most commonly employed while, for refrigeration below freezing temperatures, the ammonia-water and organic systems are applicable.

Absorption refrigeration cycles may also be used to provide both space heating and cooling. A centralized system supplying many buildings operates either in a heating or a cooling mode. Home units adapt seasonally by switching from one mode to the other. In an ammonia-water cycle operating in the cooling mode, the geothermal energy is used to evaporate the ammonia at the central location. Condensed liquid ammonia is delivered to the buildings. Evaporating ammonia (in a closed system) absorbs heat from the air in the building. In the heating mode, geothermal energy evaporates the ammonia and gaseous ammonia is delivered to the buildings. The gaseous ammonia releases its heat into the building as it is absorbed into water. The advantage of such a dual heating and cooling system is that the geothermal energy can be used all year through one central system. The disadvantage is the hazard posed by any leakage of ammonia.

Chapter 2

A REVIEW OF THE TRANS-PECOS GEOTHERMAL RESOURCE AND OF GEOTHERMAL RESOURCE APPLICATIONS

This chapter first summarizes the geologic characteristics of geothermal resource areas in the Trans-Pecos and, then, reviews geothermal resource applications being investigated throughout the U.S.

Geothermal Resources in the Trans-Pecos

The geothermal resources in the Trans-Pecos are generally thought to be associated with the Rio Grande rift, a major continental rift extending from Leadville, Colorado at least to El Paso, Texas.^a The location of the southern termination of the Rio Grande rift is uncertain. Along the western side of the Rio Grande rift is a "ribbon" of high heat flow.^a Recent volcanic activity and thermal springs coincide with the location of this zone of high heat flow. Reiter and others^a suggest that the thermal resources overlie deep crustal fractures which may penetrate the earth's mantle bringing hot magma near the surface. The magma is the heat source for overlying aquifers and the aquifers represent a geothermal resource.

Table 6 summarizes existing geologic information on this geothermal resource for three locations in the Trans-Pecos of Texas: the "Campus" Andesite area in the City of El Paso, Hueco Tanks in northeastern El Paso County, and the Presidio Bolson-Sierra Vieja area along the Rio Grande River in Presidio County. These three locations are shown on Fig. 3. Two types of geothermal temperature indicators are included on Table 6: silica geothermometry and heat flow measurements.

^a Reiter, M., C. L. Edwards, H. Hartman, C. Weidman, "Terrestrial Heat Flow Along the Rio Grande Rift, New Mexico and Southern Colorado," Geological Society of America Bulletin, Vol. 86, p. 811-818, 1975.

Table 6: Geothermal Resource Data: Three Areas of the Trans-Pecos, Texas

	Campus Andesite	Hueco Tanks	Presidio Bolson Sierra Vieja
Well or Spring Measurements			
Temperature (°C)			
Range	Unknown	18-71 ^f	32-72 ^b
Average	33 ^a	28 ^f	53 ^c
Depth of Well (ft)	1,000	400-1,000 ^g	0-11,695 ^d
Number of Wells Sampled	4 ^a	31 ^f	5 ^b
Silica Geothermometer	No Analysis		
Temperature Predicted (°C)			
Range		45-151 ^f	100-177 ^c
Average		78 ^f	Unknown
Number of Samples Analyzed		26 ^f	Unknown
Temperature Gradient ^l			
Literature	None Available		None Available
Gradient (°C/km)		4.7-468.7 ⁱ	
Number of Measurements		14 ⁱ	
UTEP			
Gradient (°C/km)	34 ^j	100 ^p	15-260 ^k
Number of Measurements	1 ^j	5 ^p	3 ^k
Temperature Predicted at 5,000 feet by the gradients (°C) ^m	58.8	7.2-714.3 152.4	22.8-396.2
Water Chemistry			
Total Dissolved Solids (ppm)	275-475 ⁿ	430-11,500 ^h	625-1,825 ⁿ
pH	7.4-9.1 ⁿ	6.4-8.2 ^h	6.9-8.9 ⁿ
Formation Producing Thermal Waters	Fine Grained sands of Santa Fe Group ^a	Permian limestone ^g (Hueco Group)	Cretaceous limestone ^e

Footnotes to Table 6:

- ^a Hoffer, J.M., 1978, Geothermal Exploration of Western Trans-Pecos, Texas, p.7.
- ^b Ibid, page 18; 3 areas of hot water occur. One is 15 miles north of Candelaria where two oil test wells encounter water of 70 and 72°C and where silica geothermometry predicts 160 to 177°C. The second is east of Ruidosa where a spring discharges at 45°C. The third is 18 miles southeast of Ruidosa where two springs discharge at 32 and 44°C.
- ^c Calculated from data in footnote b as $(32+44+45+70+72/5=52.6)$.
- ^d As noted in footnote b, several measurements are taken from springs; the oil test wells were drilled to 8,821 and 11,695 feet but the hot water is encountered at 3,000 feet. The warm springs rise along faults in the Quaternary Bolson Fill.
- ^e Ibid, page 9.
- ^f Ibid, page 12-15; this resource occurs in a belt extending into New Mexico; maximum well temperature on the Texas side are 58°C, maximum geothermometer prediction on the Texas side is 140°C.
- ^g Ibid, page 7; depths for only three wells are reported; two at 595 and 1,000 feet are producing from limestone; one at 400 feet is producing from bolson fill sediment.
- ^h Hoffer, J.M., 1978, Geothermal Exploration, Northeastern El Paso County, Texas and Southwestern Otero County, New Mexico, p. 5.
- ⁱ Ibid, (footnote h), page 5 gives 1°C/690 feet to 1°C/7 feet for 14 samples; this converts to 468.7 to 4.7°C/km; page 8 indicates that gradients on the Texas side do not exceed 1°C/30 feet or 109.4°C/km.
- ^j Letter from Professor Robert F. Roy, Department of Geological Sciences, The University of Texas at El Paso to Dr. David White, Texas Energy Advisory Council, Austin, Texas, dated September 22, 1978. This gradient was measured below the water disturbance at 280 feet; the water at 280 feet is 30°C (personal communication, Dr. Roy).
- ^k Ibid, (footnote j). Two wells had gradients of 15°C/km and one 260°C/km.
- ^l Note that earth's ambient gradient averages 25°C/km; White, Donald E. "Characteristics of Geothermal Resources" p. 73 in Geothermal Energy, edited by Paul Kruger and Carel Otte, 1973, Stanford University Press, Stanford, California.
- ^m Calculated from gradient data. For example, a gradient of 34°C/km or 34°C/3,281 feet yields 58.8°C at 5,000 feet.
- ⁿ Hoffer, J.M., "Thermal Water Occurrences in Trans-Pecos, Texas," p. 10-18.
- ^p Personal Communication, Professor Robert F. Roy, Department of Geological Sciences, The University of Texas at El Paso.

Fig. 3. Index Map of the Trans-Pecos Texas Area.

Data are sparsest for the Campus Andesite resource area. No silica geothermometry analysis has been carried out on that resource and no temperature gradients are available from the literature. A recent temperature gradient measurement taken by Professor Rob Roy of the University of Texas at El Paso (UTEP) indicated a gradient of $34^{\circ}\text{C}/\text{km}$. This is only $9^{\circ}\text{C}/\text{km}$ above the earth's average temperature gradient of $25^{\circ}\text{C}/\text{km}$. Thus, the Campus Andesite resource area is not considered further in this study.

Temperature indicator data on the Hueco Tanks resource include silica geothermometry measurements, temperature gradient measurements taken from a survey of the literature and recent temperature gradient measurements taken by Professor Rob Roy. Silica geothermometry indicates temperatures in the range of 45 to 151°C , averaging 78°C (Table 6). The highest temperature was measured in New Mexico. In Texas, the geothermometry indicated a maximum of 140°C . Temperature gradient data available in the literature are in the range of 4.7 to $468.7^{\circ}\text{C}/\text{km}$ and UTEP data indicate a gradient greater than $100^{\circ}\text{C}/\text{km}$.

In the Presidio Bolson-Sierra Vieja resource area, geothermometry indicates temperatures in the range of 100 to 177°C and heat flow data taken by Professor Roy indicate temperature gradients of 15 to $260^{\circ}\text{C}/\text{km}$. The highest values are in the northern extent of the resource near the Presidio-Jeff Davis County Line (Fig. 3).

Water chemistry measurements indicate generally low dissolved solids throughout the Trans-Pecos. In the Campus Andesite area, dissolved solids measurements taken from wells indicate TDS concentrations of 275 to 475 ppm; in the Hueco Tanks area, measured concentrations range from 430 to 11,500 ppm; and, in the Presidio-

Bolson area, concentrations range from 625 to 1,825 ppm (Table 6). No data are available on the depth, the lateral extent, or the flow rates which might be sustained from these resources.

In summary, data on geothermal resource temperatures for two resource areas have been derived using two types of indicators: silica geothermometry and heat flow. For the Hueco Tanks resource area, these indicate temperatures of 45 to 151°C (geothermometry) and 152°C (extrapolation of UTEP's temperature gradient to a depth of 5,000 feet, see Table 6). For the Presidio-Bolson resource area, they indicate temperatures of 100 to 177°C (geothermometry) and 23 to 396°C (extrapolation of UTEP's temperature gradient to a depth of 5,000 feet). Only heat flow data are available for the Campus Andesite resource area and that indicates a temperature of 59°C (extrapolation of UTEP's temperature gradient to a depth of 5,000 feet).

Geothermal Resource Applications

Geothermal energy may be used as a steam or hot water source to generate electric power or as a heat source for direct use in the residential, commercial, and industrial sectors. For electric power generation, the resource temperature must be above 250°C (482°F); 300°C (572°F) or more is desirable.^a In contrast, resources with temperatures greater than 30°C (86°F) may be used directly.

^a Reistad, G.M., "Potential for Nonelectrical Applications of Geothermal Energy and Their Place in the Economy," Proceedings: Second U.N. Symposium on the Development and Use of Geothermal Resources. Government Printing Office, Washington, D.C., p. 2155-2164, 1976 and Howard, J.H., "Principal Conclusions of the Committee on the Challenges of Modern Nonelectrical Applications Project," Ibid, p. 2127-2140, 1976.

The advantages of using a geothermal resource for electric power generation are two fold: (i) electric power is relatively easy to transmit, while transporting geothermal energy is difficult and expensive and (ii) electric power from geothermal energy can be integrated readily into a utility system so that specific final demand users do not need to be identified and no new final demand technology is required. However, there are some disadvantages. The efficiency with which electric power can be generated from geothermal energy is low (10 to 18%) and resources with temperatures greater than 300°C are much less abundant than resources with lower temperatures.

In contrast, low to moderate temperature resources are at least an order of magnitude more abundant than higher temperature resources. Furthermore, direct uses of low to moderate temperature resources can be highly efficient since these uses are not constrained by the large thermodynamic irreversibilities which characterize electric power generation. In addition, a very significant portion of the energy needs of the U.S. are for low to moderate temperature heat. Reistad^a (1976) estimates that 40% of the U.S. energy needs are for heat at temperatures less than 200°C (392°F), 30% at temperatures less than 150°C (302°F), and 20% at temperatures less than 100°C (212°F). The issue, then, for direct use applications is not one of availability,

^a Reistad, G.M., "Potential For Nonelectrical Applications of Geothermal Energy and Their Place in the Economy," Proceedings: Second U.N. Symposium on the Development and Use of Geothermal Resources. Government Printing Office, Washington, D.C. p. 2155-2164, 1976.

but one of identifying suitable users, transporting the energy, and designing appropriate final demand technology.

Table 7 lists the direct use applications of geothermal energy that have been suggested in the literature since 1970. Included are the temperature requirements of each application. Applications in the residential-commercial sectors for heating and cooling require temperatures from 30 to 110°C (86 to 230°F). In agriculture, temperatures of 30 to 100°C (86 to 212°F) are required. Process heat temperature requirements in the industrial sector range from 78 to 250°C (172 to 482°F).

The U.S. Department of Energy (DOE) recently funded 18 engineering and economic studies of direct use applications. The applications and sites studied are listed in Table 8. Four studies analyzed applications of geothermal energy to space conditioning; six analyzed applications of process heat from geothermal resources to food processing; one analyzed applications of heat to crop drying; one of refrigeration to food processing; two studied applications of geothermal heat to growing food (fish farming or greenhouses); one studied applications of heating and chilling milk at a dairy; and three analyzed industrial applications (fertilizer production, evaporation/crystallization, and industrial complex development).

The U.S. DOE has recently moved to the demonstration phase on eight projects: six for space heating (2 district), one for potato processing, and one for a combination of space heating and grain drying.^a

^a Memoranda: MIS Project Description Sheets, Morris Skalka, U.S. Department of Energy, March 9, 1978.

Table 7: Potential Direct Use Applications of Geothermal Resources

Potential Application	Geothermal Resource Temperature Requirements	
	(°C)	(°F)
Residential and Commercial		
Space Heating	30-80 ^a	86-176
District		
Individual Houses or Businesses		
Apartment Complexes		
Hot Water Supply	80	176
Space Cooling	110	230
District		
Individual Houses or Businesses		
Apartment Complexes		
Swimming Pools	30	86
Agricultural		
Greenhouses: vegetables, horticulture, mushrooms	50-60	122-140
Animal Husbandry	60	140
Heating cattlestalls, pigsties, chicken houses		
Cleaning milk rooms		
Cook and sterilize garbage feed for pigs		
Dairy Farm - including milk chilling	100	212
Aquaculture: Fish Farm	30-50 ^b	86-122
Soil Warming	40	104
Crop Drying	60-100 ^c	140-212
Industrial		
Petroleum Refining: Process Steam and Preheating	200-250	392-482
Pulp & Paper Products: Drying	120-180	248-356
Wood Chemicals: Hydrolysis	160-180	320-356
Food Processing: corn products, potato products	140	280
Heavy Water Production	170	338
Production of Fresh Water from Geothermal Water	120	248
Refrigeration: for example in food processing	100-150	212-302
Biodegradation-Fermentation	78	172
Milk Pasteurization	100	212
Evaporation/Crystallization Industries	150	302
Preservation of Fruits & Vegetables		
Sugar Beet Refining		
Sodium Chloride Production		
Caustic-Chlorine Production		

^a Much of the literature on space heating applications of geothermal energy indicates that a minimum of 80°C is required; however, there is successful commercial use of 30°C geothermal water for space heating.

^b Depending on the fish species and the extent of the life cycle included on the farm.

^c Depending on the crop.

Table 8: Engineering & Economic Studies of Non-electric Applications of Geothermal Heat: Projects Funded by the U. S. Department of Energy^a

Primary Application	Reservoir/Area
Space/Water Heating	Casa Diablo/City of Mammoth, Lakes, CA
Space Conditioning	Desert Hot Springs, CA
Food Production & Processing	Lake County, CA
Sugar Refining	Brawley KGRA/Western U. S.
Production of Fertilizer	Heber KGRA, CA
Food Processing	Louisiana (geo-pressured resources)
Salmon Aqua-culture	Alaska
Food Processing	Klamath & Snake River Basin, OR
Space Heating	Six Alaskan towns
Integrated Industrial-Agricultural Complex	Raft River/KGRA, ID
Livestock Production (Dairy)	Wendel Hot Springs, NV
Sugar Beet and Barley Process.	San Luis Valley, CO
Space/Water Heating	Madison Aquifer System/Midland, SD
Refrigeration for Food Process.	Western U. S.
Evaporation & Crystallization of Industrial Liquids & Wastes	Western U.S.
Industrial Complex	Western U.S.
Crop Drying	Western U.S.
Greenhouses: fishfarming	Western U.S.

^a Memorandum: E & E Studies of Non-Electric Applications, Morris Skalka, U. S. Department of Energy, 1976.

Chapter 3

UTILIZATION OF THE HUECO TANKS RESOURCE

This chapter is divided into three parts. The first part describes climatic, demographic, and industrial characteristics of El Paso; the second part identifies the most suitable users of the Hueco Tanks resource and describes the procedures used to identify them; and the third part presents quantitative information on the amount of geothermal energy required by each user type and on the amount of fossil fuel that use would replace. Our focus is on the kind of industry and other potential users that already exist in the El Paso area. This assumes that the future mix of potential users will be similar to the current mix. That assumption is supported by data from the El Paso Chamber of Commerce on the kind of industry that is moving to El Paso.

Characteristics of the Hueco Tanks Resource Area

The Hueco Tanks geothermal resource is located in the northeast corner of El Paso County, Texas (see Fig. 4). Although it is shown as a point on Fig. 4, it actually extends for about 10 miles trending northwest to southeast across the corner of the County. Distances from the resource area are shown on Fig. 4 by radii of 5, 15, and 25 miles. The City limits begin about 17 miles east and southwest of the resource. Residential development along Route 180 to the east of the City currently extends to within 15 miles of the resource and is moving east. There is a trailer park and a recreational facility on Route 180 about 10 miles from the resource. One campus of the El Paso Community College (EPCC), the El Paso Airport, and the town of Horizon City are each located about 20 miles from the resource. Ft. Bliss and the majority of El Paso's industrial development are located between 20 and 25 miles from the resource.

FIG. 4. MAP OF EL PASO COUNTY

Legend:

- Hottest geothermal waters in Texas as indicated by well water surface temperatures.^a
- Point from which radii are measured.

^a Source: Jerry M. Hoffer, "Geothermal Exploration, Northeastern El Paso County, Texas and Southwestern Otero County, New Mexico" September, 1978.

El Paso and Juarez form an international metropolitan area of about 1,000,000 people, with 416,450 people in the City of El Paso as of 1977.^a The City of El Paso's population grew at a rate of 7.6% per year between 1950 and 1960, at 1.5% per year between 1960 and 1970, and at 2.4% per year between 1970 and 1977.

Many electronics and apparel manufacturing companies operate under the "Twin Plant Concept." By dividing manufacturing operations between companion plants in El Paso and Juarez, production costs are reduced. For example, in the electronics industry, U.S. raw materials are converted in an El Paso plant to identifiable parts which are delivered to a Juarez plant for assembly. The product is then returned to the El Paso plant for finishing, packaging, and distribution. Labor costs and favorable government regulations in Mexico hold down overall production costs.

The City of El Paso encompasses about 160 square miles of which 40.4% are devoted to single-family residential development (72,736 units), 1.2% to multi-family residential development (30,331 units), 2.5% to commercial development, 1.7% to industrial development, 13.2% to public facilities, and 1.5% to agriculture. The remaining 39.5% is undeveloped. There are 36 public housing complexes with 5,700 living units. These occur throughout the city with some in the northeast.

The climate is one characterized by an abundance of sunshine, moderate temperatures, low humidity, and low rainfall. The mean temperature in January is 44.7°F and in July is 81.8°F. Annual

^a El Paso Area Fact Book.

mean humidity is 39% and annual rainfall averages 8.5 inches. There are about 2,500 heating degree days and 2,000 cooling degree days.

The municipal water source is primarily groundwater from two fields, one in the Hueco Bolson east of the City and one from the La Mesa Bolson northwest of the City. Rio Grande River water is used by industry and for agriculture. All surface water in the Rio Grande is fully appropriated. In fact, the Rio Grande Regional Environmental Project (RGREP) which extends from Elephant Butte, N.M. to Ft. Quitman, Texas comes closer to consuming every available drop of water than any other major river basin in the U.S. When the River reaches Ft. Quitman, it is dry. In El Paso, municipal and industrial water use totals 120,000 acre feet per year (12,000 from the Rio Grande and 108,000 from groundwater) and agricultural use totals 272,000 acre-feet per year (207,000 from the Rio Grande and 65,000 from groundwater).^a Excluding agriculture, per capita consumption is 232 gallons per day. Groundwater withdrawals do exceed recharge rates in the Hueco Bolson well field. However, the extent of groundwater mining is uncertain. A recent study indicates that the well field will be depleted sometime between the years of 2010 and 2030, depending on assumptions about the recharge rate and population growth rates.^b

^a 67,930 acres are irrigated in El Paso County with the major cash crops being cotton and cottonseed, milk, beef, vegetables, pecans, and eggs.

^b The Present and Future Social, Economic, and Water-Resource Setting of El Paso County by Darrell D. Mach, Regional Planning Officer, Bureau of Reclamation-Southwest Region, Amarillo, Texas.

Consumptive energy use within the City is not known. Nearly all space heating is by natural gas and nearly all space cooling is by evaporative coolers. Evaporative cooling is used nearly exclusively for single-family residences and predominates in industrial, commercial, and multi-family residential development. Evaporative cooling is considerably less expensive than refrigerated air and most residents find it more comfortable. Refrigerated air is used to some extent in multi-story office buildings, hotels, and apartment buildings. The two electric power plants located in the County are natural gas fired. Peak demand occurs in the summer months due to electric consumption for space cooling.

Table 9 lists the number of industries in El Paso County by major Standard Industrial Classification (SIC) category. Of the manufacturing categories, food processing, apparel manufacturing, printing industries and metal product manufacturing dominate. The number of businesses in these four industrial groups represents 50% of all manufacturing businesses in El Paso County.

