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BERLIN, MARYLAND

DISTRICT HEATING ASSESSMENT PROGRAM

FEASIBILITY STUDY

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EBASCO

EBASCO SERVICES INCORPORATED

SEPTEMBER 1982

BERLIN, MARYLAND
DISTRICT HEATING ASSESSMENT PROGRAM

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BERLIN, MARYLAND
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TECHNICAL AND ECONOMIC ASSESSMENT

1.0 INTRODUCTION

Ebasco Services, Incorporated was contracted by the town of Berlin, Maryland to participate with them in a study to evaluate the feasibility of using geothermal energy as a source for a district heating system. The town District Heating Assessment Work Group (DHAWG) under Chairman E. Phillips, together with the Town Administrator, R.L. Bireley, sought out the potential customers and then gathered the data requested by Ebasco.

The Applied Physics Laboratory, (APL) and the Metro Center at Johns Hopkins University (JHU) have been investigating extensively the use of geothermal energy along the Atlantic Coastal Plain and have developed a computer program to assist in these investigations. Ebasco has used this program, Geothermal Resource Interactive Temporal Simulation (GRITS), with assistance from F. C. Paddison of APL and P. Kroll of the Metro Center in conducting this study.

2.0 SUMMARY

Ebasco conducted the technical and economic portion of this study to determine the feasibility of constructing a district heating system with a geothermal energy source for the town of Berlin, Maryland.

The Berlin District Heating Assessment Work Group (DHAWG) provided the information on the energy needs of all potential users. Ebasco utilized previous work, primarily that of Johns Hopkins University (JHU), to estimate the potential geothermal energy available beneath the town. We also utilized a computer program, GRITS, developed by JHU to evaluate various district heating systems that would satisfy the town's needs.

It is concluded that a district heating system is technically and economically feasible based on the criteria and data used in this study.

3.0 ENERGY SOURCES

The results of work done by the Applied Physics Laboratory (APL) of the Johns Hopkins University (JHU) and others on the geothermal resource potential of the Atlantic Coastal Plain were utilized to characterize the geothermal resource available in the general location of Berlin. This was done and those characteristics were used to model the energy source for a proposed district heating system. In this modeling we also included the use of oil-fired boilers for peaking and standby functions and investigated the recovery of waste heat from the diesel generators of the town power plant.

3.1 GEOTHERMAL RESOURCES

3.1.1 Geologic Background Information

The town of Berlin, Maryland, is situated on the Delmarva Peninsula, which is part of the Atlantic Coastal Plain (Figure 3-1). The Atlantic Coastal Plain, extending from New England southward to Florida and continuing as the Gulf Coastal Plain from Florida to the Yucatan Peninsula, is the surface expression of a thick wedge of clastic sediments that were deposited during the Mesozoic and Cenozoic Eras (past 200 million years). These sediments consist primarily of sand, silt, and clay that were deposited under nonmarine, shallow marine, and marine conditions. The depositional units dip gently to the east and southeast increasing in thickness in the seaward direction. It is within this thick wedge of sediments beneath Berlin that potentially favorable conditions for supplying geothermal energy have evolved⁽¹⁾.

Detailed information on the subsurface geology in the Berlin area is available from the logs of the James D. Bethards No. 1 well drilled by the Socony-Vacuum Oil Company in 1945. This well was located approximately 5 miles southwest of Berlin (N38°18'15", W75°16'30") and is considered indicative of the subsurface conditions expected to be encountered in the proposed geothermal well for the town of Berlin. The well was drilled to a depth of 7168 feet (7116 feet below sea level) and the data collected include ditch samples at 10 foot intervals, 31 cores, 27 side-wall cores, and electric logs. Anderson described these

Figure 3-1. LOCATION OF WELLS IN THE DELMARVA PENINSULA.

data and correlated them with data from the Hammond and Esso deep wells (2) (Figure 3-3). The well was plugged and abandoned after data acquisition.

The Patuxent Formation (Figure 3-2) is the stratigraphic unit of particular interest beneath Berlin because it contains the deepest zones that have good geothermal potential. The stratigraphic interpretations presented by several investigators (References 2-5) indicate that the section identified by Anderson as the Patuxent formation is primarily non-marine in origin and consists mostly of fine to very coarse arkosic and quartzitic sands interbedded with relatively thinner layers of shale and sandy shale. Gravels occur throughout the Patuxent formation. However, they are more concentrated in the basal portions of the formation. Sand beds in the Patuxent formation commonly have a minor shale component and generally become more arkosic and coarse-grained with depth. The basal portions of the formation contain the potential geothermal resources.