Suitable Applications of the Hueco Tanks Resource

Substantial uncertainty on the temperatures and flow rates that might be attained from the Hueco Tanks geothermal resource still exists. Resource data, by itself, indicates that electric power generation, requiring temperatures greater than 300°C, is probably not an option. On the other hand, resource data indicate that the resource is suitable for space heating and cooling (heating requires 30-80°C and cooling 110°C) and the demand for space heating and cooling clearly exists in the El Paso metropolitan area. Thus, we begin by excluding electric power generation from further consideration and

Table 9: Number of Industries in Each Standard Industrial Classification (SIC)
El Paso County^a

SIC Code	Name	Number of Businesses ^b
Manufacturing		
20	Food and Kindred Products	57
22	Textile Mill Products	2
23	Apparel and Other Finished Textile Products	37
24	Lumber and Wood Products, Except Furniture	17
25	Furniture and Fixtures	22
26	Paper and Allied Products	3
27	Printing, Publishing, and Allied Industries	44
28	Chemicals and Allied Products	14
29	Petroleum Refining and Related Industries	5
30	Rubber and Miscellaneous Plastic Products	20
31	Leather and Leather Products	14
32	Stone, Glass, Clay and Concrete Products	21
33	Primary Metals Industries	10
34	Fabricated Metal Products	57
35	Machinery, Except Electrical	24
36	Electrical Machinery, Equipment & Supplies	23
37	Transportation Equipment	3
38	Professional Scientific Instruments	18
Industrial Services		
40	Railroad Transportation	5
42	Motor Freight Transportation & Warehousing	61
45	Transportation by Air	10
47	Transportation Services	45
49	Electric, Gas, and Sanitary Services	7
50	Wholesale Trade-Durable Goods	22
72	Personal Services	5
73	Business Services	45
75	Automotive Repair, Services and Garages	16
76	Miscellaneous Repair Services	26
89	Miscellaneous Services	77

^a From Directory of Manufacturers and Industrial Services, El Paso Chamber of Commerce, El Paso, Texas, 1978-1979 Edition, 60 pp.

^b A business may have more than one location.

by including resource utilization for space heating and cooling. The uncertainty, then, relates to applications in the industrial sector of El Paso. Resource data, by itself, does not provide sufficient criteria to eliminate from further consideration any of the industrial applications listed in Table 7 or 9. Thus, criteria for assessing applications in the industrial sector center around what is known about industries that can use low to moderate temperature heat and about industries that now exist in the El Paso area or are likely to expand because their material inputs are produced in the El Paso area. Resource data are utilized as a criteria only to the extent that temperature needs must be low to moderate (not greater than 200°C).

An iterative sequence of assessment of potential applications followed by elimination of some from further consideration is used here to identify the most suitable applications. First, the temperature requirements of industries in El Paso are compared with those expected from the resource; this first level assessment eliminates many industries from further consideration. Secondly, the remaining industrial applications as well as space heating and cooling applications are assessed on more detailed criteria; this second level eliminates several more applications. Finally, information acquired directly from potential users is applied to a third-level assessment.

First-Level Assessment

For the industrial sector, the first iteration is carried out at the level of two digit SIC industrial categories. Referring to Table 9 which lists the number of industries in El Paso by two digit SIC categories, the industrial services group (SIC 40 through 89)

does not normally need process heat or refrigeration. In the manufacturing group (SIC 20 through 38, Table 9), process heat constitutes a significant portion of energy consumption in nine categories:^a Food and Kindred Products (SIC 20), Textile Mill Products (SIC 22), Apparel Products (SIC 23), Paper and Allied Products (SIC 26), Chemicals and Allied Products (SIC 28), Petroleum Refining and Related Industries (SIC 29), Rubber and Miscellaneous Plastic Products (SIC 30), Stone, Glass, Clay, and Concrete Products (SIC 32), and Primary Metals Industries (SIC 33).

However, of these nine categories, three require very high temperatures for most of their process heat consumption. In the petroleum refining industry, most process heat is utilized at temperatures between 375 and 500°C. In the stone, glass, clay, and concrete products industries, the bulk of process steam use is for firing kilns at very high temperatures. Almost all glass industry energy requirements are for heating at temperatures greater than 500°C. The primary metals industry is similar in that it is characterized by high temperature energy needs. Of the remaining six industrial categories, one (chemical and allied products) is marginal. Industries in the chemicals and allied products category include chlorine-caustic soda, synthetic soda ash, and the alumina industry. A wide variety of processes are used by these

^a Reistad, G.M., "Potential for Non-electrical Applications of Geothermal Energy and Their Place in the National Economy" p. 2155-2164 in Proceedings: Second U.N. Symposium on the Development and Use of Geothermal Resources, 1976, 3 volumes, Government Printing Office, Washington, D.C.

industries. Some (e.g. the ammonia and methanol processes) require temperatures about 250°C. Potential applications of moderate temperature geothermal energy are numerous in the remaining five SIC categories: food and kindred products, textile mill products, apparel products, paper and allied products, and rubber products. These five as well as the chemical and allied products category are considered further. In addition, self-desalination of water for irrigation is considered since irrigated agriculture exists in El Paso County and its water is limited.

In summary, the direct use applications of geothermal energy considered for the second-level of assessment include: space conditioning in the residential, commercial, and industrial sectors; process heat and refrigeration applications in the food and kindred products industry; process heat applications in the textile, apparel, paper, rubber, and chemical industries; and self-desalination of geothermal waters for irrigation.

Second-Level Assessment

Table 10 lists the potential applications of low to moderate temperature geothermal energy chosen for further consideration. Included in the Table are five assessment indicators; each application is assessed qualitatively on each indicator. The following discussion delineates the rationale for the assessment.

1. Load Factor

Load factor considerations are important in assessing geothermal economics because of the capital intensive nature of geothermal development. Geothermal development requires substantial investment capital but the installation has a long life and

Table 10: Direct Use Applications of the Hueco Tanks Resource: Assessment Indicators

Application	Load Factor	Market	Distance	Environmental	Efficiency: Fossil Fuel Displacement	Totals Poor-Good-Excellent
Space Heating & Hot Water Heating						
Residential						
Single Family District	Poor	Excellent	Poor	Good	Excellent	2-1-2
Multi Family	Poor	Excellent	Poor	Good	Excellent	2-1-2
Commercial	Poor	Excellent	Poor	Good	Excellent	2-1-2
Industrial	Poor	Excellent	Poor	Good	Excellent	2-1-2
Space Heating & Cooling & Hot Water Heating						
Residential						
Single Family District	Good	Good	Poor	Good	Excellent	1-3-1
Multi Family	Good	Good	Poor	Good	Excellent	1-3-1
Commercial	Good	Good	Poor	Good	Excellent	1-3-1
Industrial	Good	Good	Poor	Good	Excellent	1-3-1
Industrial Process Heat						
Food Processing	Excellent	Excellent	Poor	Good	Excellent	1-1-3
Textile Mills	Excellent	Poor	Poor	Good	Good	2-2-1
Apparel Manufacturing	Excellent	Excellent	Poor	Good	Good	1-2-2
Paper Manufacturing	Excellent	Poor	Poor	Good	Good	2-2-1
Rubber Manufacturing	Excellent	Good	Poor	Good	Good	1-3-1
Chemical Manufacturing	Excellent	Good	Poor	Good	Poor	2-2-1
Industrial Refrigeration						
Food Processing	Excellent	Excellent	Poor	Good	Excellent	1-1-3
Self-Desalination for Irrigation	Poor	Good	Excellent	Poor	Poor	3-1-1

utilizes a minimum of operating supplies and labor. Thus, annual costs consist mainly of fixed charges such as interest, depreciation, and taxes. Variable costs, which depend on the quantity of energy produced, are relatively unimportant. Since fixed costs constitute most of the annual costs^a and since they must be paid even when the capacity of the geothermal production and delivery system is not being used, the overall annual costs of the system decrease dramatically as load factor increases. A graph showing heating and hot water demand by month for one single-family residence^b in El Paso is given in Fig. 5.^c Heating demand occurs during seven months of the year. If the geothermal production and delivery system were sized to meet peak heating demand, the annual load factor would be only 41%. If it were sized to meet half of the peak demand, the annual load factor would be 59%. This poor load factor rating is reflected in Table 10 for all space heating applications.

The situation improves somewhat if cooling is also carried out with geothermal energy. Fig. 6^c shows the sum of space heating, hot water heating and space cooling demand for one single-family residence^b in El Paso. If the geothermal production and delivery system were sized to meet peak demand, the annual load factor would be 60 to 74%. If it were sized to meet half the peak demand,

^a One study indicates that fixed costs represent 75% of annual costs; Einarsson, Sveinn S., "Geothermal Space Heating and Cooling," p. 2117-2126 in Proceedings: Second U.N. Symposium on The Development and Use of Geothermal Resources, 1976, 3 volumes, Government Printing Office, Washington, D.C.

^b 1,800 ft² home.

^c Data in support of Figs. 5 and 6 are given in Appendix A.

Fig. 5. Space Heating and Hot Water Demand in El Paso. One 1800 square foot single-family residence heated with natural gas (a) and electricity (b). Data from Southern Union Gas Company, see Appendix A.

Legend:
 ----- Hot Water Heating
 Space Heating
 _____ Total

Fig. 6. Space Heating and Cooling and Hot Water Demand in El Paso. One 1800 square foot single-family residence, all electric (a) and gas heating and hot water with electric air conditioning (b). Data from Southern Union Gas Company, see Appendix A.

the annual load factor would be 93 to 99%.

The load factor is essentially constant for all applications of geothermal heat for industrial process heat and industrial refrigeration (thus, the excellent assessment shown on Table 10). Since the irrigation season is limited to only a few months, the load factor for self-desalination applications is shown as poor.

2. Market

Market assessments shown on Table 10 generally reflect size, the number of potential users, and/or their potential mobility. In the case of space heating, the market clearly exists in El Paso. The market for space cooling is poor for single-family residences since nearly all are cooled with evaporative coolers. Most of the populace in the El Paso area prefer evaporative cooling not only because of the low cost but also because of the greater comfort it offers in comparison to refrigerated air. However, evaporative cooling is not as effective in multi-family residences or in commercial and industrial establishments. Thus, the market is assessed as good for those applications. In the case of industrial process heat and refrigeration applications the market is assessed in terms of the number of establishments that already exist in El Paso. This assessment, then, reflects the importance of an industry to El Paso, the potential for expansion of that industry, and the likelihood that an industry can economically move nearer to the geothermal resource as it expands. Two industries are assessed as excellent in this regard: apparel manufacturing and food processing. There are 57 food processing businesses and 37 apparel manufacturing

businesses in El Paso (Table 9). They predominate in the industrial character of the City. Apparel manufacturing employs more people than any other industry (15,000 or 57.7% of industrial employment) and food processing is second (2,300 or 8.8% of industrial employment). Similarly, wages paid by the apparel manufacturing industry represent 35.2% of industrial wages and those paid by the food processing industry represent 10.9% of industrial wages.^a In contrast, there are only 20 rubber manufacturing businesses and 14 chemical businesses (assessed as good) and two textile companies and three paper products manufacturing firms (assessed as poor) (Table 9).

3. Distance

The distance indicator reflects the present location of the potential user relative to a geothermal resource. While some potential users can move, the indicator of mobility is included in the market assessment category and, therefore, not included in this category. In El Paso County, nearly all potential users are located 20 to 25 miles from the nearest geothermal resource.^b While temperature losses can be held to 10°F with proper insulation over distances of 25 miles,^c costs escalate rapidly with distance. Most estimates

^a Measured as value added by manufacturing, from El Paso Area Fact Book, 1978, El Paso Industrial Development Corporation, Section VII, p. 4.

^b Assuming the Campus Andesite does not constitute a geothermal resource.

^c Applications of Geothermal Resources in the Evaporation and Crystallization Industry, Bechtel Corporation, 1977, SAN/1328-2, p: 12-2.

project geothermal energy transmission costs in the range of \$170,000 to \$270,000 per kilometer depending on the size of the pipe (10 to 16 inches). While cost becomes significant in absolute terms over distances of 20 to 25 miles (32 to 40 km), transmission costs are a small fraction of total costs. For example, in the case of district space heating and cooling applications where a distribution system is required, the cost of one-kilometer transmission pipeline system represents only 2.5% of the total costs.^a If a distribution system is not required, the pipeline cost (one kilometer) represents 6.7% of total costs. Data from Einarsson^a indicates that the cost of a system supplying a user located 20 to 25 miles from the resource would be about two times the cost were the user located at the resource. Since all potential industrial users are located in El Paso 20 to 25 miles from the nearest resource,^b they are all given a poor rating in the distance assessment category (Table 10).

4. Environmental

The environmental assessment category is intended to indicate the potential for subsidence, groundwater degradation, and/or release of non-condensable gases into the atmosphere.

Subsidence is caused by sub-surface extractions of water. Saturated sediments, and some rocks, are supported in part by the water matrix. When this fluid support is removed, the overburden sediment weight may be sufficient to cause compression of the

^a Einarsson, Sveinn S. "Geothermal Space Heating and Cooling," p. 2117-2126 in Proceedings: Second U.N. Symposium On the Development and Use of Geothermal Resources, 1976, 3 volumes, Government Printing Office, Washington, D.C.

^b Assuming that the Campus Andesite does not constitute a geothermal resource.

formation. There are many documented subsidence occurrences in groundwater, oil, and geothermal production fields.

Degradation of groundwater quality and quantity can result from geothermal development. Quality degradation can occur if the geothermal well casings leak to surrounding potable groundwater supplies. Proper selection of materials and proper construction methods normally minimize, if not eliminate, this problem. Withdrawal of geothermal water can also cause drawdown in surrounding wells used as potable or irrigation water sources. The extent to which this occurs depends on natural leakages between the aquifers above the geothermal aquifer and the geothermal aquifer itself.

The only non-condensable gas that can pose an air quality problem is hydrogen sulfide. No measurements of hydrogen sulfide concentrations in the geothermal waters of the Trans-Pecos are available, thus, potential problems can not be assessed.

In any case, none of these environmental problems would be serious if the geothermal water were utilized in a closed loop and reinjected. In a closed loop system, the geothermal water is used to heat fresh water and then is reinjected. The fresh water simply circulates in a closed loop from the user to the geothermal water. In such a system, no non-condensable gases are released and the same quantity of geothermal water that was removed is replaced in the aquifer. In contrast, if the geothermal water is not reinjected, then subsidence and groundwater degradation can pose significant problems.

Since a double transmission system is required for reinjection, it is practical only when the user is located in close proximity to

the resource. Thus, assuming a user locates near a resource, reinjection is possible for all potential applications except self-desalination for irrigation. All applications are rated good in this assessment category except self-desalination which is rated poor.

5. Efficiency: Fossil Fuel Displacement

The efficiency assessment category reflects the portion of the user's fossil fuel energy consumption that can potentially be displaced by geothermal energy. If more than 75% of the users energy consumption can be displaced by low to moderate temperature geothermal energy, the application is rated as excellent in this category. These include all space heating applications and food processing applications. In the textile, apparel, paper, and rubber manufacturing industries, the potential for geothermal to replace fossil fuel energy use is variable with displacement representing less than 50% of overall industrial energy use (assessed as good). In the chemical industry, only 11% of energy use is at temperatures less than 250°C (assessed as poor). Self-desalination represents a new use of energy in the Trans-Pecos and thus no displacement of current fossil fuel use.

6. Summary

Based on the assessment indicators given in Table 10, four kinds of applications emerge as most suitable. These are listed in Table 11 and include: (i) space heating and cooling, (ii) food processing including the use of geothermal energy for process heat and refrigeration, (iii) apparel manufacturing, and (iv) rubber manufacturing.

Table 11: Most Suitable Applications Based on Assessment Indicators

Indicators ^a Poor-Good-Excellent	
1-1-3	Food Processing: Process Heat and Refrigeration
1-2-2	Apparel Manufacturing: Process Heat
1-3-1	Space Heating and Cooling and Hot Water Heating: Residential, Commercial, Industrial Sectors Rubber Manufacturing: Process Heat

^a From Table 10.

Third-Level Assessment

1. Industrial Applications

Based on the results of the second-level assessment, three industrial groups in the El Paso area were selected for further analysis of their geothermal resource utilization potential: the food, apparel and rubber industries. All of those industries are listed by name in Table 12. Since some businesses manufacture more than one kind of commodity (as classified by the SIC codes), some are listed more than once. Repetitive listings are shown in parentheses on Table 12. There are 114 different businesses listed, 57 food processing companies, 37 apparel companies, and 20 rubber manufacturing companies. In order to determine which of these companies actually uses process heat at temperatures less than 200°C or requires refrigeration, a representative sample of each industrial category (based on the four-digit SIC classification) was telephoned. The two largest companies (based on employment) in each four-digit SIC category were telephoned. If both indicated that no process heat or refrigeration was required, then no more companies in that category were phoned and none were considered further in this study. If one or both indicated use of process heat and/or refrigeration, then more were phoned. Fifty-six companies, or 50% were telephoned, 21 food processing companies (37%), 28 apparel companies (76%), and seven rubber companies (35%). A summary of information acquired via these phone calls is given in Appendix B. Use or non-use of process heat or refrigeration in the food processing and rubber industries was consistent within four-digit SIC categories; it was not consistent within the four-digit apparel categories. Thus, a higher

Table 12: Food Processing, Apparel, and Rubber Industries in El Paso^a

SIC Code	SIC Description	Name of Industry ^b	Process Heat/ Refrigeration ^c	Location ^d /Employees ^f	
2011	Meat Packing	Eckrich Food Service	Yes	B	E
		El Paso Meat Company	Yes	C	C
		El Paso Packing Company	Yes	C	B
		Peyton Packing Company	Yes	C	I
		Prepared Foods, Inc.	Yes	B	C
		Western Packing Company	Yes	B	E
		El Paso Cheese Company	Yes	B	B
2022	Cheese				
2024	Ice Cream & Frozen Desserts	Price's Dairies	Yes	B	E
		Wholesome Dairy	Yes	B	D
2026	Fluid Milk	Escobar Dairy Company	Yes	B	B
		Farmer's Dairies	Yes	B	E
		Horizon Dairy Farm	Yes	C	A
		Lane's Dairy	Yes	B	B
		(Price's)			
		(Wholesome)			
2032	Canned Specialties	Ashley's Inc.	Yes	B	D
2033	Canned and Preserved Fruits, Vegetables, Sea Food	Mountain Pass Canning Company	Yes	C	H
		(Ashley's Inc.)			
2035	Pickled Fruits and Vegetables; sauces and seasoning	(Mountain Pass Canning Company)			
		(Ashley's Inc.)			
2037	Frozen Milk and Vegetables	(Mountain Pass Canning Company)			
		Valley Foods Company	Yes	C	C
2041	Flour and Other Grain Mill Products	(Wholesome Dairy)			
		Paul's Fine Feeds	Yes	C	A
2042	Prepared Foods for Animals & Fowl				
		(Paul's Fine Feeds)			
		Jerky Treats	Yes	B	D
		Valley Feed Mills	Yes	C	B

Table 12: Food Processing, Apparel, and Rubber Industries in El Paso^a (cont'd)

SIC Code	SIC Description	Name of Industry	Process Heat/ Refrigeration ^c	Location ^d /Employees ^f
2051	Bread and Other Bakery Products	Commercial Bakery	No	C A
		Helen's Pastries	No	B A
		Jack & Jill Pastries	No	B B
		Kahn's Bakery Company	No	C D
		Don Martin Bakery	No	C A
		Mead's Bakery	No	C E
		National Bakery	No	C B
		Rainbo Baking Company	No	C E
		Sharp's Bakery	No	B A
		Sun Valley Bakery	No	C A
2071	Candy and Other Confectionery Products	Sir B's	No	B A
2086	Soft Drinks	Dr. Pepper Bottling Company	Yes	C B
		Magnolia Coca Cola Bottling Company	Yes	B F
		Nicholson Bottling Works	Yes	C A
		Pepsi Cola Bottling Company	Yes	B C
		Seven-Up/Royal Crown Bottling Company	Yes	B C
		Wes-Tex Custom Bottlers, Inc.	Yes	B A
2087	Flavoring Extracts and Syrups	Duffy's Draft Beverage Company	Yes	C A
2091	Cotton Seed Oil Mills	SWIG Cotton Oil Mill	Yes	C U
2097	Manufactured Ice	Consumers' Ice and Fuel Company	No	C B
		Fabens Ice Company	No	C A
2099	Food Preparations, not elsewhere classified	Azar Nut Company	Yes	B, C F
		Best Buy Tortilla Factory	No	B A
		Clover Club Food Company	No	B A
		El Paso Tortilla Company	No	B A
		Ideal Tortilla Factory	No	B C
		La Colonia Tortilla Factory	No	B A
		La Mexican Mexican Foods	No	B A
		La Rotative, Inc. (Tortilla Factory)	No	C B
		La Tapatia, Inc.	No	C B
		La Tolteca Tortilla Factory	No	C B
		Mexi-Snax Corporation	No	B B
		Morton Foods (food processing)	No	B B
		National Molasses Company	No	B B

Table 12:--Food Processing, Apparel, and Rubber Industries in El Paso^a (cont'd)

SIC Code	SIC Description	Name of Industry ^b	Process Heat/ Refrigeration ^c	Location ^d /Employees ^f	
2099 (cont'd)	Food Preparations, not classified elsewhere	Sylvia's Sandwich Shop	No	C	A
		Tejano Products Company	No	B	A
		Tekita House Foods, Inc.	No	B	A
		Tri-Mor Sandwich Shop	No	B	A
2311	Men's and Boy's Suits, Coats	Union Manufacturing Company	Yes	C	G
2321	Men's and Boy's Shirts	Billy the Kid, Inc.	Yes	B	L
		Maher Manufacturing Company	Yes	B	I
		Ruddock Manufacturing Company	Yes	C	D
		Jerry Shore Sportswear	Yes	C	G
2327	Men's and Boy's Separate Trousers	Tex-Togs, Inc.	No	C	G
		Trimex, S.A. ^e	No	B, C	E
		Zenith Shirt Company ^e	No	C	D
		Allied Manufacturing Company (Billy the Kid, Inc.)		B	F
		Blue Bell, Inc.	No	C	I
		Clothing Manufacturers of El Paso ^e	No	C	A
		D. P. Cajal's	Yes	C	E
		El Paso Apparel Division-Silton Bros.	No	B	F
		Farah Manufacturing Company	Yes	B	L
		Mann Manufacturing Company			K
		Sahara Slacks (Jerry Shore Sportswear)	No	C	D
		Levi-Strauss and Company (Tex-Togs, Inc.)	Yes	B, C	J
		(Trimex, S.A.)			
		(Union Manufacturing Company)			
2328	Men's and Boy's Jeans and Work Clothing	Action West Manufacturing Company (Allied Manufacturing Company)	Yes	C	E
		(Billy the Kid, Inc.)			
		(Blue Bell, Inc.)			
		(Farah Manufacturing Company)			
		(Maher Manufacturing Company)			
		(Mann Manufacturing Company)			
		Sew Rite Manufacturing, Inc. (Levi-Strauss and Company)	No	C	D

Table 12: Food Processing, Apparel, and Rubber Industries in El Paso^a (cont'd)

SIC Code	SIC Description	Name of Industry ^b	Process Heat/ Refrigeration ^c	Location ^d /Employees ^f	
2328 (cont'd)	Men's and Boy's Jeans and Work Clothing	Sun Apparel (Tex-Togs, Inc.) (Trimex, S.A.) (Union Manufacturing Company)		C	D
2329	Men's, Youth's, and Boy's Clothing, not elsewhere classified	Viola Sportswear (Billy the Kid, Inc.) (Farah Manufacturing Company) Garro Industries of Texas (Sew Rite Manufacturing, Inc.) (Jerry Shore Sportswear) (Levi Strauss and Company) (Viola Sportswear)	No	B	E
2321	Women's and Misses' Blouses, Waists and Shirts	Krisel Manufacturing Company (Maher Manufacturing Company) (Jerry Shore Sportswear)	No	C	C
2335	Women's and Misses' Dresses	CMT Industries (Maher Manufacturing Company) Summit Fashions, Inc. ^e	No	C	E
2337	Women's, Misses', and Junior's Suits, Skirts and Coats	Hide-Away Creations Primrose Fashions (Jerry Shore Sportswear)	No No Yes	C C C	D B U
2339	Women's and Misses' Outerwear	Brittania Sportswear (El Paso Apparel Div.-Silton Bros.) Royal Key Corporation (Ruddock Manufacturing Company) Don Shapiro Industries (Jerry Shore Sportswear) (Summit Fashions, Inc.) (Zenith Shirt Company)		C	G
2341	Women's and Misses' Underwear	Acapulco Fashions of Texas ^e	No	C	E
2361	Girls', Infants' and Children's	(Krisel Manufacturing Company)		C	E
2386	Leather and Sheep Lined Clothing	(Hide-Away Creations)		C	E

Table 12: Food Processing, Apparel, and Rubber Industries in El Paso^a (cont'd)

SIC Code	SIC Description	Name of Industry ^b	Process Heat/ Refrigeration ^c	Location ^d /Employees ^f
2387	Apparel Belts	S. D. Myres Saddle Company	No	B A
2391	Curtains and Drapes	Decorator's Outlet	No	C A
		Rutherford's		C A
2392	House Furnishings	(Decorator's Outlet)		
2393	Textile Bags	Commercial Sales Manufacturing Co.	No	C B
2394	Canvas and Related Products	Am-Champ	No	A B
2396	Automotive Trimmings	Dallas Bias Fabrics of El Paso	No	B B
SIC 30: Rubber and Miscellaneous Products				
3069	Fabricated Rubber Products	American Excelsior Company	No	C A
3079	Misc. Plastic Products	Bacchus Industries	No	C A
		Border Fiberglass	No	C A
		Cemco Products	No	C C
		Composition Supply Company	No	C A
		Consolidated Industrial Develop- ment of El Paso	No	A A
		Crown World, Inc.	No	A B
		EJR Cultured Marble		A A
		El Paso Plastics International	No	B D
		Fiberglass Cooler Contractors Division	No	B B
		Gibson Fixture and Plastics Co., Inc.	No	C A
		Handgards, Inc.	No	B D
		Harris Cooling & Heating	No	B B
		Rodriguez Plastics	No	C A
		Southwest Cultured Marble	No	C C
		Southwest Laminated Plastics and Millwork	No	C B
		Thunderbird Container Corporation	No	C D
		Wahler Specialties		B U
		Washco Plastics Corporation	No	B C
		Whipples Enterprises		C A

Footnotes to Table 12:

^a Source: El Paso Chamber of Commerce, Directory of Manufacturers and Industrial Services, 1978-1979.

^b Industry is given in parentheses if it is listed in a previous SIC category.

^c Yes means that the business uses energy for process heat at temperatures less than 200°C and/or uses energy for refrigeration.

^d A = 15-20 miles from the geothermal resource.

B = 20-25 miles from the geothermal resource.

C = more than 25 miles from the geothermal resource.

^e Twin Plant: El Paso/Juarez.

^f Number of Employees: A is 1 to 10; B is 11 to 25; C is 26 to 50; D is 51 to 100; E is 101 to 200; F is 201 to 300; G is 301 to 400; H is 401 to 500; I is 501 to 750; J is 751 to 1,000; K is 1,001 to 2,500; L is 2,501 to 5,000; and M is more than 5,001; U is unknown.

percentage of apparel industries than food processing and rubber industries was called. For example, none of the bakery companies (SIC 2051) and none of the companies preparing Mexican food (SIC 2099) use process heat below 200°C; rather their needs are for temperatures greater than 230 to 260°C. The rubber companies (SIC 3069 and 3079) are either distributors or use electricity in their processing. Conversely, all of the meat packing companies (SIC 2011) require refrigeration (-10 to +35°F or -23 to +1.7°C). All of the milk processing companies (SIC 2026) require refrigeration and process heat, and all of the canning (SIC 2032 and 2033) and soft drink bottling companies (SIC 2086) require process heat. The use of process heat within the apparel industries depends entirely on whether or not pressing is carried out. Some companies are only distributors, some press in a twin plant in Mexico, and some press in their U.S. plants.

Based on this phone call summary, the use of process heat or refrigeration is designated with a "yes" or "no" on Table 12. The "yes" companies are relisted on Table 13 along with employment data for each.

Five groups of industries (at the four-digit SIC code level) emerge as dominant in their potential for utilizing geothermal energy for process heat or refrigeration: meat packing (refrigeration), dairies (process heat for pasteurization and refrigeration for chilling), canning (process heat), soft drink bottling (process heat for sterilization) and the major apparel manufacturers (process heat for pressing).

Table 13: Companies Requiring Process Heat and/or Refrigeration

Name	Number of Employees ^a
Refrigeration	
Eckrich Food Service*	101-200
El Paso Meat Company	26- 50
El Paso Packing Company	11- 25
Peyton Packing Company	501-750
Prepared Foods, Inc.*	26- 50
Western Packing Company*	101-200
El Paso Cheese Company*	11- 25
Refrigeration and Process Heat	
Price's Dairies*	101-200
Wholesome Dairy*	51-100
Escobar Dairy Company*	11- 25
Farmer's Dairies*	101-200
Horizon Dairy Farm	1- 10
Lane's Dairy*	11- 25
Valley Foods Company	26- 50
Process Heat	
Ashley's Inc.**	51-100
Mountain Pass Canning Company	401-500
Paul's Fine Feeds	1- 10
Jerky Treats*	51-100
Valley Feed Mills	11- 25
Dr. Pepper Bottling Company	11- 25
Magnolia Coca-Cola Bottling Company*	201-300
Nicholson Bottling Works	1- 10
Pepsi-Cola Bottling Company*	26- 50
Seven-Up/Royal Crown Bottling Company**	26- 50
Wes-Tex Custom Bottlers, Inc.*	1- 10
Duffy's Draft Beverage Company	1- 10
SWIG Cotton Oil Mill	Unknown
Azar Nut Company*	201-300
Union Manufacturing Company	301-400
Billy The Kid*	2,501-5,000
Maher Manufacturing Company**	501-750
Ruddock Manufacturing Company	51-100
Jerry Shore Sportswear	301-400
Allied Manufacturing Company*	201-300
D. P. Cajal's	101-200
Farah Manufacturing Company*	2,501-5,000
Levi-Strauss & Company**	751-1,000
Action West Manufacturing Company	101-200
Blue Bell, Inc.	501-750

* Located 20 to 25 miles from the Hueco Tanks Resource; non-starred companies are located greater than 25 miles.

** Located together in an industrial park about 22 miles from the Hueco Tanks Resource.

^a From: Directory of Manufacturers and Industrial Services, El Paso Chamber of Commerce, 1978-79 Edition.

The number of employees, shown in Table 13, is taken as a size indicator. Within a four-digit SIC category, it can be assumed that the company with the greatest number of employees uses the most energy. This is, of course, not the case across four-digit SIC categories since the manner in which energy is used varies across categories. Size may also indicate the potential for expansion to a new location.

All of the 38 companies listed in Table 13 are located at distances greater than 20 miles from the Hueco Tanks resource, 21 are located between 20 and 25 miles (those starred on Table 13) and 17 at distances greater than 25 miles. Four companies (those with a double star in Table 13) are located together in an industrial park which is near the El Paso International Airport at a distance of about 22 miles from the resource. Quantitative data on energy use in the meat packing, dairy, canning, and apparel industries were obtained with a focus on the largest companies in those categories and on those companies with manufacturing plants located nearest the resource.

2. Residential and Commercial Applications: Space Conditioning

The El Paso area is characterized by nearly equivalent heating and cooling demand. On the average, there are 2500 heating degree days and 2000 cooling degree days. Monthly demand in degree days is shown in Fig. 7. If heating and cooling systems operated with equivalent efficiencies, then energy demand for space conditioning would follow the pattern shown in Fig. 7, peaking in December and June. On a peak monthly basis, such a system would be used during

Heating and
Cooling
Degree Days

Fig. 7. Heating and Cooling Degree Days: El Paso, Texas. Numerical details are given in Appendix C, Table C-1.

55% of the year. A system providing only space heat would be used during 31% of the year. If a geothermal system were sized to meet half of the peak demand for heating and cooling, it would be used during 85% of the year.

In order to assess how energy demand for space conditioning varies among different kinds of users, this section gives data and information about energy use in single-family residences, multi-family residences, schools, office complexes, and at Ft. Bliss Military Reservation. At the present time, residential and commercial development in El Paso extends to within 17 miles of the Hueco Tanks Resource Area; however, it is extending slowly to the northeast. Ft. Bliss is about 22 miles from the resource and a new 150,350 ft² campus of the El Paso Community College is located about 20 miles from the resource (see Fig. 4).

Table 14 gives load factor and fossil fuel energy consumption data on a million Btu per thousand ft² basis for Ft. Bliss, an office complex, a single-family residence, an apartment complex, a school, and two industries. Space and hot water heating are considered separately and in conjunction with space cooling. For each user type, a case in which geothermal development is sized to meet peak monthly demand and a case where development is sized to meet one half of the peak demand are considered. Figs. 8-13 show monthly energy consumption graphically and Appendix C provides these monthly data in tabulated form.

For a system providing space and hot water heating only and sized to meet peak demand, annual load factors range from 32 to 76% and the geothermal energy replaces from 18.8 to 90.3 million Btu's of fossil fuel per thousand square feet of space. The load factor range reflects primarily different patterns of use while the fossil

Table 14: Load Factor and Fossil Fuel Substitution Information for Space Heating and Cooling Applications^d

	Space and Hot Water Heating		Space and Hot Water Heating and Space Cooling	
	Load Factor (%)	Fossil Fuel Offset ^a	Load Factor (%)	Fossil Fuel Offset ^a
Ft. Bliss				
Sized for Peak	48	90.3		not applicable ^c
Sized for Half Peak	72	67.5		not applicable ^c
Office Complex				
Sized for Peak	33	48.7	71	105.6
Sized for Half Peak	48	36.1	99	73.6
School ^b				
Sized for Peak	33	29.6	55	69.8
Sized for Half Peak	47	20.6	81	51.1
Apartment Complex				
Sized for Peak	40	26.3	57	70.3
Sized for Half Peak	57	19.0	85	52.2
Single-Family Residence				
Sized for Peak	41	47.6	74	99.4
Sized for Half Peak	59	34.2	99	67.1
Industry				
Sized for Peak	32-76	18.8-58.6		not available ^c
Sized for Half Peak	43-99	12.7-37.9		not available ^c

^a 10⁶ Btu's per 1000 ft² per year; electric consumption for cooling was converted to Btu's(th) using a heat rate of 10,500 Btu's/kwh.

^b Operated all year.

^c Ft. Bliss and industries surveyed use only evaporative coolers for space cooling.

^d Detailed data obtained from users in each category are given in Appendix C.

fuel displacement range reflects primarily differences in building insulation. If the same system were sized to meet half of the peak monthly demand, annual load factors increase to 43 to 99%, but fossil fuel displacement by the geothermal energy decreases to 13 to 67.5 million Btu's per thousand square feet. Increasing the load factor by 1.5 times decreases the amount of fossil fuel displaced by 1.3 times. Industrial use is somewhat anomalous due to highly variable demand for hot water.

The comparison is somewhat different for a system providing both heating and cooling. A system sized for peak demand has a load factor of 55 to 74% and displaces 69.8 to 105.6 million Btu's per thousand square feet. Sized to meet half of monthly peak demand, the load factor increases to 81 to 99% and fossil fuel displacement decreases to 51.1 to 73.6 million Btu's per thousand square feet. A load factor increase of 1.4 times reduces fossil fuel displacement by 1.4 times.

Overall, a system providing both heating and cooling would double the load factor in comparison to a system providing only heating and more than double the amount of fossil fuel replaced by geothermal energy. Clearly, a combination of heating and cooling would provide the most favorable overall economics and the greatest savings in fossil fuel. Among users, some industries may offer the advantage of relatively high consumption of hot water and, thus, a relatively high load factor for the heating mode only.

Fig. 8. Energy Consumption for a School in El Paso: Space and Hot Water Heating and Space Cooling. Numerical details are given in Appendix C, Table C-6.

Fig. 9. Energy Consumption for Space Heating and Hot Water Heating, Ft. Bliss, Texas. Total area of Base heated is 17,030,000 ft². Numerical details are given in Appendix C, Table C-2.

Fig. 10. Energy Consumption for Space Heating and Hot Water Heating: Two Industries in El Paso. I is a manufacturing firm which uses gas only for space heating and hot water heating and II is a warehouse. Numerical details are given in Appendix C, Table C-10.

Fig. 11. Energy Consumption for Space Heating: Apartment Complex, El Paso, Texas. Numerical Details are given in Appendix C, Tables C-5 and C-8.

Fig. 12. Energy Consumption: Single-Family Residence, El Paso, Texas. See Appendix C, Table C-7 for Numerical Details.

Fig. 13. Energy Consumption for Space Heating and Space Cooling: One Office Building in El Paso, Texas. Numerical Details are given in Appendix C, Table C-4.

Quantitative Information on Geothermal Energy Requirements

This section gives quantitative information on the geothermal energy flow rates required by the applications selected as suitable to the Hueco Tanks resource. For each application, beginning with space heating and cooling annual geothermal flow rates are given in Btu's per year and gallon's per year; peak rates are given in Btu's per hour and gallons per minute (gpm). The quantity of fossil fuel replaced by the geothermal energy is given for each application in Btu's per year, thousand cubic feet of gas (mcf) per year, and barrels of oil equivalent per year.

Space Heating and Cooling

Data for space heating, space cooling, and heating and cooling are given in Table 15 on the basis of 1000 ft² of space. These data are applicable primarily to single-family residential demand patterns. As discussed previously (Table 14), demand patterns vary greatly. Apartment complexes, schools, and office complexes have a lower heating demand than single-family residences but a similar cooling demand.

On Table 15, geothermal flow rates for space heating are expressed as heat delivered to the residence. A 50°F ΔT or a usable energy content of 50 Btu per pound of water^a is assumed in order to evaluate the required flow rate in gallons. The cooling cycle is assumed to have a coefficient of performance of 0.7 and a usable temperature drop of 140°F (140 Btu/lb water). All supporting data

$$\Delta H = c\Delta T; c = 1 \text{ Btu/lb}^\circ\text{F}.$$

**Table 15: Space Heating and Cooling in the Residential Sector of El Paso:
Geothermal Energy and Water Requirement
(Per 1000 ft² of Space)**

	Space Heating and Hot Water	Space Cooling	Heating and Cooling
Geothermal Flow Rates^a			
Energy			
Total: Btu's/yr	37.5 X 10 ⁶	185 X 10 ⁶	222.5 X 10 ⁶
Peak: Btu's/hr	28 X 10 ³	14 X 10 ³	28.0 X 10 ³
Water			
Total: Gal/yr	90,000	158,400	248,400
Sized for Peak: gpm	1.1	0.3	1.1
Sized for Half Peak: gpm	0.6	0.15	0.6
Fossil Fuel Offset			
Sized for Peak: Btu fuel/yr	50 X 10 ⁶	57.2 X 10 ⁶	107.2 X 10 ⁶
kwh/yr	---	5,450	---
Sized for Half Peak: Btu's fuel/yr	35 X 10 ⁶	37.4 X 10 ⁶	72.4 X 10 ⁶
Annual Load Factor^b			
Sized for Peak (%)	41	42	74
Sized for Half Peak (%)	59	55	99

^a The calculations which form the basis of these numbers are derived in Appendix D.

^b Calculated based on the monthly, not hourly peak.

and calculations are given in Appendix D. In the heating mode, a flow rate of 90,000 gallons per year for 1000 ft² of space is required to supply all heating and hot water demand (Table 15). The peak flow rate in the heating mode is 1.1 gallons per minute. Sized to meet peak demand, a geothermal heating system would substitute for 50 million Btu's of fuel and operate with a load factor of about 41%. Sized to meet half of the peak, the system would substitute for 35 million Btu's of fuel per year and operate with an annual average load factor of about 59%.

For cooling 1000 ft², a flow rate of 158,400 gallons per year is required for the cooling season (Table 15) with a peak of 0.3 gallons per minute. The system would operate with an annual average load factor of 42% if sized to meet peak cooling demand and 55% if sized to meet half of the peak. This amount of geothermal energy would replace 5,450 kwh of electricity (assuming electric refrigerated air conditioning was the system being replaced).

For heating and cooling on a per 1000 ft² basis (Table 15), a total of 248,400 gallons per year would be delivered with the peak of 1.1 gallons per minute occurring in the heating season. Sized to meet peak demand, the system would offset 107 million Btu's of fuel (18.5 barrels of oil equivalent) and operate with an annual average load factor of 74%. If the system were sized to meet half of the peak, fuel replacement would be reduced by 32% but the load factor would be nearly 100%.

There are 72,736 single-family residences in El Paso, 30,331 units of a multi-family type including 5,700 units in public housing complexes and, of course, many schools, office complexes, and industries. In short, demand exists for almost any quantity of

geothermal energy for space heating and cooling applications. Table 16 gives geothermal flow rates required by typical size users. For example, Ft. Bliss heats about 17 million square feet of space. A flow rate of 2,700 million gallons per year with a peak of 11,170 gallons per minute would supply heating demand at the Base, substituting for 1.5 billion cubic feet of gas and operating with an annual average load factor of 48% (Table 16). Similar data for heating and cooling a 100,000 ft² apartment complex (100 units) are: a geothermal flow rate of 17 million gallons per year with a peak of 63.2 gallons per minute, substituting for 7,030 million Btu's of fuel, and operating with an average annual load factor of 57% (Table 16). On a load factor basis, district heating and cooling of single-family residences appears favorable. The geothermal flow rate required to heat and cool 50 homes (1800 ft² each) is 22.3 million gallons per year with a peak of 99 gallons per minute; 9,650 million Btu's of fuel would be replaced by the geothermal energy (Table 16).

Industrial Applications

Table 17 summarizes the geothermal energy requirements of each industrial application considered. For each industrial application, the quantity of geothermal energy consumed per unit of product output and the approximate total output in El Paso are given.

Tables 18 through 22 give further details about each industry's energy consumption. For a typical size facility, geothermal energy demand and fuel offset potential are evaluated. For typical size facilities, geothermal flow rate requirements range from 21.9

Table 16: Geothermal Energy Demand for Heating and Cooling Typical Size Facilities in El Paso^a

	Geothermal (million Gal/yr)	(GPM)	Fuel Offset (million Btu's/yr)	Load Factor (%)
Heating				
Ft. Bliss (17 X 10 ⁶ ft ²) School	2700	11,170	1.5 X 10 ⁶	48
(150,000 ft ²) Industry	7.9	45.5	4,440	33
(10,000 ft ²) Office Complex	1.1	2.9	586	76
(50,000 ft ²) Apartment Complex	4.3	25.8	2,400	33
(100,000 ft ²) Single-Family Residences	4.7	22.9	2,630	40
(50 homes, 1800 ft ² each)	8.1	99	4,500	41
Heating & Cooling				
School (150,000 ft ²)	24.8	96.1	10,470	55
Office Complex (50,000 ft ²)	12.2	38.7	5,280	71
Apartment Complex (100,000 ft ²)	17.0	63.2	7,030	57
Single-Family Residences (50 homes, 1800 ft ² each)	22.3	99.0	9,650	74

^a Sized to meet peak demand; data derived using demand values given in Table 14, a usable geothermal enthalpy of 50 Btu/lb of water in the heating mode, a usable enthalpy of 140 Btu/lb in the cooling mode with a coefficient of performance of 0.7.

Table 17: A Summary of Geothermal Energy Requirements by Industry

Industry	Energy Application	Product Unit	Energy Consumption ^a (Btu's/unit)	Product Output in El Paso County ^b (No. of units/yr)
Meat Packing	Refrigeration	pound	340	300 X 10 ⁶
Soft Drink Bottling	Bottle washing and sterilization	ounce	14.2	600 X 10 ⁶
Dairy	Pasteurization	gallon	600	16.2 X 10 ⁶
Apparel	Pressing	pair	3,000	60 X 10 ⁶
Canning	Cooking	case	27,000	6 X 10 ⁶

^a Expressed as Btu's of geothermal heat, not as Btu's of fuel.

^b Approximate.

gallons per minute (a dairy producing 15,000 gallons of milk per day, Table 20) to 2,038 gallons per minute (a canning plant producing 2 million cases per year, Table 22).