3.1.2 Regional Extent Of Aquifers

Correlating the well logs and sample descriptions with those of other nearby deep wells allows us to interpret the data from the Bethards No. 1 well within the context of regional geology. Five deep wells, four of which penetrated the basement, have been drilled within 50 miles of the Bethards well (Figure 3-1). Data from these wells indicate that the major geologic units increase in depth and thickness to the east and southeast. The Hammond well lying 11.5 miles to the WNW and the Esso well lying 14 miles to the NE are quite indicative of this trend (Figure 3-2). The Patuxent formation appears to be continuous beneath a significant portion of the Mid-Atlantic Coastal Plain, including eastern Maryland. In the area of interest, it ranges in thickness from about 550 feet in the Cambridge well to well over 2,000 feet in the Esso and Taylor wells. The logs of wells drilled in the formation indicate that the formation contains numerous beds of fine to coarse sediments, a number of which are possibly extensive. All available information indicates that the basal portions of the Patuxent formation contain relatively extensive layers of sediments which could yield large quantities of geothermal water.

Figure 3-2 GEOLOGIC CROSS SECTION, EASTERN MARYLAND (modified after Anderson).

Figure 3-3 GEOPHYSICAL LOGS OF BETHARD WELL, BERLIN, MARYLAND (after Anderson).

3.1.3 Resource Depth And Temperature

In order to establish a basis for predicting the geothermal gradient beneath Berlin, the available temperature/depth data from the deep wells in eastern Maryland were examined (Table 3-1). The temperature gradients measured in a number of shallow (1,000 feet or less in depth) holes drilled in the Atlantic Coastal Plain were also considered, but emphasis was placed on measurements taken in deep holes within the Patuxent formation. Most of the shallow hole information came from the Johns Hopkins University reports referred to in references No. 1 and 7.

The electric logs from the Bethards well indicate several major and numerous minor possible aquifers within the Patuxent, the more prominent of which are shown on Figure 3-3. Based on these logs, the most promising zones lie between 5,400 and 6,350 feet. Analysis of the available information indicates a temperature at the bottom of this section of 150 F to 170 F with a nominal resource temperature of 160 F. However, additional information is required to substantiate the well yield and the temperature of the geothermal resource beneath Berlin. In any case, the well head temperature will be slightly lower than that of the production zones due to heat loss during pumping. This decrease in temperature due to heat loss at equilibrium is expected to be about 1 to 3 degrees. ⁽⁶⁾

3.1.4 Resource Yield

Initial results of pump tests run in the Cambridge and Crisfield wells indicate that the zones within the Patuxent formation can yield geothermal water. A recent report prepared for the Johns Hopkins University ⁽⁶⁾ concluded that aquifers in the Patuxent formation under Ocean City, Maryland, located about 10 miles east of Berlin, can provide geothermal water at a sustained yield of 400 gpm. The aquifers in the Patuxent beneath Berlin are expected to be similar; therefore, they can reasonably be expected to yield 300 gpm of geothermal water. The well drawdown is estimated to be about 1300 to 1600 feet below the static water level assuming that the aquifer

characteristics are similar to those for the Crisfield well (transmissivity and storativity values of $0.5 \text{ cm}^2/\text{sec}$ and 3.9×10^{-3} , respectively).

Generally the flow rate from a small drawing area in one zone is less and it is not unreasonable to expect that a higher flow rate can be attained by intersecting several producing zones with relatively large screened well segments. The interconnection of sand horizons, at greater distances from the well can increase the yield of the well and reduce the drawdown. However, data from long duration pump tests are needed to establish a reliable sustained yield and to predict the steady state drawdown in the well. Results of a long duration test will also help finalize the well design and determine size and setting of the pump.

3.1.5 Water Quality

Based on chemical analyses of well head water samples from the Cambridge and Crisfield wells, the water from the producing zones in the Berlin well will be very saline and high in dissolved solids. The salinity of the resource is expected to be twice that of sea water (about 70,000 ppm). The high salinity water, in addition to providing thermal energy, can also be used to extract chemicals as planned for the nearby proposed geothermal well at Lewes, Delaware⁽¹⁾. Having another marketable product from this resource would, of course, increase the economic attractiveness of this project.