Table 18: Meat Packing

Information Base

1. Refrigeration temperature requirements range from -10°F to $+35^{\circ}\text{F}$; electricity is the current energy source for refrigeration.
2. Based on a survey of meat packing companies, 0.05 to 0.1 kwh of electricity per pound of meat output are consumed; at a heat rate of 10,500 Btu's/kwh, this is equivalent to 525 to 1,050 Btu's of fossil fuel per pound of meat. One study of refrigeration throughout the U.S. gives 1143 Btu's fuel per pound of meat.^a
3. Total output in El Paso is about 300×10^6 pounds per year; in September, the peak month, output is about 25% higher than average.
4. 340 Btu's of geothermal energy per pound are required for freezing and chilling^a; this represents a coefficient of performance of 0.55. The heat extracted from the meat is 189 Btu's/lb (45 Btu's/lb to chill it from 72 to -5°F plus 144 Btu/lb latent heat of fusion); $189/340 = 0.55$.

Hypothetical Meat Packing Plant: Energy For Freezing and Chilling
(100×10^6 lbs/year)

Geothermal Energy Demand	
Btu's/yr ^b	34×10^9
Btu's/hr ^c	17×10^6
Gal/yr ^d	45×10^6
Gal/min ^d	375
Electric Offset: kwh/yr ^e	10×10^6
Fuel Offset	
Natural Gas: mcf/yr ^f	0.1×10^6
Oil Equiv.: barrels/yr ^g	17,200

- ^a Geothermal Absorption Refrigeration for Food Processing; Aerojet Energy Conversion Co.; Sacramento, CA, 1977, p. 129-131.
- ^b $340 \text{ Btu's/lb} \times 100 \times 10^6 \text{ lbs/yr}$.
- ^c Plant operates 2000 hrs/yr.
- ^d Assumes a usable enthalpy of 90 Btu's/lb or 754.7 Btu's/gal.
- ^e $0.1 \text{ kwh/lb} \times 100 \times 10^6 \text{ lbs/yr}$.
- ^f 10,500 Btu/kwh and 10^6 Btu/mcf .
- ^g $5.8 \times 10^6 \text{ Btu/barrel}$.

Table 19: Soft Drink Bottling

Information Base

1. Heat is used at temperatures of 160°F (71.1°C) for washing and 180°F (82.2°C) for water heating; natural gas is the current heat source.
2. Based on a survey of bottling companies, 19 Btu's of natural gas per ounce of soft drink bottled are consumed. At 75% efficiency, this converts to 14.25 Btu's of heat per ounce.
3. Total output in El Paso is about 600×10^6 ounces per year with a summer peak about 20% higher than average production.
4. Natural gas is also used for space heating at bottling plants such that consumption of natural gas overall is higher in winter than in summer even though product output is higher in summer.

Hypothetical Soft Drink Bottling Company: Energy For Bottle Washing and Water Heating (100×10^6 oz/year)		
Geothermal Energy Demand		
Btu's/yr ^a		1.4×10^9
Btu's/hr ^b		7.0×10^5
Gal/yr ^c		3.4×10^6
Gal/min ^c		28
Fuel Offset		
Natural Gas: mcf/yr ^d		1900
Oil Equivalent: barrels/yr ^e		327

- ^a $14.25 \text{ Btu's/oz} \times 100 \times 10^6 \text{ oz/yr}$.
- ^b Plant operates 2000 hrs/yr; $1.4 \times 10^9 / 2000$.
- ^c Assumes a usable enthalpy of 50 Btu's/lb of geothermal water or 417 Btu's/gal.
- ^d $19 \text{ Btu's/oz} \times 100 \times 10^6 \text{ oz/yr}$ and 10^6 Btu's/mcf .
- ^e At $5.8 \times 10^6 \text{ Btu's/barrel}$.

Table 20: Dairy

Information Base

1. Milk must be heated to 165°F for pasteurization; the water temperature for pasteurization is generally 172°F and hot milk is generally used to preheat cool milk; natural gas is the current energy source.
2. Based on a survey of dairies, about 700 Btu's of natural gas per gallon or about 525 Btu's of heat per gallon are required. A theoretical calculation of the energy required to raise the temperature of milk from 70°F to 165°F yields 792.8 Btu's/gal if the system operates at 100% efficiency. The higher theoretical than actual is apparently due to the use of hot milk for preheating of the cool milk. The analysis tabulated below is based on a requirement of 600 Btu's of heat per gallon.
3. Total output in El Paso is about 65,000 gallons of milk per day.

Hypothetical Dairy: Energy for Pasteurization (15,000 gallons per day)		
Geothermal Energy Demand		
Btu's/yr ^a		2.25×10^9
Btu's/hr ^b		1.1×10^6
Gal/yr ^c		2.7×10^6
Gal/min ^c		21.9
Fuel Offset		
Natural Gas: mcf/yr ^d		3.0×10^3
Oil Equivalent: barrels/yr ^e		517.2

^a 600 Btu's/gal X 15,000 gal/day X 250 working days/yr.

^b 2.25×10^9 Btu's/yr $\div$ 2,000 working days/yr.

^c For an inlet temperature of 200°F and a usable enthalpy of 100 Btu/lb water (834.5 Btu's/gal).

^d 600 Btu's heat/gal is equivalent to 800 Btu's fuel/gal at 15,000 gal/day and 250 working days/yr and 10^6 Btu's/mcf.

^e 5.8×10^6 Btu's/barrel.

Table 21: Apparel

Information Base

1. Heat is used at temperatures of 215 to 400°F (101 to 204°C) for pressing at 80 to 100 lbs. of pressure; natural gas is the current energy source.
2. Based on a survey of apparel manufacturing companies, about 4,000 Btu's of natural gas per unit of clothes pressed (usually one pair) are consumed. At 75% efficiency, this is 3,000 Btu's of heat per unit.
3. Total output in El Paso where pressing is involved is about 60×10^6 units per year; peaks are demand responsive and highly variable.

Hypothetical Apparel Plant: Energy for Pressing (10×10^6 units per year)	
Geothermal Energy Demand	
Btu's/yr ^a	30.0×10^9
Btu's/hr ^b	15×10^6
Gal/yr ^c	35.9×10^6
Gal/min ^c	299
Fuel Offset	
Natural Gas: mcf/yr ^d	40,000
Oil Equivalent: barrels/yr ^e	6,896

a $3,000 \text{ Btu's/unit} \times 10 \times 10^6 \text{ units/yr.}$

b Plant operates 2000 hrs/yr.

c For a usable enthalpy of 100 Btu/lb water or 835 Btu/gal.

d $3,000 \text{ Btu's/unit} \times 10 \times 10^6 \text{ units/yr}$ and 10^6 Btu's/mcf.

e $5.8 \times 10^6 \text{ Btu's/barrel.}$

Table 22: Canning

Information Base

1. Temperature requirements are: 220 - 245°F (104 - 118°C) for sterilization, 150 - 204°F (65 - 96°C) for washing and blanching, and 135 - 190°F (57 - 88°C) for processing hot water; natural gas is the current energy source.
2. Based on a survey of canning industries, natural gas consumption ranges from 22,000 to 68,000 Btu's of gas per case of canned output depending on which products are being canned. The average is 36,000 Btu's per case. Energy consumption varies seasonally with the peak month being 2.5 times average consumption.
3. Total output in El Paso is about 6 million cases per year.
4. Data for the hypothetical plant shown below is based on average annual energy consumption of 36,000 Btu's gas per case or about 27,000 Btu's heat per case; the peak geothermal flow rate shown is based on 68,000 Btu's of gas per case or about 51,000 Btu's of heat per case.

Hypothetical Canning Company (2 million cases per year)		
Geothermal Energy Demand		
Btu's/yr ^a		54 X 10 ⁹
Btu's/hr ^b		51 X 10 ⁶
Gal/yr ^c		64.7 X 10 ⁶
Gal/min ^d		1,018
Fuel Offset		
Natural Gas: mcf/yr ^e		72,000
Oil Equivalent: barrels/yr ^f		12,400

^a 27,000 Btu's heat per case X 2 X 10⁶ cases per year.

^b 2 X 10⁶ cases/yr ÷ 2,000 working hours per year = 1,000 cases/hr at the peak energy consumption of 51,000 Btu's heat per case yields 51 X 10⁶ Btu's/hr.

^c Assumes a usable enthalpy of 100 Btu's/lb water or 835 Btu's/gal; 54 X 10⁹ Btu's/yr ÷ 835 Btu's/gal = 64.7 X 10⁶ gal/yr.

^d 51 X 10⁶ Btu's/hr ÷ 60 min/hr ÷ 835 Btu's/gal = 1,018 gal/min.

^e 36,000 Btu's gas per case X 2 X 10⁶ cases/yr ÷ 10⁶ Btu's/mcf.

^f 5.8 X 10⁶ Btu's/barrel.

Chapter 4

UTILIZATION OF THE PRESIDIO-BOLSON RESOURCE

This chapter first describes climatic, demographic, and industrial characteristics of the Presidio-Bolson area, then identifies suitable users of the resource, and, finally, presents quantitative information on the amount of geothermal energy required by each user type.

Characteristics of the Presidio-Bolson Resource Area

The Presidio-Bolson geothermal resource extends for 70 to 75 miles along the Rio Grande River in Presidio County, Texas; see Fig. 14. Four Counties (Presidio, Hudspeth, Jeff Davis and Culberson) are in or near the resource. On the U.S. side of the River, two small towns (Candelaria and Ruidosa) and four settlements occur within the resource area. On the Mexico side of the River, 15 settlements occur within the resource area. Two larger towns in the U.S. are located just outside of the resource area, Presidio in Presidio County and Valentine in Jeff Davis County. Other towns which occur at greater distances from the resource area are: Marfa and Shafter in Presidio County; Ft. Davis in Jeff Davis County; Lobo, Kent and Van Horn in Culberson County; and Sierra Blanca and Allamore in Hudspeth County. A map indicating the locations of towns and settlements is given as Fig. 14 and Tables 23 and 24 summarize some relevant information about the four Counties. The towns in or closest to the resource are discussed in greater detail.

Fig. 14. Location of Towns and Settlements Relative to the Presidio-Bolson Resource Area.

Legend:

- Resource Area
- Hottest Resource Area
- Settlements in Mexico

Table 23: Relevant Statistics - Four Counties in the Trans-Pecos

	Population	Dwellings	Business Establishments ^a	Schools	Electric Utility ^b	Temperature (°F)	
						Min.	Max.
Presidio County	4,900		134	7		33	100
Marfa ^c	2,500	930	92	2	WTUC		
Shafter	31	3	1	0	WTUC		
Presidio	1,160	400	36	2	WTUC		
Candelaria	55	12	0	1	RGEC		
Ruidosa	43	12	2	1	RGEC		
Jeff-Davis County	1,400		26	4		31	82
Ft. Davis ^c	1,000	350	23	2	WTUC		
Valentine	314	60	9	2	WTUC		
Culberson County	3,429		102	4		30	95
Lobo	40	U	0	0	EPEC		
Kent	60	U	2	0	EPEC		
Van Horn ^c	2,889	1,000	100	3	EPEC		
Hudspeth County	2,600		48	7		27	93
Sierra Blanca ^c	800	200	12	2	EPEC		
Allamore	15	3	0	1	EPEC		

U - Unknown

^a An establishment is defined as a "single physical location where business is conducted or where services or industrial operations are performed." From County Business Patterns, 1976, Texas; U.S. Department of Commerce, Bureau of the Census.

^b WTUC = West Texas Utility Co.; EPEC = El Paso Electric Co.; RGEC = Rio Grande Electric Co-op.

^c County Seat.

Table 24: Business Establishments:^a Four Counties in the Trans-Pecos
In the Vicinity of the Presidio-Bolson Geothermal Resource

Type of Establishment	Presidio	Jeff Davis	Hudspeth	Culberson
Agricultural Services, forestry fisheries	2		1	
Mining	1	4	3	3
Contract Construction	7	5	4	3
Manufacturing	2			3
Transportation & other Public Utilities	11	1	3	5
Wholesale Trade	8		5	8
Retail Trade	60	11	22	49
Finance, Insurance & Real Estate	11	2	5	3
Services	30	3	5	26
Non-Classifiable Establishments	<u>2</u>	—	—	<u>2</u>
Total	134	26	48	102

^a An establishment is defined as a "single physical location where business is conducted or where services or industrial operations are performed." From County Business Patterns, 1976, Texas; U.S. Department of Commerce, Bureau of the Census.

Presidio (with a population of 1,160 in 1977) is primarily a retail trade center (Tables 23 and 24), furnishing U.S. manufactured goods to the citizens of Ojinaga, Mexico and to citizens of southern Presidio County. In addition, tourist activity is important to Presidio's economy. Tourists visiting Big Bend National Park sometimes also visit Presidio and Ojinaga. From Table 23, there are approximately 400 dwellings averaging 350-700 square feet. All use evaporative cooling and heat with butane or electricity. Presidio has a public water supply system (operated by the Presidio Water Supply Corporation). Groundwater is obtained from one 82-foot deep well. Total annual water use was 47.5 million gallons in 1974, 52.7 million gallons in 1975, 58.1 million gallons in 1976^a and 54.3 million in 1978, or about 140 gallons per capita per day. Water demand peaks in May, June and July at about 165 gallons per capita per day. Presidio does not have a sanitary sewer system or a hospital. It does have a school of approximately 450 students (kindergarten through 12th grade),^b two seasonal packing companies (cantalopes and onions), a seasonal stockyard, and a seasonal cotton seed processing operation.

In Presidio County, a total of about 150 people live in small towns and settlements along the River on the U.S. side. As indicated in Table 23, Ruidosa has a population of about 43 with about a dozen adobe houses (200-400 square feet on the average). Ruidosa has one school (first through eighth grade) with a daily attendance of 13,

^a Water use data are from: Economic Resource, Community Needs, and Historic Preservation Study: Presidio County, Texas, 1977, by Dan Glass, Consulting Engineer. Monthly data are given in Appendix E.

^b The school uses evaporative cooling and heats with butane and electricity.

and a Baptist church. There is no space cooling and heating is with butane. Water for domestic use is hauled from the Kingston Hot Springs seven miles away. The Hot Springs is a resort with eight cabins and bath-houses supplied with 113°F water from one spring.

Nearby Candelaria has a population of 55 and approximately 12 adobe houses (Table 23) with no cooling and butane heating. The one school (kindergarten to 6th grade) has 41 students.

Historically, crop and livestock production sustained these towns and settlements. However, both have declined since 1965 and are continuing to decline. This negative socio-economic spiral is thought to be correlated with the deterioration in the water quantity and quality of the Rio Grande. Because of surface water resource development upstream of Presidio County, the Rio Grande River in this area carries water only after heavy rains.^a The Rio Conchos River from Mexico discharges into the Rio Grande downstream of this area at Presidio. Use of groundwater has been from shallow aquifers. Because these shallow alluvial aquifers are recharged primarily from Rio Grande River seepage, they have deteriorated as the River flow declined. Wells in the immediate vicinity of the channel yield water with a total dissolved solids content of 3,000 to 8,000 milligrams per liter. Farther from the River on the floodplain, groundwater ranges from 1,500 to 3,000 milligrams per liter total dissolved solids. In 1928, about half of the floodplain from Presidio upriver

^a Economic Resource, Community Needs, and Historical Preservation Study: Presidio County, Texas, 1977, by Dan Glass, Consulting Engineer.

to Candelaria was under irrigation. The irrigated area peaked in 1930 when 10,000 acres were under cultivation on the U.S. side and 8,200 acres on the Mexico side. In 1950, irrigated acreage was 4,400 on the U.S. side and 3,900 on the Mexico side declining to 1,950 and 2,450 respectively by 1976.^a

Valentine, in Jeff Davis County, is primarily a railroad town with a population of 314 (Table 23). The 60 houses (an average of 800-900 square feet) have no space cooling and are heated primarily with butane. The two schools (elementary and high) have 99 students and total approximately 23,700 square feet.^b Agricultural production is expanding in Valentine. One project, operated by the Two Bar M Ranch Company of Wyoming, has approximately 4 or 5 square miles (2,560-3,200 acres) of barley, wheat and alfalfa under irrigation with groundwater. Olson Brothers from Atkinson, Nebraska, is planning to drill 52 wells (3 are now complete) for irrigating a total of 40,000 acres of corn.^c Both the corn and alfalfa are dried in the field prior to being shipped out. The West Texas Council of Governments is applying to the U.S. Housing and Urban Development Administration (HUD) for a grant to expand housing in Valentine.

In summary, the Presidio-Bolson resource area is characterized by dispersed, small towns with little industry (Tables 23 and 24). Butane is the current major source of energy for space and hot water heating on the U.S. side; wood supplies most of the same on the Mexican side. Cooling on the U.S. side, where present, is

^a Economic Resource, Community Needs, and Historic Preservation Study: Presidio County, Texas, 1977, by Dan Glass, Consulting Engineer.

^b They are heated with diesel fuel.

^c 5,760 acres will be planted this spring.

by evaporative coolers and most domestic water sources are groundwater. The West Texas Utility Company is the major supplier of electricity in the area (Table 23).

Suitable Applications of the Presidio-Bolson Resource

As indicated in Chapter 2, temperatures as high as 400°C may occur in the Presidio-Bolson resource area. Since this is more than adequate for electric power generation, utilization of this resource for power generation as well as direct uses for heating and cooling are considered.

The following discussion examines the potential of using the area's geothermal resources to generate electric power, to provide space and hot water heating by themselves and in conjunction with space cooling. Utilization of the resource as a water supply is also assessed because the economic problems of some towns (e.g. Candelaria and Ruidosa) are closely tied to inadequate and steadily declining water availability.

Assessment Indicators

Five indicators are employed to assess the suitability of various applications: location, load factor, market, fossil fuel offset potential, and environmental effects of resource use. Resource data are insufficient to evaluate and compare applications quantitatively. The results of a qualitative assessment are given in Table 25 and the following discussion provides documentation for each variable. The assessment is relative within the resource area, that is, use of the geothermal resource in the Presidio-Bolson resource area is not assessed relative to use of the geothermal

Table 25: Applications in the Presidio-Bolson Resource Area: Assessment Indicators

Application	Assessment Criteria				
	Location	Load Factor	Market	Fossil Fuel Offset	Environmental Impact
Space & Hot Water Heating Valentine Candelaria/Ruidosa and Other Settlements Presidio	Poor	Poor	Good	Good	Excellent
	Excellent	Poor	Poor	Good	Excellent
	Good	Poor	Excellent	Good	Excellent
Space Heating & Cooling Valentine Candelaria/Ruidosa and Other Settlements Presidio	Poor	Good	Good	Poor	Excellent
	Excellent	Good	Poor	Poor	Excellent
	Good	Good	Excellent	Poor	Excellent
Space Heating & Cooling with Water Supply Valentine Candelaria/Ruidosa and Other Settlements Presidio	Poor	Good	Good	Poor	Poor
	Excellent	Good	Excellent	Poor	Poor
	Good	Good	Good	Poor	Poor
Electric Power Generation Within a 60-mile radius of the hottest resource area	Excellent	Excellent	Excellent	Excellent	Good

resource in the Hueco Tanks area or relative to any other geothermal resource. Rather, use among towns and among types of applications are compared to each other.

1. Location

The location assessment indicator is intended to be one economic indicator; that is, it is intended to express the relative economics of distance. Table 26 gives the distance upriver from Presidio of settlements along the Rio Grande River on the U.S. and Mexican side. The Presidio-Bolson geothermal resource begins about 3 miles upriver from Presidio and extends for about 72 miles to a point about 75 miles upriver. The hottest area, however, begins about 60 miles upriver and extends for about 15 miles. As indicated in Table 26, nearly all of the settlements are within the resource area and Presidio is only three miles away. The town of Valentine, in Jeff Davis County, is about 20 miles from the hottest portion of the resource area. On the locational variables and for direct uses, all settlements along the River are assessed as excellent, Presidio as good, and Valentine as poor. Location is not an economic constraint for electric power applications since electricity is easily and cheaply transmitted.

2. Load Factor

The load factor assessment indicator is intended to represent another component of the economics of resource development. The heating season in Valentine extends from the end of November through the beginning of April (four to five months). In Presidio and along the River, it is shorter and highly variable even in January. That is, nights are frequently cold but daytime temperatures are high

Table 26: Settlements Along the Rio Grande River
in the Presidio-Bolson Resource Area^a

U.S. ^b	Mexico ^b	Miles to Presidio-Ojinaga
Jeff-Davis/Presidio County Line		85
Bennett Ranch	Lomas De Arena	77
	E Emilio Carranza	77
	Ejido Nuevo Porvenir	71
Pilares	Ejido Pilares	66
	Los Fresnos	60
	Los Palomas	47
Candelaria	San Antonio	46
	La Oficina	44
	La Macolla	38
Ruidosa	Barrancos de Guadalupe	36
	Chiuarrías Blancas	33
	Los Conchas	30
	Vado De Piedra	25
Chinati		23
	Buenos Aires	19
Adobes		18
Indio		15
Presidio	Paradero Ojinaga	6 0

^a The resource area begins three miles upriver from Presidio and extends 75 miles upriver from Presidio. The hottest area begins 60 miles upriver from Presidio and extends for about 15 miles to 75 miles upriver of Presidio.

^b Source: Rio Grande Boundary Preservation, Draft EIS by the International Boundary and Water Commission, September, 1978.

even in winter. In January, the average temperature in Presidio and Candelaria is 50°F, but the daily range is 17°F to 84°F (see Table E-2). Summer temperatures also exhibit a large daily range. The average temperature is 84°F in June at Candelaria with a daily range of 49 to 108°F (see Table E-2). The area is currently supply limited in terms of water and could use nearly any quantity for crop irrigation.

If resource development were sized to meet space heating needs, the production system would be used at capacity less than 30% of the time and probably less than 20% of the time.^a Use of the system for space heating and cooling would approximately double the load factor. Since crops can be grown in the area eight months out of the year (March through October), water demand for irrigation is relatively constant showing a decrease only during the four-month heating season. Thus, load factor considerations lead to a poor assessment for space and hot water heating and good for space heating and cooling by themselves or in conjunction with water supply. Since a geothermal electric power plant is well suited to provide base load capacity, power generation is assessed as excellent on this indicator.

3. Market

The market assessment category is intended to be an indicator of current and future demand for heating and cooling energy and/or water and for electric power. In the case of heat energy for space and hot water heating and space cooling, Presidio has the greatest demand because it has the largest population, Valentine is next,

^a Assuming a four-month heating season ($4/12 = 0.33$) and heating during half of the hours ($0.33/2 = 0.17$).

and the settlements along the River show the least current demand (assessed as excellent, good, and poor, respectively). Based on the decline in agricultural activity along the River, a decline correlated with water availability declines, the current market for water for crop irrigation along the River is assessed as excellent. Since the market for electricity is that which occurs in all towns within the 60-mile radius under consideration, it is assessed as excellent on this indicator.

4. Fossil Fuel Offset

Little data are available on energy consumption for space heating in this area and almost no space cooling (other than evaporative) is carried out. For perspective, the 23,700 square foot school in Valentine consumes about 2,000 gallons per month for four months or 32×10^6 Btu's per thousand square feet per year.^a Use of the resource for space cooling in addition to heating would approximately double the amount of fossil fuel displaced (assuming there is existing cooling and that geothermal cooling represents a substitution, not an addition). If geothermal resources are used for cooling or as a water supply where no cooling previously occurred or where there is not an existing water supply, the pumping energy required to extract the resource represents an increase in fossil fuel consumption. Since this is likely to be the case in the Presidio-Bolson resource area, utilization of geothermal energy for heating and cooling by themselves and in conjunction with a water supply system is assessed as poor in terms of fossil fuel offset

^a $2,000 \text{ gallons} \times 4 \text{ months} \times 95,500 \text{ Btu/gal} \div 23.7 \text{ thousand square feet.}$

potential. The heating option by itself is assessed as good. Demand for electric power per residential customer in this area is 3,000 to 7,300 kwh/yr representing 31.5 to 76.6 million Btu's of fossil fuel^a per residential customer per year. Thus, the electric power application is assessed as excellent.

5. Environmental Impact Factors

The environmental impact assessment of these potential applications is based primarily on the possibility of reinjection of the geothermal fluid. This assumes that environmental impacts are primarily associated with land subsidence and groundwater mining. ReInjection is, of course, not possible if the resource is used as a water supply. Consequently, that option at all locations is assessed as poor in terms of environmental impact potential. It should be noted, however, that not enough is known about the rock types from which geothermal waters would be withdrawn to predict the severity or lack thereof of land subsidence. ReInjection is possible for the space heating and cooling alternatives and these are assessed as excellent on the environmental parameter at all locations.^b For electric power generation reinjection is possible, but land disturbances would be greater than for direct use; thus, it is assessed as good.

^a At a heat rate of 10,500 Btu/kwh.

^b ReInjection may not be practical for uses at Valentine because of distance, but distance is assessed under the locational variable.

Summary

The results of the resource use assessment based on five indicators are summarized in Table 27. For direct uses, three locations and three applications or nine combinations were examined. As indicated in Table 27, space and hot water heating is the best direct application and Presidio is the best location for direct uses. But, overall, electric power applications appear quite favorable. In a rural area, the flexibility of electric power compared to hot water as an end use source of energy makes it highly attractive.

Quantitative Information on Geothermal Energy Requirements

Data on geothermal flow rates and the amount of fossil fuel those rates would replace are given for the direct use applications and for electric power applications.

Direct Use Applications

Geothermal energy demand on a per 1,000 ft² basis is given in Table 28 for heating and cooling separately and in combination. Monthly demand data were not available, thus no load factor information is included. However, the load factor would obviously be substantially greater if the resource were used for both heating and cooling rather than for one or the other. On Table 28, geothermal flow rates for heating are expressed as heat delivered to the residence. A 50°F ΔT or a usable energy content of 50 Btu per pound of water^a is assumed in order to evaluate the required flow rate in gallons. The cooling cycle is assumed to have a

^a $\Delta H = c \Delta T$; $c = 1 \text{ Btu/lb} \cdot ^\circ\text{F}$.

Table 27: Summary of Assessment: Direct Use Applications in the Presidio-Bolson Resource Area

Number Excellent-Good-Poor	Description of Application and Location
4-1-0	Electric Power: 60-mile radius
2-2-1	Space and Hot Water Heating: Presidio Space Heating and Cooling: Presidio
2-1-2	Space and Hot Water Heating: Settlements along River Space Heating and Cooling: Settlements along River Space Heating and Cooling with Water Supply: Settlements along River
1-2-2	Space and Hot Water Heating: Valentine Space Heating and Cooling: Valentine
0-3-2	Space Heating and Cooling with Water Supply: Settlements along River
0-2-3	Space Heating and Cooling with Water Supply: Valentine

Table 28: Geothermal Flow Rates for Direct Use Applications^a
(per 1,000 ft² of Space)

	Space Heating		Space Cooling	Heating & Cooling
	Valentine	Presidio	Presidio	Presidio
Geothermal Flow Rates				
Energy				
Total: Btu's/yr	27X10 ⁶	24.7X10 ⁶	226X10 ⁶	250.7X10 ⁶
Peak: Btu's/yr	28X10 ³	19.3X10 ³	15X10 ³	19.3X10 ³
Water				
Total: Gal/yr	86,000	79,000	193,200	272,200
Sized for Peak:				
gpm	1.1	0.8	0.3	0.8
Fossil Fuel Offset				
Sized for Peak:				
Btu fuel/yr	36X10 ⁶	33 X10 ⁶	69.5X10 ⁶ ^b	102.5X10 ⁶
Mcf gas ^c	36	33	69.5	102.5
Barrels oil	6.2	5.7	12.0	17.7
Electric (kwh)	NA	NA	6,620	NA

NA = not applicable

^a The calculations which form the basis of these numbers are derived in Appendix D.

^b At a heat rate of 10,500 Btu/kwh.

^c 10⁶ Btu's/mcf.

^d 5.8 X 10⁶ Btu's/barrel.

coefficient of performance of 0.7 and a usable temperature drop of 140°F (140 Btu/lb water). All supporting data and calculations are given in Appendix D.

Flow rates of 79,000 gallons per year (Presidio) to 86,000 gallons per year (Valentine) are required to heat 1,000 ft² of space (Table 28, including hot water heating). Peak flow rates designed for peak heating demand are 0.8 to 1.1 gallons per minute (Presidio and Valentine, respectively). A geothermal system sized to meet peak heating demand would substitute for 33 to 36 million Btu's of fuel annually.

For cooling 1,000 ft², a flow rate of about 193,200 gallons would be required for the entire cooling season (Table 28) with a peak of 0.3 gallons per minute. This amount of geothermal energy would replace 6,620 kwh of electricity (assuming electric refrigerated air conditioning was the system being replaced).

For heating and cooling on a per 1,000 ft² basis, (Table 28), a total of 272,200 gallons per year would be delivered with the peak of 0.8 gallons per minute occurring in the heating season. Sized to meet peak demand, the system would offset 102 million Btu's of fuel (17.7 barrels of oil equivalent).

In Presidio, district heating and cooling of all 400 residential dwellings would require a flow rate capacity of about 256 gallons per minute delivering 87.1 million gallons per year of geothermal water (Table 29). This would replace 32.8 billion Btu's of fuel or the equivalent of 5,655 barrels of oil. If the geothermal water was not reinjected but was utilized for irrigation, it would

**Table 29: Geothermal Flow Rates for District Heating and Cooling:
Valentine and Presidio**

	Valentine ^a (60 homes)	Presidio ^b (400 homes)
Geothermal Btu's/yr	10,176 X 10 ⁶	80,224 X 10 ⁶
Gal/yr	11.7 X 10 ⁶	87.1 X 10 ⁶
GPM	52.8	256
Fossil Fuel Offset Btu's fuel/yr	4.5 X 10 ⁹	32.8 X 10 ⁹
Natural gas mcf/yr	4,500	32,800
Oil Equivalent: barrel/yr	775.9	5,655

^a A total of 48,000 ft² assuming 800 ft²/home; cooling is based on data for El Paso from Chapter 3, Table 15.

^b A total of 320,000 ft² assuming 800 ft²/home.

be adequate for about 53.4 acres of alfalfa or 106.9 acres of vegetables.^a

In Valentine, district heating and cooling of the 60 residential dwellings would require a flow rate capacity of about 53 gallons per minute delivering 11.7 million gallons per year of geothermal water (Table 29). This would replace 4.5 billion Btu's of fuel or the equivalent of 776 barrels of oil.

Electric Power Applications

Table 30 presents geothermal flow rate information for electric power applications. El Paso Electric Company, West Texas Utilities Company, and Rio Grande Electric Co-op^b now serve the area. We estimate that about 100 million kwh per year of electricity^c are consumed by residential and commercial customers within a 60-mile radius (in the U.S.) of the hottest wells that occur in the Presidio-Bolson resource area. Assuming an inlet temperature of 300°C and an outlet temperature of 29.4°C, about 7.6 gallons of geothermal water are required to generate one kwh of electricity; the power plant operates with a geothermal energy to electric power efficiency of 11%. Thus, as indicated in Table 30, a geothermal power plant with a capacity of 15 Mwe and operating with an annual average load factor of 75% could supply the electricity demand within the 60-mile radius. A flow rate capacity of 1,900 gallons per minute would be required.

^a 87.1 million gallons per year is 267.2 acre-feet per year. Alfalfa requires about 5 acre-feet/acre and vegetables about 2.5 acre-feet/acre.

^b Rio Grande Electric Co-op purchases power from the other two utilities.

^c See Appendix E for details.

Table 30: Electric Power Applications: Presidio-Bolson
Information Base

1. Towns in the U.S. within a 60-mile radius of the hottest wells: Presidio County - Marfa, Presidio, Shafter, Plata, Candelaria, Ruidosa; Jeff Davis County - Ft. Davis, Valentine; Culberson County - Van Horn, Lobo, Kent; Hudspeth County - Sierra Blanca, Allamore.
2. Electric utilities serving these towns: West Texas Utilities Company, Rio Grande Electric Co-op, El Paso Electric Company.
3. Data from West Texas Utilities Company and El Paso Electric Company indicate that there are about 4,000 residential customers within the 60-mile radius and that each residential customer consumes from 3,000 to 7,300 kwh per year. For each residential customer, an additional 18,000 kwh per year are consumed by commercial, industrial, and public customers. See Appendix E for details.
4. Total consumption within the 60-mile radius, then, is about 94×10^6 kwh/year $[4,000 \text{ residential customers} \times (5,500 + 18,000 \text{ kwh})]$. A power plant producing 100×10^6 kwh/yr and operating at a 75% load factor has a capacity of 15,221 or 15.2 Mwe $[100 \times 10^6 / (8,760 \text{ hrs/yr} \times 0.75)]$.

Table 30 (continued)

Hypothetical Geothermal Electric Power Plant (75% load factor)		
	1 Mwe (100% load factor)	15 Mwe (75% load factor)
Electric Power Generated		
Total: kwh/yr ^a	8.76 X 10 ⁶	98.55 X 10 ⁶
Peak: kwh/hr ^a	1,000	15,000
Geothermal Energy Demand		
Btu's/yr ^b	271.8 X 10 ⁹	3,057.7 X 10 ⁹
Btu's/hr ^b	31.6 X 10 ⁶	474.0 X 10 ⁶
Gal/yr ^c	66.8 X 10 ⁶	751.9 X 10 ⁶
Gal/min ^c	127	1,907
Fuel Offset		
Natural gas: mcf/yr ^d	92 X 10 ³	1,034 X 10 ³
Oil equivalent: barrels/yr ^d	15.8 X 10 ³	178.3 X 10 ³

^a 1 Mw at 100% load factor generates 1,000 kwh/hr or 8.76 X 10⁶ kwh/yr (8,760 hrs/year). 15 Mw at 75% load factor generates 98.55 X 10⁶ kwh/yr (8.76 X 10⁶ X 15 X 0.75).

^b Power plant is 11% efficient and 3,413 Btu(e) = 1 kwh. Thus, 8.76 X 10⁶ kwh/yr = 29.9 X 10⁹ Btu's electric (8.76 X 10⁶ X 3,413) or 271.8 X 10⁹ Btu's geothermal (29.9 X 10⁹/0.11). Per hour this is 31.0 X 10⁶ Btu's geothermal (1,000 kwh/hr X 3,413 Btu(e) kwh ÷ 0.11). For a 15 Mwe power plant at 75% load factor the annual value is multiplied by 15 and 0.75 and the peak hourly value by 15.

^c For an inlet temperature of 572°F (300°C) and an outlet temperature of 85°F (29.4°C), enthalpy is 487 Btu's/lb water or 4,064 Btu's/gal. This is 7.63 gal/kwh (3,413 Btu(e) ÷ 0.11 ÷ 4,064). This calculated value agrees with that of 7.61 gal/kwh given in Energy Alternatives, Government Printing Office, p. 8-25.

^d 1,500 Btu's fuel/kwh; 10⁶ Btu's per mcf; 5.8 X 10⁶ Btu's/barrel.

Chapter 5

GEOHERMAL ENERGY TECHNOLOGIES

This chapter briefly describes the technologies which are developed or are being developed to extract geothermal energy, use it to generate electric power, or use it directly for heating and cooling. A final section describes potential environmental impacts of geothermal development in general.

Extraction

The extraction system for geothermal energy is similar to oil and gas in that a well is drilled to sufficient depth, cased, and completed to provide a stable conduit for fluids. Facilities required to control and transport the fluid to its point of utilization are added at the wellhead.

Production begins when the steam or water lines are connected to the wellhead. Natural pressure differentials force the steam and/or water to the surface. For direct use of a geothermal resource, it is often desirable to maintain the water in a liquid form. In that case, the water is pumped out (using downhole pumps) in order to maintain enough pressure to prevent the hot water from "flashing" to steam.

Electric Power Generation

Several electric power generation technologies designed to utilize hot water as the energy source for power generation are under development. The most promising appears to be the binary fluid system in which the geothermal fluid is used to heat a second fluid. The second fluid, termed the working fluid, drives the turbine in the power plant. Isobutane, which vaporizes at relatively

low temperatures, is being used as the working fluid in pilot plants.

A binary fluid power plant is illustrated in Fig. 15. Hot water is pumped from the geothermal reservoir and transported through a heat exchanger where its heat is transferred to the second fluid. The cool geothermal fluid is then reinjected into the reservoir through another well. The second fluid, which flows in a closed loop, vaporizes and expands as it goes through the turbine. The expansion force on the turbine blades turns the turbine shaft which is connected directly to the generator shaft. The second fluid is cooled in a condenser and pumped back to the heat exchanger.

Space Heating and Cooling

This section discusses possible technologies for heating and cooling with a geothermal source. First, space cooling and refrigeration are discussed, followed by space heating. Finally, a central system capable of supplying space heating and cooling for a district is discussed.

Cooling

The efficiency and capacity of equipment for cooling varies in response to three principle conditions; the temperature of the heat supply, the temperature at which spent heat is rejected, and the temperature at which heat is received by the equipment from the space being cooled.^a For decentralized cooling, there are two basic

^a Newton, Alwin B., "Solar Cooling" in Applications of Solar Energy for Heating and Cooling of Buildings, ed. by Richard C. Jordan and Benjamin V. H. Liv. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 1977. p. XIII-1.

Fig. 15. Binary Fluid Geothermal Power Plant

Source: Department of the Interior (1973), Final Environmental Statement for the Geothermal Leasing Program, Vol. 2, p. V-156. U.S. Government Printing Office.

types of systems which can be used effectively when input temperatures are 300°F or less: absorption cooling systems and Rankine systems.

The most common type of system used with a low temperature heat source is absorption cooling. Basically, this is a system involving temperature, pressure and phase (physical state) changes in a pair or more of chemical species. There are over a hundred possible chemical pairs that can be used in an absorption system, but only a few can be used with a source temperature of approximately 200°F.^a Three types of absorption cooling systems are considered applicable: ammonia-water, organic, and lithium bromide-water.

Fig. 16 is a simplified diagram of an absorption cooling process. It is discussed in terms of an ammonia-water system where ammonia is the refrigerant (or cooling agent) and water is the solute. Starting with the generator, the geothermal water is circulated through the solution of ammonia dissolved in water. The heat energy from the geothermal source, via a heat exchanger, drives the ammonia out of the water and creates ammonia vapor under high pressure conditions.

From the generator, the high pressure vapor goes to the condenser (Fig. 16), where it is condensed into a pure ammonia liquid. Cooling water is circulated through the condenser and by a heat exchanger removes the heat released by the latent heat of condensation. The ammonia is still under high pressure.

^a Christiansen, Chris C., "Self Start Manuel for Direct Use Applications of Geothermal Resources" U.S. Department of Energy, June 1978.

Fig. 16. Absorption Refrigeration Process

Source: Barry Breindel, Robert L. Harris and Gerald Olson, "Geothermal Absorption Refrigeration for Food Processing Industries," Direct Utilization of Geothermal Energy: A Symposium, 1978, p. 85.

As shown in Fig.16, from the condenser the liquid ammonia goes through an expansion valve where it is slowly allowed to spray out into the evaporator. The decrease in pressure causes the liquid to evaporate into a vapor and absorb heat. The evaporator, thus, is a cold coil of circulating low pressure vapor. For space cooling, a fan and air ducts may be used to disperse the cold air, while for refrigeration the coils going through the space are sufficient for cooling.

After the evaporator, the low pressure vapor goes to the absorber (Fig.16), where it is remixed into the water, making a strong solution. Heat is released upon absorption and cooling water circulating through the absorber (via a heat-exchanger) removes it. From the absorber, a pump is used to carry the strong solution to the generator where heat is used to de-mix the solution. This causes a weak solution which is then returned directly to the absorber.

As mentioned previously, there are different pairs of chemicals that can be used for this process, but they all operate in the same manner. In the organic absorption system monochlorodifluoromethane (R-22) is used as the refrigerant and dimethyl formamide (DMF) is the absorbant, and in the lithium bromide system water is the refrigerant and lithium bromide the absorbant.

For space cooling, only two absorption systems are viewed as being currently practical; the ammonia-water and lithium bromide water.^a The lithium bromide system is more common and preferred

^a Edward F. Wehlage, "Geothermal Heat - instead of electrically powered compression - proposed for cooling a small residence or office building" Geothermal Energy Magazine, Vol. 5 (6): 34. June 1977.

for space cooling. It is simpler, performs better, is less expensive to maintain and does not pose a hazard (as ammonia does) if there is an accident.^a The inlet temperature for a lithium bromide system must be at least 200°F and the rated capacity rises proportionally with higher inlet temperatures.^b Thus, efficiency decreases with the temperature of the geothermal waters.

For refrigeration or freezing below 32°F, however, the lithium bromide system cannot be used since water is the refrigerant. The two absorption systems capable of freezing are the ammonia and organic systems. One study compared these two systems for cooling to temperatures of +32°F to -40°F with a resource temperature of 212° to 300°F.^c The study showed that for an evaporator temperature of -40°F the organic system is more effective at higher inlet temperatures while at lower temperatures the ammonia system is more effective. The coefficient of performance (COP) is used as an efficiency measure; it is the useful refrigerating effect divided by the amount of external energy supplied. At an inlet temperature of 300°F, the COP for the ammonia system is 0.75 for evaporator temperatures of +32°F, and for the organic system it is 1.20. For a cooling temperature of -40°F, the COP is 0.2 and 0.24 for the ammonia and organic systems, respectively.^c In addition, the organic system requires a smaller geothermal flow rate for equivalent cooling than does the ammonia system. However, the organic system requires a larger heat exchange surface area, and thus is more expensive.

^a Christiansen, Chris C., "Self Start Manual for Direct Use Applications of Geothermal Resources," U.S. Dept. of Energy, June 1978, p. 44.

^b Ibid, Vol. II, p. 48.

^c Breindel, Barry, Robert L. Harris, Gerald K. Olson, "Geothermal Absorption Refrigeration for Food Processing Industries," Direct Utilization of Geothermal Energy: A Symposium. April 1978, pp. 85-90.

The second type of system which can be used for cooling is the Rankine System. The basic difference between an absorption type of system and the Rankine is that the latter functions as a mechanical engine, powered by the geothermal source.

Fig. 17 illustrates a Rankine System. The geothermal source in the boiler provides heat to evaporate an organic fluid (for example, fluorocarbons), producing a high pressure vapor.

At the expander (Fig. 17) the vapor goes from low to high pressure and the pressure changes of the vapor produce available shaft power. From Fig. 17, after the expander, the organic vapor is condensed in the condenser and pumped back to the boiler. Cooling water removes the heat from condensation.

The shaft power may be coupled with a conventional vapor compression unit to provide air conditioning or refrigeration. The Rankine System, thus, may be used to provide mechanical work energy, in place of the usual electric motor, to compress vapor in a freon type of refrigerator. One company has produced a 10 kw "Freon Rankine Cycle" power generating unit and reports that conversion of the shaft power into cooling energy can have a COP of 2.5.^a

Space Heating

Space heating with a geothermal source is described for a central, district heating system. This involves extraction of the heat at the source and distribution of secondary heated water to community buildings. While space heating with geothermal water may be through

^a Christiansen, Chris C., "Self Start Manuel for Direct Use Applications of Geothermal Resources" U.S. Department of Energy, June, 1978, p. 46.