3.1.6 Geothermal Well And Costs

Based on the above investigations and known well drilling practices, a drilling program and estimated well cost can be established for this study. The geothermal well will be designed as a water well with a gravel pack around the screen at aquifer locations. The effective radius of the well will be 12 inches. A drilling rig with a derrick of minimum rated capacity of 300,000 lbs is specified. It has been assumed that town owned land is available at acceptable sites for the required wells and surface facilities.

3.1.6.1 Casing Program

A tentative casing program is proposed as shown below and in Figure 3-4.

<u>OD, in</u>	<u>Setting Depths, ft</u>	<u>Wt. Lb/ft</u>	<u>Grade</u>	<u>Conn</u>
16	0 - 150	65	H-40	ST&C
9 5/8	0 - 4000	36	K-55	ST&C
7	3800-6600	26	P-110	LT&C

Johnson Super-WeldTM type 316 ELC stainless steel screen sections totalling about 200 feet will be installed at appropriate aquifer locations.

3.1.6.2 Logging Program

A tentative borehole geophysical logging program is proposed as outlined here:

Upper Section 150-4000 ft

Natural Gamma Ray

Induction Electrical Survey

Density/Borehole Compensated (including caliper survey).

Lower Section 4000' - T.D.

Natural Gamma Ray

Induction Electrical Survey

3-D Velocity

Borehole Compensated Density (including caliper survey)

Borehole Compensated Neutron

Cement Bond Locator

Temperature Log.

The program will include computer processing of the geophysical logs.

Figure 3-4 WELL SCHEMATIC

3.1.6.3 Geothermal Well Pump

A multistage submersible pump capable of pumping 300 gpm (12,000 BPD) against a total dynamic head (TDH) of 2200 feet is recommended. The pump should be able to handle bottom hole temperature of 200 F and high salinity water with 1.1 specific gravity.

3.1.6.4 Reinjection Well

A reinjection well located about 2500 feet from the production well will be drilled to a depth of 3,000 feet. The exact location and the depth of the reinjection well will be determined after the geothermal well is completed. It is anticipated that a water-well drilling rig will be adequate to drill and complete the reinjection well.

3.1.6.5 Well Costs

The estimated costs in 1981 dollars for the geothermal well in Berlin are summarized below:

Production Well

Drilling Rig	180,000
Casing and Bits	160,000
Cement, Mud, Trucking, Outside Labor, Rental Equipment, Well Head, Fittings, and Well Services	200,000
Mobilization and Demobilization	70,000
Geophysical Logging	30,000
Well Screen	40,000
Well Testing and Gravel Pack	65,000
Tubing 5 1/2"	30,000
Miscellaneous Supplies and Services	65,000

Site Preparation (including installation of conductor casing and restoration)	60,000
Engineering and Well Drilling Coordination Services (including bid preparations and evaluation)	100,000
Subtotal	1,000,000
Reinjection Well (3,000 ft)	<u>100,000</u>
Total	\$1,100,000
Well Resource Assessment Cost	\$ 100,000

3.1.7 Summary Of Geothermal Resource

The expected geothermal resources of Berlin are summarized here based on the available information. However, additional information is needed to confirm the yield and temperature of the resource.

	<u>Nominal</u>	<u>Range</u>	<u>Value Used In Study</u>
Depth, ft	6,000	5,400 to 6,550	6,000
Yield, gpm	300	0 to 400	300
SWL (static water level), ft	- 150	- 50 to - 300	- 150
Drawdown below SWL, ft	1,400	1,300 to 1,600	1,300
Water quality, TDS, ppm	70,000	5,000 to 100,000	70,000
Temperature, °F	160	140 to 170	160
Reinjection well depth, ft	3,000	2,200 to 6,000	3,000
Estimated Life, Yrs	-	-	20

TABLE 3-1

TEMPERATURE GRADIENTS FROM
DEEP WELLS IN EASTERN MARYLAND AND VICINITY

Well	Total Depth (ft)	Depth To Basement (ft)	Temperature/Depth (F)/(ft)	Approx. Thermal Gradient (F/100 ft)
Hammond #1	5,568	5,498 ⁽²⁾	not available	---
Bethards #1	7,178	7,130 ⁽²⁾	not available	---
Esso #1	7,710	not penetrated	216/7,710 *	2.0
Crisfield	5,562	4,455 ⁽⁷⁾	128/3,822 *	1.8
			133/4,009 *	
			135/4,186 *	
			137/4,455	
Cambridge	3,336	3,315 ⁽⁸⁾	73/1,423	
			91/2,279	1.4
			99/2,647	
			93/2,834 *	1.2
			96/3,198 *	
			110/3,336	1.6

*Temperature recorded within Patuxent Formation

3.2 ALTERNATE ENERGY SOURCES

3.2.1 Town Electric Generating Plant

Berlin currently generates its own electric power during the four summer months. The balance of the year it purchases power from the local utility. In the future, Berlin may operate its power plant continuously. Consideration was given to recovering heat from the diesel engine exhaust gases. We discussed this issue with the diesel generator manufacturer, Fairbanks-Morse, and with the heat recovery unit manufacturer, Maxim. The conclusion was that we should only consider it for the most recently installed engine, the 1600 HP unit. The 1600 HP engine has the highest exhaust gas temperature (600F) and the highest allowable pressure drop for the exhaust gas.

The Maxim representative recommended⁽⁹⁾ a heat recovery unit, model GTW-35-52, that would recover 1,300,000 Btu/hr. This would increase the system water temperature by 8.7F at an installed cost of approximately \$48,000.

In our study we investigated the effects of recovering this waste heat on the economic feasibility of the system.

3.2.2 Oil Fired Boilers

When the outdoor temperature goes below a certain point, defined as the system design temperature in the GRITS program, the geothermal heat source will have to be supplemented to assure adequate temperature of the heating water delivered to the user. In addition to this condition there has to be a standby source available to provide heat to the distribution system in the event the geothermal well is shutdown for maintenance or due to a malfunction. The alternate source considered in this study is oil-fired boilers. Some large existing oil-fired boilers within user facilities may be considered for part of this purpose. An example is the boiler plant at the Elementary School. If such facilities are not available or not practical, new boilers would have to be provided for the entire load. This was considered in our study.

4.0 SYSTEM CONCEPTS

4.1 POTENTIAL USERS

Berlin established a list of major potential customers for the District Heating System and Ebasco prepared forms for their use in conducting an energy use survey. The locations of each of the individually identified users and summary of residential energy use is shown on Figure 4-1.

Berlin gathered data regarding energy consumption by the potential users and also on the heating degree days for the area. This information was used as input to determine the design heating load using the degree-day method described in Chapter 28 of the 1981 ASHRAE Handbook of Fundamentals⁽¹⁰⁾. The results compared favorably with a report issued by Argonne National Laboratory⁽¹¹⁾, ANL/ICES-TM-11, "An Assessment of the Potential for District Heating in Four Major Eastern Cities." That report was also used to establish the domestic hot water heating load used in this study.

4.2 SYSTEM DEVELOPMENT

A review of the established values for the geothermal production well (Par 3.1.7) showed that a single well could provide a maximum of approximately 7,500,000 BTUH for district heating purposes based on a flow of 300 GPM, a wellhead temperature of 160F, and a reinjection temperature of 110F.

The potential demand in Berlin greatly exceeds the well capacity. Also, the highways US 113 and US 50 divide the potential users and the cost of crossing beneath them with piping was considered to be excessive. Based on these two considerations (Berlin could not identify any other geographic obstacles) and potential long runs between some users lead to dividing the town into two thermal zones separated by US 113.

Potential users G and N were dropped from consideration. User G, Chesapeake Foods, has a large demand that requires several wells of its own. This might

Figure 4-1
Potential Users and Residential
Energy Use
Berlin, Maryland

lead to use of other technical and economic parameters than those established for this study. It was decided to limit the study to systems that would serve a greater cross section of Berlin. By reviewing those results, Chesapeake Foods could decide if they wished to investigate geothermal energy further and if they preferred to develop their own system or make arrangements to join the town system. A possible approach that could be explored is for Chesapeake Foods to buy the excess thermal energy from the District Heating System. This would mean that the system could operate twelve months of the year and thereby reduce the cost of geothermal energy from that shown in this study.

An alternative could be for Chesapeake Foods to develop the geothermal wells and sell the energy to a distribution utility. There are a variety of possible approaches that are based on cooperation between Chesapeake Foods and Berlin that may be worth exploring for their mutual benefit. This would have to be the subject of a separate study that could be undertaken after establishing some basic criteria for a cooperative effort. The GRITS program can be used to study industrial applications of geothermal energy and may be applied in investigation of these alternatives.

Ceva Labs, user N, was not considered in the study because of the need to cross US 50 and the long extension of the distribution system beyond the otherwise last user. If the resulting denser zone proved to be economically feasible, extending the system to Ceva Labs could be readily considered in Phase II.

The final thermal zone arrangements used in this study are shown on Figures 4-2 and 4-3. Each zone is labeled by the letter designations for each user included in that zone.