Fig.17. Rankine System

Source: Chris C. Christiansen, Program Manager, "Direct Use Applications of Geothermal Resources at Desert Hot Springs, California" Vol. II, p. 51.

a decentralized system, it is not generally considered practical for several reasons. For example, corrosion and fouling of equipment from the geothermal fluid and maintenance would be confined to one area in centralized systems. Direct use of geothermal fluid in radiators have caused corrosion problems and been banned in some places because of possible hazards from H₂S and CO₂ emissions.^a In addition, one study found that in a decentralized system some equipment (small heat exchangers) had to be replaced within 8-11 years and therefore a centralized system would offer more reliability.^b

The two basic technological considerations for centralized space heating are: (i) the technology for extracting the heat from the geothermal source and (ii) the ease with which standard systems in the buildings can be converted to geothermally augmented systems. These are discussed in turn.

Geothermal heat is transferred to a secondary fluid by heat exchangers. There are a variety of designs of heat exchangers but they are all based on one principle. A secondary fluid, cool water, is allowed to flow around the geothermally heated source water and the heat is conducted through the exchanger material to the secondary water. The material that the exchanger is made of is important and is selected for its conductive properties as well as corrosion resistance. The two most commonly used materials are mild steel and stainless steel.^a

^a Shannon, Robert J., "Geothermal Heating of Government Buildings in Rotorua" Proceedings: Second United Nations Symposium on the Development and Use of Geothermal Resources, May 1975, p. 2166.

^b Gries, J. P., "Geothermal Applications on the Madison (Pahasapa) Aquifer System in South Dakota" September 1977, p. 411.

Five heat exchanger designs are shown in Fig. 18. The most common type is the shell and tube, and it has two basic designs: the large storage type and the battery type. The battery type has several advantages: it occupies less space, some parts can be cleaned without a total shutdown, and additional parts can be added to increase the heating capacity.

In the sleeve heat exchanger (Fig. 18) the geothermal water goes through the center pipe and the secondary water goes through the annulus. A high heat transfer rate can be produced based on counter-flow and turbulence. However, since the unit is welded into the pipeline, it is difficult to clean.^a

The plate type exchanger is composed of a series of plates and fluid flows through them in alternate directions. The counter-current type of plate exchanger has a better heat transfer rate than the shell and tube on a per square foot of surface area basis, and is more compact. Plate exchanger units can also be easily expanded or changed in response to load or temperature changes, and the plates may be dismantled for maintenance and cleaning without having to take the exchanger out of the system.^b The principle problem is that the plate seals have a limited life.

The final type of system shown on Fig. 18 is the immersed coil exchanger. This type of exchanger, consisting of Teflon tubes and

^a Shannon, Robert J., "Geothermal Heating of Government Buildings in Rotorua," Proceedings: Second U.N. Symposium on the Development and Use of Geothermal Resources, May 1975, p. 2167.

^b Gries, J.P., "Geothermal Applications in the Madison (Pahasapa) Aquifer System in South Dakota" South Dakota School of Mines and Technology, September 1977, p. 46.

Fig. 18. Five Types of Heat Exchangers

Source: Robert J. Shannon, "Geothermal Heating of Government Buildings in Rotorua," Proceedings: Second United Nations Symposium on the Development and Use of Geothermal Resources, May 1975. p. 2167.

polypropylene balls, is placed in a concrete tank containing the geothermal fluid. It has a high heat transfer rate and the tubes have a high resistance to chemical attack. The tubes do have to be cleaned of algae annually and precaution must be taken to install a proper pre-filter to prevent small particles from blocking them.^a

After the heat is transferred from the geothermal fluid to the secondary fluid in the heat exchanger, the secondary fluid is piped for distribution in the district. Space heating is performed in a variety of ways, depending on the type of heating system in the building. Some types function better with a low temperature source; conversion of these existing systems for use with a geothermal source is readily accomplished.

One of the most common residential heating systems is forced air. In a conventional forced air system, a natural gas flame heats a container. "Fins," or pieces of metal coming off the can are used to transfer the heat from the can to the surrounding air (a surface-air heat exchanger). Room air is blown by a fan across the fins, and ducts carry the heated air for distribution throughout the building. Fig. 19 shows how a forced air system can easily be adapted for geothermal heating. From Fig. 19, the "new heating coil," or surface-air heat exchanger, is used to transfer the heat from the geothermally heated water. The blower, or fan, that was already in the system blows room air across the geothermally heated "fins" or coil, as well as across the coil heated with natural gas.

^a Shannon, Robert J., "Geothermal Heating of Government Buildings in Rotorua," Proceedings: 2nd U.N. Symposium on the Development and Use of Geothermal Resources, May 1975. p. 2167.

Fig. 19a. Conversion of Forced Air Heating System for Geothermal Heating.

Fig. 19b. Conversion of Hot Water Space Heating System for Geothermal Heating

Source: J. F. Kunze, et al, "Nonelectric Utilization Project, Boise, Idaho" Proceedings: Second United Nations Symposium on the Development and Use of Geothermal Resources, p. 2144.

The ducts for distributing the heated air are already in place and thus a minimal amount of changes are necessary to convert or include geothermal heating with an existing forced air system.

The second most common residential space heating system is the hot water type; it is also easily adaptable to geothermal heating. Conventional hot water space heating involves a boiler, or tank of water usually heated by natural gas. The heat source either heats the tank directly or indirectly, through a coil (heat exchanger). A pump circulates the piped hot water to rooms in the building. As the hot water is piped through radiators, natural convection provides the heat exchange from the water in the radiator to the air. Fig. 19b shows the conventional hot water heating system with the additional water inlet and heat exchanger for the geothermal system. If the secondary water from the central location (where heat from the geothermal fluid has already been transferred to a secondary fluid) is hot enough, a secondary exchanger may not be necessary. Fig. 19b shows that the existing pump and radiators (heat convectors) are used to distribute the geothermally heated water throughout the house.

Neither steam or electric heating systems are practical for adaptation to geothermal heating. Steam heating requires higher temperature water (to form a vapor) and considerable alteration of existing equipment would be required to adapt it for geothermal.^a Conversion of an electric system would also involve a lot of changes.

^a Kunze, J.F., A.S. Richardson, K.M. Hollenbaugh, C.R. Nichols, and L.L. Mink, "Non Electric Utilization Project, Boise, Idaho," Proceedings: Second U.N. Symposium on the Development and Use of Geothermal Resources, May 1975, p. 2144.

In addition, one study recommended that electrically heated homes in the area not be redone because most of the electrically heated homes were new and the homeowners were the most likely to be unreceptive to a new heating system.^a

The use of geothermal energy for hot water heating requires only the addition of a water-water heat exchanger to transfer the heat from the geothermally heated water to the existing hot water tank.

Space Heating and Cooling

The final system to be discussed is a combined central heating and cooling system. This system is a central absorption refrigeration system, where use is made of the cooling part of the cycle in the summer and use of the heating part in the winter. The system which is discussed here is the ammonia-water absorption unit. As described previously, the system has a generator, condenser, evaporator and absorber; cooling is produced in the evaporator and heat in the condenser and absorber.^b

Fig. 20 illustrates the system for the summer, or cooling mode. The generator (where geothermal heat is used to evaporate the ammonia) is located at the source or wellhead. The ammonia vapor is then condensed to liquid ammonia also at the site and delivered to the buildings as a liquid. At the building, the liquid goes through a pressure release valve and into an evaporator coil. The coil is located in the return air system for dispersion throughout

^a Gries, J.P., "Geothermal Applications on the Madison (Pahasapa) Aquifer System in South Dakota," South Dakota School of Mines and Technology, 1977. p. 54.

^b An absorption cooling system is described in detail on pages 98-101.

Fig. 20. Space Cooling: Conceptual Ammonia Absorption Geothermal System.

Source: J. P. Gries, "Geothermal Applications On the Madison (Pahasapa) Aquifer System in South Dakota," South Dakota School of Mines and Technology. September 1977. p. 78.

the building. The ammonia is then pumped back to the central system to the absorber where it is remixed with water. The heat produced by absorption is not used in the cooling mode and is removed from the absorber by heat exchangers and cooling water. The cooling water from the absorber goes to a cooling tower to reject the heat, and the remixed solution of ammonia and water returns to the generator.

In the winter, the heating mode is used and it is diagrammed in Fig. 21. From the generator at the geothermal source, ammonia gas is delivered to the buildings. The condenser and evaporator part of the cycle are bypassed and the vapor goes directly to an absorber. The absorber is installed in the return air system and releases heat as water absorbs the ammonia. The concentrated solution is returned to the generator.

There are advantages and disadvantages to this system. The main advantage is that the geothermal source can be used all year through one central system. However, the central plant could be only in a heating or cooling mode, and the system is difficult to operate efficiently. Also, leakage of ammonia may pose a hazard and the home units are recommended to be installed outside for this reason.^a

Environmental Impacts

The environmental impacts which may result from geothermal development include land subsidence, seismicity, water quantity and quality, air quality, and land use. These impacts are discussed very generally; the degree of impact is site specific and dependent on

^a Gries, J.P., "Geothermal Applications on the Madison (Pahasapa) Aquifer System in South Dakota," South Dakota School of Mines and Technology, 1977, p. 77.

Fig.21. Space Heating: Conceptual Ammonia Absorption Geothermal System.

Source: J. P. Gries, "Geothermal Applications On the Madison (Pahasapa) Aquifer System in South Dakota," South Dakota School of Mines and Technology, September 1977. p. 79.

the technology used and mitigation measures.

Subsidence of the ground surface can result from withdrawals of large quantities of geothermal fluid. As the fluids are removed from the groundwater aquifer there is a decrease in fluid pressure and the overlying rocks and soil compact and compress. The amount of subsidence (if any) depends on the site characteristics and, in general, it is irreversible. ReInjection of the geothermal fluid after the heat has been removed will reduce this impact.

Seismic activity may result from instabilities caused by changes in the geothermal reservoir pressures. Withdrawals of the geothermal fluid (pressure reduction) as well as reinjection (pressure increase) have been reported to generate seismic activity.^a

Impacts on both the quantity and quality of groundwater may be caused by geothermal development. Quantity impacts result from drawdown in surrounding water wells as the geothermal fluid is extracted. During drilling, pumping or reinjection, the mineralized geothermal fluid may leak into fresh water or potable aquifers, causing quality degradation through mixing. Proper materials and construction can minimize this impact. Surface water quality may be degraded during construction by silty runoff; and mineral or thermal contamination may occur by spills, blowouts and surface discharge of the geothermal fluid during operations.

Geothermal development can cause air quality impacts by emissions of pollutants during exploration, construction and operation. During

^a Source: Russell O. Pearson, Principal Investigator, "Use of Geothermal Heat for Sugar Refining" Final Report, TRW System and Energy, May 1977.

operations, the major air pollutants are noncondensable vapors, particularly hydrogen sulfide. In geothermal electric power plants, other chemicals, including mercury, radon, boron and fluorides, may drift from the cooling towers and heat is, of course, rejected to the atmosphere. In any closed loop system, such as the binary fluid power cycle described earlier, no air emissions other than heat would occur.

Land use for the facility and pipelines may result in environmental impacts.^a Loss of vegetation, disruption of wildlife, and erosion can result from construction of the plant/pipelines and to a lesser extent during operation. The degree of impact depends on the location, for example, erosion will be more severe in areas with steep terrain.

^a Approximately 3,000-5,000 acres are required for a 1,000 Mwe plant. 7-10% are used for the facility, the rest is required to serve the plant.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Geochemical and geophysical measurements indicate that geothermal resources do exist in the Trans-Pecos of Texas, primarily in two areas: in the vicinity of Hueco Tanks in Northeastern El Paso County and along the Rio Grande River in Presidio County. Substantial uncertainty about the geothermal resource temperatures and potential flow rates still exists for both resource areas. Current data indicate that the Hueco Tanks resource is not sufficiently hot for electric power generation, but that temperatures are sufficient for direct use applications. Current data on the Presidio resource, however, indicate that temperatures may be sufficiently hot for power generation.

The principal deterrent to applications of the Hueco Tanks resource is its distance from the urban areas of El Paso. Applications of that resource would require that a user re-locate in the vicinity of the resource or that the hot water be transported at least 15 miles and probably 20 miles. Such transport, with only minor temperature losses, is technically feasible but expensive. Five types of industries are most suitable as users of the Hueco Tanks Resource -- the meat packing industry of which there are 6 companies in El Paso; the dairy industry (6 companies); the soft drink bottling industry (6 companies); the canning industry (2 companies); and the apparel industry (37 companies). Additionally, the geothermal resource is suitable for applications aimed at providing both space heating and space cooling in the residential, commercial, or industrial sector.

Because electric power generation compared with direct uses offers flexibility for a rural area, application of the Presidio geothermal resource for power generation emerged as the most suitable use of that resource. Since the irrigation season in Presidio County extends for 9 to 10 months of the year, use of the geothermal water, which are rejected from the power plant, for irrigation could make utilization of the Presidio resource even more attractive.

Recommendations

- Highest priority should be given to additional geologic investigations aimed at defining geothermal reservoir temperatures, lateral extent, depth, and flow rates. Both the Hueco Tanks and Presidio Resource areas are sufficiently attractive to warrant continued geologic exploration.

Utilization of the Presidio Resource

- Develop international contacts with Mexico in order to explore the possibility of a joint geothermal development venture. The Presidio resource is especially suitable for such a joint venture since many of the settlements on the Mexican side of the Rio Grande do not have electricity and since towns and settlements on both the U. S. and Mexican sides are in need of water.
- Explore the possibility of a joint State of Texas - U. S. Department of Energy (DOE) - U. S. Economic Development Administration (EDA) venture. Because the Presidio area has been in a negative socio-economic spiral, EDA may be interested in opportunities which could revitalize the areas economy. Geothermal development coupled with renewed agricultural development (both additional irrigation as well as food processing plants) could provide such an opportunity.

Local support has been expressed in writing by the West Texas Utilities Company and the City of Valentine (see Appendix F of this report).

- Investigate the interests of the agricultural companies that are already involved in irrigated crop development in the vicinity of Valentine, Texas (the Two Bar M Ranch Company of Wyoming and Olson Brothers of Nebraska). These companies may wish to consider use of the geothermal resource for pumping and/or food processing in some kind of joint government-private sector venture.

Utilization of the Hueco Tanks Resource

- Pending results of further geologic exploration, re-consider the potential for electric power generation from this resource.
- Extend the contacts made during this study with the food processing industries in El Paso. To the extent that a meat packing company, dairy, canning company, or bottling company intends to expand or to construct new facilities, that company needs to be aware of the potential advantage of locating near the Hueco Tanks geothermal resource.
- Extend the contacts made during the study with the public institutions in the El Paso area that could use the Hueco Tanks resource for space heating and space cooling and that are located less than 25 miles from the resource (Ft. Bliss, the Trans-Mountain Campus of El Paso Community College, and public housing projects).

Appendix A: Energy Consumption Data for a Single-Family Residence in El Paso

Table A-1: Heating, Cooling, and Hot Water Energy Demand Data for El Paso .A-2

**Table A-2: Gas Heating, Gas Hot Water, Electric Air Conditioning Demand. .A-3
for El Paso**

Table A-1: Heating, Cooling, and Hot Water Energy Demand Data for El Paso^a

	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.	October	Total
Space Heating													
Gas													
mcf	8.77	15.13	15.70	11.01	7.76	2.11	0	0	0	0	0	2.18	62.65
million Btu's	8.22	14.18	14.71	10.32	7.28	1.97	0	0	0	0	0	2.04	58.72
Electric													
kwh	1806.33	3115.81	3232.93	2267.36	1599.33	434.00	0	0	0	0	0	448.62	12904.38
million Btu's ^b	18.97	32.72	33.94	23.81	16.79	4.56	0	0	0	0	0	4.71	135.49
(th)													
Hot Water Heating													
Gas													
mcf	2.42	2.76	2.82	2.82	2.78	2.61	2.44	2.26	1.88	1.88	1.94	2.20	28.81
million Btu's	2.27	2.59	2.64	2.60	2.45	2.29	2.29	2.11	1.76	1.76	1.81	2.06	27.00
Electric													
kwh	432.45	493.13	503.41	503.41	496.21	466.39	436.05	402.63	335.26	335.26	345.55	392.34	5142.09
million Btu's ^b	4.54	5.18	5.28	5.28	5.21	4.90	4.58	4.23	3.52	3.52	3.63	4.12	53.99
(th)													
Air Conditioning													
Electric													
kwh ^c	75.51	23.31	10.36	65.59	187.70	511.76	1107.23	1723.84	1760.95	1633.22	1247.47	535.06	8882.00
million Btu's ^b	0.79	0.24	0.11	0.69	1.97	5.37	11.63	18.10	18.49	17.15	13.10	5.62	93.26
(th)													
Total													
Electric													
kwh	2314.29	3632.25	3746.70	2836.36	2283.24	1412.15	1543.28	2126.47	2096.21	1968.48	1593.02	1376.02	26,928.47

^a Data from Southern Union Gas Company for one 1800 ft² single-family residence.

^b Electricity converted to Btu's(th) using a heat rate of 10,500 Btu's/kwh.

^c Excluding electricity for motors and fans.

Table A-2: Gas Heating, Gas Hot Water, Electric Air Conditioning Demand for El Paso*

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Electric Air Conditioning million Btu's(th)	5.62	0.79	0.24	0.11	0.69	1.97	5.37	11.63	18.10	18.49	17.15	13.10
Gas Heating million Btu's(th)	2.04	8.22	14.18	14.71	10.32	7.28	1.97	0	0	0	0	0
Gas Hot Water million Btu's(th)	2.06	2.27	2.59	2.64	2.64	2.60	2.45	2.29	2.11	1.76	1.76	1.81
Total (million Btu's th)	9.72	11.28	17.01	17.46	13.65	11.85	9.79	13.92	20.21	20.25	18.91	14.91
Total 178.96												

* Electricity in kwh converted to Btu's (th) using a heat rate of 10,500 Btu's/kwh.

Appendix B: Summary of Phone Calls to El Paso Industries

Table B-1: Phone Call Summary.B-2

Table B-1: Phone Call Summary

Name of Industry	Name of Individual Contacted	Notes on Energy Use (temps., how much, load factor)	Yes or No
Food Processing			
El Paso Packing Co.	Carlos Rodriguez	Refrig. temperatures needed are -10°F - +35°F	Yes
Western Packing Co.	Mr. Gray	Temperature - 0°F	Yes
Price's Dairies	Ken Kerrick	Use NG; 240°F for pasteurizing	Yes
Farmer's Dairies	Bob Navar	Need process heat for pasteurizing, homogenizing	Yes
Horizon Dairy Farms	Eric Huereque	No pasteurizing, but there is cooling	Yes
Ashley's Inc.	Mrs. Hall	Varies with product	Yes
Paul's Fine Feeds	Unidentified	Steam to soften feed and make it adhesive, 300\$/mo. for NG	Yes
Jerky Treats	Mr. Wilson	1) hot water for clean-up about 160°F (NG)	Yes
		2) NG for dehydrating - up to 600°F use several mcf/mo. - about half is for 160°F and half is for 600°F. Won't give out output.	
Rainbo Bakery	Danny Appleguard	As high as 550°F; hamburger buns 475-500°F. Seasonal - more buns in the summer but bread is all yr. (Refrigate for mixers.)	No
Mead's Bakery	Mr. Harold	Use NG, need 400-475°F	No
Dr. Pepper Bottling Co.	Mr. Ranslem	Use NG in an "Evans Heater" to sterilize bottles, 130-140°F	Yes
Pepsi-Cola Bottling Co.	Mr. Condon	Use NG to heat water to 150°F	Yes
Seven-Up/Royal Crown Bottling	Art Licon	Heat for "Evans Heater" 160°F, for washing - 120-130°F	Yes
Duffy's Draft Beverage		Use NG for washing machine, 140°F, entire bill (including space heat) is a maximum of 32\$/mo.	Yes
SWIG	Mr. Peterson	125 lb. pressure, 250 HP boiler	Yes
Azar	Bob Swanson	Wet & Dry roasters - 350°F. Use NG; canning is done with electricity.	Yes
Best Buy Tortilla Factory	Al Robert	NG to cook and to heat; pressing plates heated to 400-500°F; (about 573\$/mo. for 1.8X10 ⁶ tortillas)	No

Table B-1: Phone Call Summary (cont'd)

Name of Industry	Name of Individual Contacted	Notes on Energy Use (temps., how much, load factor)	Yes or No
Food Processing (cont'd) La Tapatia	Mr. Roles	Tortillas about 700°F; for tamales use steam from boiling water about 312°F, for cooking meat about 300-350°F. Bill is about \$500/mo.	Yes
National Molasses	Stanley Posner	A warehouse storage. They get in product and then reship.	No
Consumers Ice & Fuel	Mr. Cooley	Use electricity to expand and condense ammonia.	No
Ideal Tortilla	Mr. Ruiz	Corn & flour tortillas, 715- 850°F. Make about 250,000 tortillas/mo.	No
Apparel Levi-Strauss	Ron Murphy	Process steam for pressing garments. Need 300-325°F; use 85 HP boiler with NG.	Yes
El Paso Apparel Division	Leon Ruddock	Contract work; they sew & press	Yes
Ruddock Manufacturing		Use 12 HP boiler; about 100\$/mo. for pressing 4,000 dz. clothes	Yes
Union Manufacturing	Mr. Larocca	Pressing done with NG (with oil as emergency back-up) 300°F.	Yes
Jerry Shore Sportswear	Woody Flattmann	NG for pressing; 80-90 lb. steam; 180°C.	Yes
Zenith Shirt Co.	Larry Wegel	All electric in U.S.A., other plant in Juarez	No
Clothing Mfg. of El Paso		Plant in Mexico	No
Blue Bell		Use NG for pressing at about 400°F, and for heating a 40' long oven to bake permanent press fabrics (also 400°F)	No
D. P. Cajals	Mr. Peitzer	Use NG for pressing, require 100 lb. of pressure. \$160/mo. for NG includes space heating.	Yes
Action West Mfg. Co. Am-Champ	Jimmy Limon Mr. Denmin	NG for pressing garments, 215-220°F Only electricity	Yes No