Figure 4-4A is the conceptual flow diagram developed for Zone ABCDFHS, the area west of US 113, without diesel engine heat recovery. Figure 4-4B is the same but with heat recovery components. A flow diagram for Zone EIJLMO would be similar to Figure 4-4A.

Figure 4-2
Thermal Zone ABCDFHS
Berlin, Maryland

4.3 Application of Grits Program

The GRITS program is upgraded periodically and this study used Version 9A⁽¹²⁾, dated April, 1982. There are certain system features in the computer model that cannot be directly changed by the program input. Because of this and in order to model the system as shown on the flow diagram, some inputs had to be adjusted so that the program would model the system properly.

One example has to do with the pumps. The cost and power consumption is fixed in the model and cannot be altered. We found that the price of the submersible pump is about twice the value used in the GRITS model but that power consumption is less. The model assumes a reinjection pump identical to the production pump. Even though our conceptual system does not include a reinjection pump we did include one in the model to approximate the actual cost of system pumps. The power consumption was not adjusted and therefore the study results are considered conservative.

The GRITS program does not have provision for incorporation of heat recovery sub-systems. In order to simulate the recovery of heat from the diesel engine in our model, we increased the temperature of the water from the production well by 8.7F and increased the heat exchanger cost by \$48,000.

The program as written incorporates fossil fueled boilers into the system only to provide the heat required to fill the gap between the system design temperature and the outdoor design temperature. System design temperature is defined as that outdoor temperature down to which the geothermal system can provide the required heat without being supplemented. In our conceptual design the boilers are intended to serve a standby function and therefore must be capable of producing the entire system demand. To do this we inputted an outdoor air design temperature of -20F to provide the temperature range over which the computer would select boilers for the full heating range of the system.

The GRITS model incorporates a domestic hot water heating load in its model but only for the heating season which is approximately seven months. The balance of the year, the system could continue to run at reduced production well flow rates. The only additional cost would be for pumping energy for the period and this would be small compared to the system cost for the heating system.

The GRITS model uses the same flow rate in the secondary loop as in the primary (geothermal) loop. This may not necessarily be true but must be followed to use the model. Pipe sizing for the secondary loop will be reviewed during a final design. If flow rate and pipe size must increase it will increase the cost of the system.

The GRITS program was used to model four scenarios for Zone ABCDFHS. One scenario was for commercial users only and the second was for commercial and residential users. Commercial users were defined as all those specifically identified as Area A through S. Each scenario was then analyzed for a zero rate of return and for an 8 percent rate of return. It was found that the optimized system for Zone ABCDFHS is with 60 residences joining the system. The print-out for each of these models is in Appendix A-1 through A-4. The building types used in each model are listed in the print-out and are defined by user area as follows:

<u>Building Type</u>	<u>User Area</u>
1	A - Business Center
2	B - Worcester Country School
3	C - Middle School
4	D - Elementary School
5	F - Wash Bowl
6	H - Murray's Car Wash
7	S - Cropper & Brittingham

The area of the heated spaces was provided by Berlin for Type 2 and 4 and estimated by Ebasco for all other areas in this zone.

The third scenario for this zone was for commercial and residential users with the addition of the heat recovery from the diesel engine. The print-out for this scenario is in Appendix A-5.

The fourth scenario for this zone was using No. 2 oil fired boilers as the sole source of heat for the District Heating System. This was analyzed only for the commercial/residential users using an 8 percent rate of return. This was done for possible use as a comparison. The print-out is in Appendix A-6.

The GRITS program was used to model both the commercial and the commercial/residential scenarios for zone EJLMO. For the latter, we assumed approximately 50 percent of the residences in this zone (15 out of 29) would join the system. The system selling cost for the commercial/residential scenario was slightly lower than for the commercial. The computer print-out for the commercial/residential scenario with an 8 percent rate of return is in Appendix A-7. The building types used in the model are listed in the print-out and are defined by user area as follows:

<u>Building Type</u>	<u>User Area</u>
1	E - Berlin Nursing Home
2	J - Magee Parts
3	L - Barrett Chevrolet
4	M - Ames Shopping Center
5	O - Berlin Shopping Center

The area of the heated spaces was provided by Berlin for all areas.

Areas I, P, Q and R were not included in the study. The DHAWG considered that since these areas were recently completed or nearing completion, their conversion to district heating would likely be slow if they considered it at all.