Table B-1: Phone Call Summary (cont'd)

Name of Industry	Name of Individual Contacted	Notes on Energy Use (temps., how much, load factor)	Yes or No
Apparel (cont'd)			
Consolidated Industrial Development of El Paso	Ms. Ancelot	Use spray guns & resin	No
S.D. Myres Saddle Co.	Frank Hallah	No manufacturing, only distributing	No
Commercial Sales Mfg. Co.		Purchase fabrics for tents, awnings, covers. Make a lot of things for Ft. Bliss, special treated fabrics. (May be tied in with Am-Champ.) No process heat.	No
Dallas Bias Fabrics of E.P.	Ernie Ramirez	Distributors	No
Viola Sportswear		No pressing there; only sewing. They send garments out to be pressed.	No
Krisel Mfg. Co.	Mr. Krisel	Use electricity to heat water to boiling - steam for pressing	No
Hide Away Creations, Ltd.		Make leather & suede coats	No
Primrose Fashions	Ignacio Enriquez	Cut & sew dresses - use NG to press, doesn't know the temp. but its about 180 lb. of pressure	Yes
CMT	Mr. Newberger	Press with electricity	No
Royal Key Corp.	Ernest Goldner	Sewing, send garments out to be pressed	No
Don Shapiro Industries	Ms. Denny	Won't give any info. over the phone	
Tex-Togs		Press with steam from electrically heated water	No
Sew Rite Mfg., Inc.	Mr. Gruntzmeyer	Sew only, no pressing	No
Farah Mfg.	Bill Isaak	For pressing, use gas & electric. The pressing machine is hooked up to an electrical generator and also uses NG.	Yes
Sahara Slacks	Mr. Seamster	Mostly a warehouse, they do a very little bit of pressing and use NG.	No
Acapulco Fashions of Texas	Peter Segel	Mostly a warehouse; mfg. in Juarez.	No
Billy The Kid Inc.	Mr. Reseck	They do some pressing - with elec. NG for pressing (diesel back-up)	Yes
Summit	Mr. Salama	60 lbs. of steam pressure Sew, press with "hot shot boiler" which is electric	No

Table B-1: Phone Call Summary (cont'd)

Name of Industry	Name of Individual Contacted	Notes on Energy Use (temps., how much, load factor)	Yes or No
Rubber Handgards, Inc.	Mr. Fox	Use electricity to heat metal to cut plastic for gloves, bill of \$1500/mo. for about 3 million gloves (bill incl. lights). Need temp. of 300-450°F.	No
Thunderbolt Container Corp.	Phyllis Phaup	Use electricity for melting plastic.	No
Washco Plastics Corp.	Eloise Mata	Use electricity in a "blow mold"; heat to 375°F then seal it through the molding process, after the air is blown in, cooled to 60-80°F with water and anti-freeze.	No
EJR Cultured Marble, Inc.	Mr. Bowder	Make synthetic marble with chemicals - No process heat.	No
Cemco Products	George Munoz	Use electricity to heat molds to 120°F	No
Crown World	Tony Searson	Use electricity to heat laminated plastic to form it to a "roll" for making counter tops. Need 250°F.	No
El Paso Plastic Int'l	Al Lindsay	Use process heat about 20% of the time, depends on the product they're making. Use electricity for electric water heater to heat molds used in injection molder. Up to 230°F. Very low kw consumption/product.	No

Appendix C: Energy Consumption in El Paso for Space Heating,
Hot Water Heating and Space Cooling

Table C-1: Heating and Cooling Degree Days; El Paso, Texas. . .	C-2
Table C-2: Energy Consumption for Space Heating and Hot Water Heating; Ft. Bliss, Texas.	C-3
Table C-3: Energy Consumption in Three All-Electric Office Buildings; El Paso Texas	C-4
Table C-4: Energy Consumption in an Office Complex; El Paso, Texas.	C-5
Table C-5: Energy Consumption for Space and Hot Water Heating in an Apartment Complex; El Paso, Texas.	C-6
Table C-6: Energy Consumption in a School; El Paso, Texas . . .	C-7
Table C-7: Energy Consumption for Single-Family Residences; El Paso, Texas	C-8
Table C-8: Energy Consumption for Space Cooling in an Apart- ment Complex; El Paso, Texas	C-9
Table C-9: Hypothetical Load Factor Calculation: Apartments. .	C-10
Table C-10: Energy Consumption for Space and Hot Water Heating in Two Industries; El Paso, Texas.	C-11

Table C-1: Heating and Cooling Degree Days; El Paso, Texas^a

Month	Heating Degree Days	Cooling Degree Days	Total
January	696	0	696
February	351	0	351
March	278	19	297
April	91	84	175
May	26	338	364
June	0	540	540
July	0	459	459
August	0	378	378
September	20	181	201
October	66	34	100
November	399	0	399
December	640	0	640
Total	2567	2033	4600
Hypothetical load factor calculation:			
Heating: $2567 (696 \times 12) = 0.31$			
Cooling: $2033 (540 \times 12) = 0.31$			
Overall: $4600 / (696 \times 12) = 0.55$			

^a From the National Oceanic and Atmospheric Administration (NOAA),
Environmental Data Service, National Climatic Center, Asheville, N.C.

Table C-2: Energy Consumption for Space Heating and Hot Water Heating; Ft. Bliss, Texas^a

Month/Year	Natural Gas			L. P. Gas			Heating Oil			Total MBTU
	MCF	Convert Factor	MBTU	Gallons	Convert Factor	MBTU	Gallons	Convert Factor	MBTU	
Nov. 1978	162,309	1063	172,554	56,998	95,500	5,443	0	0	0	177,997
Oct. 1978	90,503	1059	95,843	10,192	95,500	973	0	0	0	96,816
Sept. 1978	55,057	1059	58,305	10,000	95,500	955	0	0	0	59,260
Aug. 1978	50,949	1067	54,362	11,700	95,500	1,117	0	0	0	55,479
July 1978	50,133	1064	53,342	0	95,500	0	0	0	0	53,342
June 1978	51,271	1058	54,245	20,000	95,500	1,910	0	0	0	56,155
May 1978	61,100	1050	64,155	11,700	95,500	1,117	0	0	0	65,272
April 1978	83,994	1055	88,614	21,994	95,500	2,100	20,982	.1387	2,910	93,624
March 1978	160,362	1056	169,342	46,883	95,500	4,477	42,478	.1387	5,892	179,711
Feb. 1978	203,914	1060	216,149	35,100	95,500	3,352	21,507	.1387	2,903	222,404
Jan. 1978	249,340	1060	264,300	43,502	95,500	4,154	0	0	0	268,454
Dec. 1977	<u>196,920</u>	1059	<u>208,547</u>	<u>24,581</u>	95,500	<u>2,347</u>	<u>0</u>	0	<u>0</u>	<u>210,894</u>
Total	1,415,860		1,499,758	292,650		27,945	84,967		11,705	1,539,408

^a Memorandum from Mr. R. D. Netzley, Chief, Utilities Division, Ft. Bliss, Texas; the square feet of housing space on post is 8,260,000 and non-housing space comprises 8,770,000 ft². An MBTU is 106 Btu's.

**Table C-3: Energy Consumption in Three All-Electric Office Buildings;
El Paso, Texas^a
1978**

Month	kwh			kwh/1000 ft ²		
	I	II	III	I	II	III
12/16-1/15	9300	8200	7000	1162.5	1078.9	875.0
1/16-2/15	9300		7400	1162.5		925.0
2/16-3/15	9100	9100	6200	1137.5	1197.4	775.0
3/16-4/15	7200	19400	5800	900.0	2552.6	725.0
4/16-5/15	8900		7100	1112.5		887.5
5/16-6/15	12600	13300	9500	1575.0	1750.0	1187.5
6/16-7/15	15300	16600	13100	1912.5	2184.2	1637.5
7/16-8/15	12600	13600	11300	1575.0	1789.5	1412.5
8/16-9/15	10600	13800	10500	1325.0	1815.8	1312.5
9/16-10/15	8200	10800	7000	1025.0	1421.1	875.0
10/16-11/15	7000	9300	5900	875.0	1223.7	737.5
11/16-12/15	<u>7700</u>	<u>16800</u>	<u>5000</u>	<u>962.5</u>	<u>2210.5</u>	<u>625.0</u>
Total	117800	130900	95800	14725.0	17223.7	11975.0

^a I and III are 8,000 ft² each; II is 7,600 ft²; data obtained directly from the electric bills for these buildings.

Table C-4: Energy Consumption in an Office Complex; El Paso, Texas^a

Month	For the 45,500 ft ² Building			Per 1,000 ft ²		
	Space Heating (mcf)	Lighting, Hot Water and Cooling ^b (kwh)	Cooling ^c (kwh)	Space Heating (mcf)	Cooling (kwh)	Total ^d (million Btu's-th)
Dec.	563	94,900	0	12.4	0	12.4
Nov.	408	99,400	0	9.0	0	9.0
Oct.	57	120,200	21,700	1.2	476.9	6.2
Sept.	58	137,600	39,100	1.3	859.3	10.3
Aug.	0	130,300	31,800	0	698.9	7.3
July	0	150,600	52,100	0	1145.0	12.0
June	0	143,000	44,500	0	978.0	10.3
May	30	118,700	20,200	0.7	443.9	5.4
April	87	125,800	27,300	1.9	600.0	8.2
March	286	108,500	10,000	6.3	219.8	8.6
Feb.	372	96,000	0	8.2	0	8.2
Jan.	<u>350</u>	<u>103,500</u>	<u>0</u>	<u>7.7</u>	<u>0</u>	<u>7.7</u>
Total	2211	1,428,500	246,700	48.7	5421.8	105.6

^a Data obtained directly from the electric and gas bills for this building.

^b The hourly peak for the year is 334 kwh; for a month this would be 240,480 kwh.

^c Calculated by assuming that the average of Nov., Jan., Feb., consumption represents demand for lighting and subtracting that from the lighting and cooling total. The four-month average is 98,500.

^d Data in mcf multiplied by 10⁶ Btu/mcf; data in kwh multiplied by 10,500 Btu-th/kwh.

Table C-5: Energy Consumption for Space and Hot Water Heating in an Apartment Complex; El Paso, Texas^a

40,400 ft ² Apt. Complex			million Btu's/1000 ft ^{2b}
	Date of Bill	mcf	
For Dec.	1/12/78	215	5.3
For Jan.	2/9/78	222	5.5
For Feb.	3/10/78	194	4.8
For March	4/11/78	104	2.6
For April	- - - Unknown - - -		1.7 ^c
For May	6/9/78	33	0.8
For June	- - - Unknown - - -		0.6 ^c
For July	8/10/78	17	0.4
For August	9/11/78	22	0.5
For Sept.	10/10/78	22	0.5
For Oct.	11/8/78	52	1.3
For Nov.	12/11/78	94	<u>2.3</u>
Total			26.3

^a Data obtained directly from the gas bills for this apartment complex.

^b Obtained by multiplying col. 1 by 10⁶ Btu's/mcf and dividing by 40.4 thousand ft².

^c Interpolated linearly from March to May and May to July.

Note: Load factor is $26.3 / (5.5 \times 12) = 0.398$; at half peak, load factor is $18.95 / (2.75 \times 12) = 0.574$.

Table C-6: Energy Consumption in a School; El Paso, Texas

Month	For the 62,631 ft ² Building			million Btu's/1000 ft ²		
	Space and Hot Water Heating ^a (mcf)	Electricity ^a (kwh)	Electricity for Cooling ^b (kwh)	Space and Hot Water Heating ^c	Cooling ^d	Total
September	21	94,800	48,800	0.3	8.2	8.5
October	48	49,560	3,560	0.8	0.6	1.4
November	247	43,680	0	4.1	0	4.1
December	457	40,560	0	7.3	0	7.3
January	379	34,560	0	6.1	0	6.1
February	361	46,560	0	5.8	0	5.8
March	179	46,560	0	2.9	0	2.9
April	25	62,400	16,400	0.4	2.7	3.1
May	30	60,120	14,120	0.5	2.4	2.9
June	16	105,000	59,000	0.2	9.9	10.1
July	34	105,360	59,360	0.5	10.0	10.5
August	<u>28</u>	<u>85,920</u>	<u>39,920</u>	<u>0.4</u>	<u>6.7</u>	<u>7.1</u>
Total	1835	775,080	241,160	29.3	40.5	69.8

^a Personal Communication in Memorandum form, El Paso Community College.

^b Calculated: Cooling load from Nov. through March assumed 0; cooling load April through September calculated by subtracting 46,000 kwh from the April through September usage.

^c Calculated by multiplying mcf by 106 Btu's per mcf and dividing by 62.6 thousand ft².

^d Calculated by multiplying kwh by 10,500 Btu's/kwh and dividing by 62.6 thousand ft².

Hypothetical Load Factors: Heating: $29.3/(7.3 \times 12) = 0.33$ (peak demand met)
 $20.6/(3.65 \times 12) = 0.47$ (half peak met)
 Heating & Cooling: $69.8/(10.5 \times 12) = 0.55$ (peak demand met)
 $51.1/(5.24 \times 12) = 0.81$ (half peak met)

Table C-7: Energy Consumption for Single-Family Residences;
El Paso, Texas^a
(million Btu's/1000 ft²)

Month	Heating	Hot Water	Heating and Hot Water	Cooling	Total
October	1.13	1.14	2.27	3.12	5.39
November	4.56	1.26	5.82	0.44	6.26
December	7.88	1.44	9.32	0.13	9.45
January	8.17	1.47	9.64	0.06	9.70
February	5.73	1.47	7.20	0.38	7.58
March	4.04	1.44	5.48	1.09	6.57
April	1.09	1.36	2.45	2.98	5.43
May	0	1.27	1.27	6.46	7.73
June	0	1.17	1.17	10.05	11.22
July	0	0.98	0.98	10.27	11.25
August	0	0.98	0.98	9.53	10.51
September	<u>0</u>	<u>1.00</u>	<u>1.00</u>	<u>7.27</u>	<u>8.27</u>
Total	32.60	14.98	47.58	51.78	99.36

^a Data from Southern Union Gas Company; heating and hot water with natural gas; cooling by refrigerated air (electric) with electricity consumption converted to Btu's using the heat rate of 10,500 Btu's (th)/kwh.

Table C-8: Energy Consumption for Space Cooling in an Apartment Complex; El Paso, Texas^a

Month	Electric Consumption: 96,000 ft ² (kwh)		Electric Consumption: Per 1000 ft ² Air Conditioning Only	
	Air Cond. and Lighting ^a	Air Cond.	kwh	million Btu(th) ^d
October	74,200	23,200	241.7	2.5
November	53,200	0	0	0
December	53,900	0	0	0
January	51,100	0	0	0
February	47,600	0	0	0
March	49,000	0	0	0
April	72,100	21,100	219.8	2.3
May	81,550	30,550	318.2	3.3
June	129,500	78,500	817.7	8.6
July	140,700	89,700	934.4	9.8
August	133,350	82,350	857.8	9.0
September	<u>129,150</u>	<u>78,150</u>	<u>814.1</u>	<u>8.5</u>
Total	1,015,350	403,550	4203.7	44.0

^a Data obtained directly from the electric bills for this apartment complex.

^b Calculated by subtracting 51,000 kwh for lighting from previous column; 51,000 kwh is the average use November-March.

^c Calculated by dividing value in previous column by 96 thousand ft².

^d Calculated by multiplying value in previous column by 10,500 Btu(th)/kwh.

Table C-9: Hypothetical Load Factor Calculation: Apartments
 (Data from Table C-5 and C-8)
 in million Btu's(th)/1000 ft²

Month	Heating and Hot Water	Cooling	Total
October	1.3	2.5	3.8
November	2.3	0	2.3
December	5.3	0	5.3
January	5.5	0	5.5
February	4.8	0	4.8
March	2.6	0	2.6
April	1.7	2.3	4.0
May	0.8	3.3	4.1
June	0.6	8.6	9.2
July	0.4	9.8	10.2
August	0.5	9.0	9.5
September	<u>0.5</u>	<u>8.5</u>	<u>9.0</u>
Total	26.3	44.0	70.3
Load Factor			
Sized for peak: $70.3/10.2 \times 12 = 0.574$			
Sized for half peak: $52.2/5.1 \times 12 = 0.853$			

Table C-10: Energy Consumption for Space and Hot Water Heating in
Two Industries; El Paso, Texas^a
(million Btu's or mcf)

Month	Two Establishments		Per 1000 ft ²	
	4500 ft ²	100,000 ft ²	I	II
October	19	12	4.2	0.1
November	21	72	4.7	0.7
December	26	321	5.8	3.2
January	32	492	7.1	4.9
February	32	405	7.1	4.0
March	29	379	6.4	3.8
April	24	128	5.3	1.3
May	17	26	3.8	0.3
June	18	14	4.0	0.1
July	15	18	3.3	0.2
August	12	14	2.7	0.1
September	<u>19</u>	<u>14</u>	<u>4.2</u>	<u>0.1</u>
Total	264	1,895	58.6	18.8

Hypothesized Load Factor Calculation

Sized for Peak Demand	I: $58.6 / (6.4 \times 12) = 0.763$
	II: $18.8 / (4.9 \times 12) = 0.319$
Sized for Half Peak	I: $37.9 / (3.2 \times 12) = 0.987$
	II: $12.7 / (2.45 \times 12) = 0.432$

^a Data obtained from Southern Union Gas Company with permission of the two industries.

Appendix D: Empirical and Theoretical Derivation of Heating and Cooling Geothermal Energy Demand

Empirical

Table D-1: Heating Demand. D-2

Table D-2: Cooling Demand. D-4

Theoretical

Table D-3: Basis of Calculation for Heating. D-6

Table D-4: Temperature Data: El Paso, Texas D-7

Table D-5: Temperature Data: Presidio, Texas. D-8

Table D-6: Calculation of Heating Demand D-9

Table D-7: Calculation of Cooling Demand: El Paso . . . D-10

Table D-8: Calculation of Cooling Demand: Presidio. . . D-11

Table D-1: Heating Demand

I. Data Support

- A. From Table 14: Fossil fuel consumption for space and hot water heating in El Paso ranges from 26.3 to 90.3×10^6 Btu/1,000 ft²/yr; the "typical" well insulated residence evaluated by Southern Union Gas Company consumes 47.6×10^6 Btu/1,000 ft²/yr.
- B. Using 50×10^6 Btu fossil fuel/1,000 ft²/year and assuming a conversion efficiency of fossil fuel to space heat of 75%, this is 37.5×10^6 Btu heat/1,000 ft²/year.
- C. Space heating demand derived theoretically (excluding hot water) is 31.7×10^6 Btu heat/1,000 ft²/year. The theoretical derivation is given in Table D-6. This value compares well with actual consumption for space heating (excluding hot water heating) which is 32.6×10^6 Btu's of fossil fuel (Table C-7) or 24.5×10^6 Btu's of heat.
- D. Actual energy consumption in Valentine and Presidio for hot water and space heating is 35.8×10^6 Btu's/1,000 ft²/year and 32.9×10^6 Btu's/1,000 ft²/year respectively. These are 71.6 and 65.8% as large as El Paso's consumption ($35.8/50 = 0.716$ and $32.9/50 = 0.658$).
- E. Peak consumption in El Paso (for the record low temperature of -8°F) is 28.4×10^3 Btu heat/hr., for Presidio is 19.3×10^3 Btu/hr. (record low 17°F); Valentine is assumed equal to El Paso (derived theoretically, see Tables D-3 through D-8).

II. Basis of Calculation: All values given in item II are given either in Table 15 or 28 of this report.

A. Space and Hot Water Demand

1. El Paso: 50×10^6 Btu fuel/1,000 ft²/yr = 37.5×10^6
Btu's heat; peak is 28×10^3 Btu's heat/1,000 ft²/hr
2. Valentine: 36×10^6 Btu's fuel/1,000 ft²/yr = 27×10^6
Btu's heat; peak is 28×10^3 Btu's heat/1,000 ft²/hr.
3. Presidio: 33×10^6 Btu's fuel/1,000 ft²/yr = 24.7×10^6
Btu's heat; peak is 19.3×10^3 Btu's heat/1,000 ft²/hr.

III. Calculation of Geothermal Flow Rate (Per 1,000 ft²). Starred values are given either in Table 15 or 28 of this report.

- A. Geothermal energy enters heat exchanger at 80°C; the ΔT is 50°F.
- B. Enthalpy is 50 Btu's/lb water ($\Delta H = c\Delta T = 1 \text{ Btu/lb} \cdot ^\circ\text{F} \times 50^\circ\text{F}$) or 417 Btu/gal ($50 \text{ Btu's/lb} \times 8.345 \text{ lbs/gal}$).
- C. El Paso: for delivery of 37.5×10^6 Btu's heat/yr, flow rate is 90,000 gal/yr* ($37.5 \times 10^6 \text{ Btu's/yr} / 417 \text{ Btu/gal}$); peak flow rate is 67 gal/hr ($28 \times 10^3 \text{ Btu's/hr} / 417 \text{ Btu/gal}$). Sized to meet peak = 1.1 gpm* ($67 \text{ gal/hr} / 60 \text{ min/hr}$). Sized to meet half peak 0.6 gpm* (315,360 gal/yr).
- D. Valentine: for delivery of 36×10^6 Btu's/yr heat, flow rate is 86,000 gal/yr.* ($36 \times 10^6 / 417$). Peak flow rate is as for El Paso.
- E. Presidio: for delivery of 33×10^6 Btu's/yr heat, flow rate is 79,000 gal/yr* ($33 \times 10^6 / 417$). Peak flow rate is 46 gal/hr ($19.3 \times 10^3 \text{ Btu's/hr} / 417 \text{ Btu/gal}$). Sized for peak: 46 gal/hr = 0.8 gpm; half peak is 0.4 gpm.

Table D-2: Cooling Demand

- I. Data Support (All data on a per 1,000 ft² basis)
 - A. Measured electric consumption for cooling in El Paso ranges from 3,800 to 5,400 kwh/1,000 ft²/yr (Appendix C). There are no measured data for Valentine and Presidio, since cooling is evaporative.
 - B. For a coefficient of performance of 7 for refrigerated electric air conditioning, this converts to 90.8×10^6 to 129×10^6 Btu's of heat that must be removed from 1,000 ft² of space ($3,800$ to $5,400$ kwh $\times$ 3413 Btu's(e)/kwh $\times$ 7).
 - C. The heat that must be removed is derived theoretically in Tables D-3 to D-8. For El Paso, it is 137×10^6 Btu's/yr and for Presidio, it is 158×10^6 Btu's/yr with peak heat removal demand of 14.3×10^3 Btu/hr for El Paso and 14.6×10^3 Btu/hr for Presidio.

II. Basis of Calculation

Total heat removal requirement: El Paso 130×10^6 Btu's/yr
Presidio 158×10^6 Btu's/yr
Peak heat removal: El Paso 14×10^3 Btu/hr
Presidio 15×10^3 Btu/hr

III. Calculation of Flow Rate Requirement (Starred values are given either in Table 15 or 28 of this report.

- A. Ammonia-Water Cycle at 120°C (generator temperature); 43°C (condenser temperature); and -17°C (evaporator) (ΔT is 140°F); enthalpy is 140 Btu/lb ($\Delta H = c \Delta T = 1 \text{ Btu/lb} \cdot ^\circ\text{F} \times 140^\circ\text{F}$) or 1168 Btu/gal ($140 \text{ Btu/lb} \times 8.345 \text{ lb/gal}$).

B. Coefficient of Performance for Ammonia-Water Cycle is 0.7

C. El Paso

Annual: $130 \times 10^6 \text{ Btu's/yr} \div 0.7 = 185 \times 10^6 \text{ Btu's/yr}^*$
geothermal required or 158,400 gal/yr* ($185 \times 10^6 \text{ Btu's/yr} \div 1168 \text{ Btu/gal}$).

Peak: $14 \times 10^3 \text{ Btu/hr} \div .7 = 20 \times 10^3 \text{ Btu/hr} = 17 \text{ gal/hr} = 0.3 \text{ gpm}^*$. Half peak is 0.15*.

D. Presidio

Annual: $158 \times 10^6 \text{ Btu's/yr} \div 0.7 = 225.7 \times 10^6 \text{ Btu's/yr}$
geothermal required or 193,200 gal/yr*.

Peak: $15 \times 10^3 \text{ Btu's/hr} \div 0.7 = 21.4 \times 10^3 \text{ Btu's geothermal/hr}$ or 18.3 gal/hr or 0.3 gpm*. Half peak is 0.15 gpm*.

IV. Electric and Fossil Fuel Offset

A. 130×10^6 (El Paso) and 158×10^6 (Presidio) heat removal with a coefficient of performance of 7 yields 18.6×10^6 and 22.6×10^6 Btu's respectively at 3413 Btu's/kwh yields 5450 kwh and 6620 kwh respectively. For the fossil fuel equivalent, multiply kwh by 10,500 Btu/kwh.

Table D-3: Basis of Calculation for Heating

$$\text{Heat Conducted Out by Second} = K \frac{\text{Area} \times \Delta T}{\text{Thickness}}$$

where K = heat conductivity

Area 1,000 ft²

Dimensions 40 ft X 25 ft X 9.84 ft

or 12.19m X 7.62m X 3m

Surface area over which heat loss occurs:

$$2 [(12.19 \times 7.62) + (3 \times 12.19) + (3 \times 7.62)] = 305 \text{ m}^2$$

Heat Conductivity of the Walls: 15×10^{-6} kcal/sec·m·°C

Wall Thickness 0.1m

Rate of Heat Loss = Rate of Heat Input Required =

$$= \frac{(15 \times 10^{-6} \text{ kcal/sec} \cdot \text{m} \cdot ^\circ\text{C})(305 \text{ m}^2)(\Delta T)}{0.1 \text{ m}}$$

$$= (0.046) \Delta T \text{ kcal/sec}^\circ\text{C}$$

ΔT = inside-outside temperature

Table D-4: Temperature Data, El Paso, Texas

	Average			Record Minimum & Maximum		
	°F	°C	ΔT^a	°F	°C	ΔT^a
January	43.6	6.4	14.7	-8	-22.2	43.3
February	48.4	9.1	12.0			
March	54.6	12.5	8.6			
April	63.9	17.7	3.4			
May	72.2	22.3	-1.2			
June	80.3	26.8	-5.7			
July	82.3	27.9	-6.8	109	42.8	-21.7
August	80.5	26.9	-5.8			
September	74.2	23.4	-2.3			
October	64.0	17.8	3.3			
November	51.6	10.9	10.2			
December	44.4	6.9	14.2			

^a 21.1°C (70°F) — measured in °C.

Table D-5: Temperature Data: Presidio, Texas

	Average			Record Minimum & Maximum		
	°F	°C	ΔT^a	°F	°C	ΔT
January	50.6	10.3	10.8	17	-8.3	29.4
February	55.9	13.3	7.8			
March	62.5	16.9	4.2			
April	70.5	21.4	0.3			
May	78.2	25.7	-3.6			
June	86.9	30.5	-9.4	110	43.3	-22.2
July	82.1	27.8	-6.7			
August	83.9	28.8	-7.7			
September	76.8	24.9	-3.8			
October	71.6	22.0	-0.9			
November	60.7	15.9	5.2			
December	51.8	11.0	10.1			

^a 21.1°C (70°F) — measured in°C.

Peak Heating Demand = .046 kcal/sec·°C (from Table D-3) X 29.4°C X 3.968 Btu/kcal X 3600 sec/hr.

= 19.3 X 10³ Btu's/hr. This value given in Table D-1, Item IE.

Table D-6: Heating Demand: El Paso

	kcal/sec ^a	Btu/hr ^b (10 ³)	Btu/mo ^c (10 ⁶)
January	0.68	9.70	7.22
February	0.55	7.88	5.29
March	0.39	5.64	4.20
April	0.16	2.23	1.61
May	0		
June	0		
July	0		
August	0		
September	0		
October	0.15	2.17	1.61
November	0.47	6.69	4.82
December	0.65	9.32	<u>6.93</u>
Total			31.68 ^d
Peak	1.99	28.42 ^e	

^a $0.046 \times \Delta T$: 0.046 from Table D-3, ΔT from Table D-4.

^b $3.968 \text{ Btu/kcal} \times 3600 \text{ sec/hr} = 14.28 \times 10^3$

^c January, March, May, July, August, October, December = 744 hrs/mo;
February = 672 hrs/mo; April, June, September, November = 720 hrs/mo.

^d Value given in Table D-1; item IC.

^e Value given in Table D-1; item IE.

Table D-7: Cooling El Paso: Heat That Must be Extracted from 1,000 ft² of Space

	Conduction			Radiant					Total ⁱ
	kcal/sec ^a	Btu/hr ^b (10 ³)	Btu/mo ^c (10 ⁶)	Insolation cal/cm ² /day ^d	Btu/ft ² /day ^e	Roof ^f 10 ⁶ Btu/day	Walls ^g 10 ⁶ Btu/day	Sum ^h 10 ⁶ Btu/mo	
May	0.06	0.79	0.59	675	2488	0.83	0.04	27.0	27.59
June	0.26	3.74	2.70	700	2580	0.86	0.05	27.3	30.0
July	0.31	4.47	3.32	700	2580	0.86	0.05	28.2	31.52
August	0.27	3.81	2.83	600	2212	0.74	0.02	23.5	26.33
September	0.11	1.51	1.10	550	2027	0.67	0.02	20.7	<u>21.80</u>
Peak	1.00	14.28 ^j							137.24 ^j

^a .046 X ΔT (.046 from Table D-3, ΔT from Table D-4).

^b 3.968 Btu/kcal X 3600 sec/hr = 14.28 X 10³.

^c January, March, May, July, August, October, December = 744 hrs/mo; February = 672 hrs/mo; August, June, September, November = 720 hrs/mo.

^d E.P. Odum, Fundamentals of Ecology, Third Edition. Philadelphia: W. B. Saunders Company, 1971. p. 42.

^e 3.968 X 10⁻³ Btu/cal X 929 cm²/ft² = 3.686.

^f Assumes one-third of insolation is absorbed, and half is reradiated; multiply previous column by 1000 ft² roof and divide by 3.

^g Assumes window space equal to 36 ft² or 30% of wall space; radiation on the vertical is half that on the horizontal; take value in Btu/ft²/day times 1/2 and times 36 ft².

^h Sum the previous two columns and multiply by the number of days in a month.

ⁱ Sum Btu/mo conduction and radiant.

^j These values are given in Table D-2; item IC.

Table D-8: Cooling Presidio: Heat That Must be Extracted from 1000 ft² of Space

	Conduction			Radiant ^d	Total ^e
	kcal/sec ^a	Btu/hr ^b (10 ³)	Btu/mo ^c (10 ⁶)	Btu/mo (10 ⁶)	
May	0.16	2.28	1.7	27	28.7
June	0.43	6.14	4.4	27.3	31.7
July	0.31	4.43	3.3	28.2	31.5
August	0.35	5.00	3.7	23.5	27.2
September	0.17	2.43	1.8	20.7	22.5
October	0.04	0.57	0.4	15.8	16.2
Peak	1.02	14.58 ^f			157.8 ^f

^a .046 X ΔT (.046 from Table D-3, ΔT from Table D-5).

^b 3.968 Btu/kcal X 3600 sec/hr = 14.28 X 10³.

^c 744 hrs/mo in May, July, August, October; 720 hrs/mo in June, September.

^d Same as El Paso, Table D-7 with October added at a solar insolation of 400 cal/cm²/day.

^e Sum of conduction and radiant.

^f These values are given in Table D-2, item IC.

Appendix E: Climate and Water Use Data: Presidio County

Table E-1: Water Use in Presidio.	E-2
Table E-2: Temperature and Precipitation: Presidio and Candelaria. .	E-3
Table E-3: West Texas Utilities Company System.	E-4
Table E-4: Residential Electric Use: Some towns in the Trans-Pecos .	E-5

E-1: Water Use in Presidio

Month	Water Use (Gallons)			
	1974a	1975a	1976a	1978b
January	3,271,100	3,207,500	3,774,800	3,411,600
February	3,104,200	3,224,200	3,814,200	3,087,900
March	3,330,600	4,244,600	4,703,600	4,539,500
April	3,984,000	4,940,000	5,388,100	5,751,900
May	4,800,800	5,000,800	5,699,900	6,606,100
June	4,900,100	5,100,100	5,789,800	6,511,900
July	4,906,000	5,150,600	5,789,900	6,171,400
August	4,796,000	5,060,600	5,200,500	4,749,200
September	4,310,600	5,006,000	4,700,600	3,921,500
October	3,785,600	4,385,600	4,783,300	3,246,700
November	3,176,600	3,896,600	4,395,500	2,862,900
December	<u>3,160,000</u>	<u>3,536,800</u>	<u>3,988,600</u>	<u>3,396,300</u>
Total	47,525,600	52,753,400	58,028,800	54,256,900

^a Economic Resource, Community Needs, and Historic Preservation Study: Presidio County, Texas prepared by Dan Glass, Consulting Engineer, 1977.

^b Personal Communication, Presidio Water Supply Corporation.

Table E-2: Temperature and Precipitation: Presidio and Candelaria^a

		Average Temperature Degrees F												
		Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Annual
Presidio		50.6	55.9	62.5	70.5	78.2	86.9	82.1	83.9	76.8	71.6	60.7	51.8	69.3
Candelaria		49.8	54.3	60.9	66.9	74.1	83.8	80.0	80.8	73.6	67.1	54.6	49.1	66.3
		Daily Temperature, High and Low, Degrees F												
Presidio	Low	17	23	34	38	52	58	65	62	47	42	29	19	
	High	84	83	91	101	102	110	104	105	100	97	91	85	
Candelaria	Low	19	25	29	36	45	49	60	57	41	39	18	19	
	High	79	83	90	99	102	108	102	104	96	96	87	79	
		Monthly Precipitation for 1975, Inches												
Presidio		0.12	0.48	0.00	0.00	0.43	0.95	4.17	2.50	1.51	0.07	0.00	0.00	10.23
Candelaria		0.23	0.31	0.02	0.05	0.45	1.09	3.35	1.35	4.63	0.17	0.00	0.53	12.18

^a Economic Resource, Community Needs, and Historic Preservation Study: Presidio County, Texas prepared by Dan Glass, Consulting Engineer, 1977.

Table E-3: West Texas Utilities Company System^a
(For the year Jan. 1, 1974-Dec. 31, 1975)

Customer Class	Number	kwh/yr	kwh/customer/yr
Residential	105,973	773,074,000	7,295
Commercial/Industrial			
Small	18,869	648,600,000	34,374
Large	4,167	982,083,000	
Public Street and Highway Lighting	196	27,368,000	
Other Public	<u>2,611</u>	<u>266,131,000</u>	
Total	131,816	2,697,256,000	
Resale	117	1,379,007,000	
Total	131,933	4,076,264,000	
Based on a per residential customer basis, this is 7,300 kwh in the resi- dence plus 18,000 kwh per residential customer for all other (648,600,000 + 982,083,000 + 27,368,000 + 266,131,000/105,973 = 18,157).			

^a From Statistics of Privately Owned Electric Utilities in the United States, 1975, Federal Power Commission, Washington, D.C.

Table E-4: Residential Electric Use: Some Towns in the Trans-Pecos^a

Town	Residential (kwh/yr)	Residential Customers (number)	Per Customer Average (kwh/customer/yr)
Alpine	11,722,274	2,128	5,509
Balmorhea	1,500,366	329	4,560
Ft. Davis	3,027,749	625	4,844
Marfa	5,904,315	1,075	5,492
Presidio	2,454,932	538	4,560
Valentine	372,397	133	2,800
Redford	267,679	82	3,264
Shafter	127,097	29	4,383
Marathon	1,160,659	249	4,661
Saragosa	1,029,434	202	5,096

^a Personal Communication, West Texas Utilities Company.

Appendix F: Letters of Interest

El Paso Community College.	F-2
City of Valentine.	F-3
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el paso COMMUNITY college

February 23, 1979

Dr. Martha W. Gilliland
Executive Director
Energy Policy Studies Inc.
P.O. Box 13245
El Paso, Texas 79912

Dear Dr. Gilliland:

The Transmountain campus of El Paso Community College was designed to provide for maximum flexibility of the mechanical systems in order that the college might at some future date utilize an alternative energy source in heating and cooling that campus. The design of the boilers is such that retrofitting to accommodate geothermal energy resources should be quite easy.

Also, the college is currently developing a very large number of additional vocational-technical programs in an on-going effort to significantly expand the college's involvement in the graduation of large numbers of qualified technicians. A number of energy related technical programs are being looked at. For example, the solar energy technician program was reviewed through a comprehensive community needs assessment conducted in December. The possible use of geothermal energy at the Transmountain campus would be a very important educational resource to our growing number of technician training programs as well as a vital supplement to our heating and cooling system which could be easily retrofitted to accommodate geothermal energy. The college is very much interested in the work being conducted by the Texas Energy Advisory Council and Energy Policy Studies. We would indeed be interested in pursuing the possible major use of geothermal energy at our Transmountain campus. We would appreciate receiving notification of the meeting on March 23 and will have a representative there.

Please keep us informed as to any ways we might encourage this alternative energy development which would be most useful to the community and particularly would be useful to El Paso Community College.

Sincerely yours,

Robert E. Shepack
President

City of Valentine

Box 6

Valentine, Texas 79854

March 8, 1979

Martha W. Gilliland
Energy Policy Studies Inc.
P.O. Box 13245
El Paso, Texas 79912

Dear Martha Gilliland:

As mayor of Valentine, I would like to express my interest on this research toward geothermal development in West Texas. I would also like to request a draft of the final report on your research.

The little that I know about this project is enough to convince me that the future of geothermal energy is very promising and possibly a step toward solving our energy shortage. We at Valentine certainly feel fortunate to be close to a geothermal energy tap and are looking forward toward its development.

On behalf of the people of Valentine, I would like to encourage further research and development of this project. I would also like to ask that I be kept informed and updated on your accomplishments. If I can be of any further assistance to you, please don't hesitate to call on me.

Sincerely,

Jesus Calderon
Mayor of Valentine

HOUSING AUTHORITY
OF THE CITY OF EL PASO

GENERAL OFFICES
1221 E. SAN ANTONIO
TELEPHONE 332-5678
POST OFFICE BOX 95
EL PASO, TEXAS 79909

March 7, 1979

Ms. Martha W. Gilliland
Executive Director
Energy Policy Studies, Inc.
P. O. Box 13245
El Paso, Texas 79912

Dear Ms. Gilliland:

Re: Geothermal Energy Resources in
El Paso Area

We have received your letter of February 15, 1979, describing the subject program and requesting the extent of our interest in this matter.

The program as described in your letter is of interest to this Housing Authority, especially as pertains to capital funding and energy savings.

We are interested in being considered a consumer but final arrangements and agreements must be approved by our Board of Commissioners.

Thank you for your consideration.

Sincerely,

Enrique Bustamante, P. E.
Executive Director

EB/la

RAY SALAZAR
MAYOR
JIM KIRBY
EXECUTIVE ASSISTANT
ROBERT H. GABEL
ADMINISTRATIVE OFFICER

City Council

DAN PONDER
MAYOR PRO TEM
RICHARD WAGNER
RICHARD A. NAJERA
DR. J. B. JONES
JIM SCHERR
POLLY HARRIS
W. L. RIEGER
CITY CLERK

The City of El Paso
Office of Energy Conservation
UTEP - Solar House
El Paso, Texas 79968

March 9, 1979

Dr. Martha Gilliland
Energy Policy Studies, Inc.
P. O. Box 13245
El Paso, Texas 79912

Dear Dr. Gilliland:

The Office of Energy Conservation is very interested in supporting research and development of economically feasible alternative energy resources. Your determination of the suitability of El Paso County geothermal energy for space heating and cooling is exciting. My discussions of the geothermal energy potential of this area with a local water well driller confirms your findings.

We would be pleased to participate in the proposed geothermal engineering - economic analysis to the extent of coordinating the use of municipal structures as test facilities and collecting energy use data for the study. A fruitful possibility might be to install a centralized geothermal heating/cooling unit in one or more of the 36 Public Housing Authority complexes in El Paso.

Please let me know how we can further assist your efforts.

Sincerely,

Anthony S. Mixer
Anthony S. Mixer

ASM:bjf

El Paso, Texas, The International City
F-5

The mild-mannered
Mexican foods you can
season hot...or not.

March 13, 1979

Martha W. Gilliland
Executive Director
Energy Policy Studies Inc.
P. O. Box 13245
El Paso, Texas 79912

Dear Ms. Gilliland:

With reference to your letter of March 7, should like to advise Ashley's Inc. would be interested in the State of Texas and/or the U. S. Department of Energy pursuing the development of engineering and economic cost details of using geothermal energy as the process heat source for the canning industry.

Sincerely

ASHLEY'S INC.

Blanche Hall (Mrs.)
Purchasing Manager
:BTH

WEST TEXAS UTILITIES COMPANY

GENERAL OFFICE: P.O. BOX 841 / ABILENE, TEXAS 79604 / (915) 672-3251

Randal G. Meador
Vice-President
Director of Engineering

March 16, 1979

Ms. Martha W. Gilliland
Executive Director
Energy Policy Studies, Inc.
P. O. Box 13245
El Paso, TX 79912

Re: Trans-Pecos Geothermal Research

Dear Ms. Gilliland:

This letter is in regard to your inquiry dated February 26, 1979, and subsequent telephone call on March 13 placed by Mr. Cecil Johnson, pertaining to the geothermal research project in the Trans-Pecos region.

As indicated during your conversation with Mr. Johnson, and as later verified through a telephone call to Mr. David White with the Texas Energy Advisory Council, your present research plans are connected with the Trans-Pecos Geothermal Project in which Central and South West Fuels, Inc., El Paso Electric Company, and the University of Texas at El Paso are participants. Since West Texas Utilities Company is a member of the Central and South West System, in effect WTU is represented in the study.

In short, West Texas Utilities is certainly interested in the development of this research, and would encourage you in seeking support from the State of Texas and the U. S. Department of Energy to develop the engineering and economic cost details of geothermal development for electric power generation in the Trans-Pecos region.

We appreciate the opportunity to express our interest in this project. If we can be of further assistance, please advise.

Sincerely,

Randal G. Meador

RGM/khh

A MEMBER OF THE CENTRAL AND SOUTH WEST SYSTEM

Central Power and Light
Corpus Christi, Texas

Public Service Company of Oklahoma
Tulsa, Oklahoma

Southwestern Electric Power
Shreveport, Louisiana

West Texas Utilities
Abilene, Texas

GOALS FOR EL PASO

POST OFFICE BOX 12822

EL PASO, TEXAS 79912

March 27, 1979

Dr. Martha W. Gilliland, Executive Director
Energy Policy Studies, Inc.
P. O. Box 13245
El Paso, Texas 79912

Dear Dr. Gilliland:

The Energy Task Force of Goals for El Paso enthusiastically endorses the continuation of research into the technical and economic aspects of geothermal resource development in the El Paso area. We agree with your general assessment of the areas in which geothermal energy can best be used in this region.

We wish you the best of luck with your work in this vital aspect of alternate energy utilization.

Sincerely,

Edward A. Leonard

Edward A. Leonard
Chairperson, Energy Task Force