5.0 ECONOMIC ANALYSIS

5.1 ECONOMIC CRITERIA

The economic criteria used in this study are summarized in Table 5.1. They were established by discussion between Berlin and Ebasco and reflect actual experience of Berlin for some criteria and Ebasco recommendations for others. These and any other criteria used in variations of the computer model are shown in the print outs of each scenario in Appendix A.

The rate of return of eight percent is the profit allowed to a utility by the Maryland Public Service Commission.

The interest rate of 12 percent is the current rate of interest applicable to bonds issued by Berlin.

Taxes are considered to be zero since it is assumed that the District Heating System will be operated as a municipal utility.

Operating and maintenance cost was set at one percent of the initial capital cost. This is the default value in the GRITS program and was considered to be a reasonable figure for this study.

The discount rate was taken as the difference between the interest rate and the inflation rate.

TABLE 5-1

ECONOMIC CRITERIA

Rate of return (limitation by State of Maryland)	8%
Interest rate (current municipal bonds rate)	12%
Taxes	None
*Operating and maintenance cost	1%
*Discount Rate	4%
*Average annual inflation rate	8%
Cost of electricity, 1981 Dollars (\$/kWH)	0.0528
Cost of #2 oil, 1981 Dollars (\$/Gal)	1.00
*Escalation in cost of #2 oil and electricity	3%
*Start of 2 yr resource assessment period	January 1, 1983
*Start of system operation	January 1, 1985

*Values estimated by Edasco. All others established by Berlin.

5.2 ECONOMIC FACTORS USED IN GRITS MODEL

The current version of the GRITS program is based on use of 1981 dollars. The cost of oil and electricity in 1981 was obtained from Berlin and then escalated to 1983 levels for start of system operation.

The GRITS model is based on all capital costs being spent in the first year of operation. Obviously this is not real since the well will be drilled during the beginning of the assessment period and all other system equipment will have to be in-place before start of operation. What is implicit here is that all users join the system in the first year.

An average hook-up cost of \$1524 for each commercial user was incorporated in the model. This was based on estimated lengths and sizes of pipe and then the installed cost was determined from the formula in the GRITS Program Users Manual. The hook-up is defined as the piping running from the distribution main, presumably buried in the street, to the building.

Any individual user costs associated with converting an existing system to one compatible with the District Heating System are not included. Cost of equipment and installation, including piping, valves, meters, pumps and heat exchangers, inside the building, are not included. It is recognized that this is an important factor in determining if a user should convert from his existing system. But it is also an individualized cost that will be dependent on the type of the existing system, space available for installing new equipment, relationship of building entrance point to existing heating equipment, and numerous other conditions. This cost should be estimated as part of a detailed engineering phase. Some studies have been made on this subject. For converting a hot water heating system from a boiler source to a district heating source, estimates in 1978 ranged from 0.32 \$/Sq.ft. to 0.76 \$/Sq.ft.⁽¹⁴⁾

No land costs have been included. It is assumed that all wells, boiler plants, and other facilities associated with the District Heating System will be located on town owned land.

There are two lines in the print-out titled "Operating Cost Saved this Year" and "Payback in the Year." This is part of the standard program output but should be ignored for this study. It is intended to show a comparison with a system that has a fossil plant energy source, a condition that we are not modeling in this study.

5.3 RESULTS AND DISCUSSION

The graphs in Appendix B Figures B-1,2,4, are intended to show the variation between energy costs for different energy sources over the twenty year life of the system. An explanation of the curves is as follows:

The geothermal district heating system cost (GEO) represents the price of energy produced by the district heating system expressed as a multiple of the No. 2 oil price. The cost as shown on the graphs also represents the minimum the utility should charge assuming an 8 percent rate of return.

Discounted average cost (DAC) indicates the cost of producing energy over the life of the system. That is, the utility charging the DAC to its customers, constantly, over the life of the system would just break even in the last year of system operation.

The cost of oil at 55 percent efficiency (OIL) represents the price a customer actually pays for heating energy assuming a 55 percent seasonal efficiency for his oil fired boiler. This estimate of efficiency is based on reports by Argonne National Laboratory⁽¹¹⁾.

The cost of oil at 100 percent efficiency represents the price of No. 2 oil as delivered to the respective customer.

It can be readily seen that a geothermal district heating system is competitive with both electric and oil heating. Assuming a 55 percent seasonal efficiency for an individual oil fired system, the district heat is competitive when it is priced at less than 1.82 times the price of No. 2 oil, as delivered to the user.

Figure B-3 shows the cash flow, including the annual cost components for the Geothermal District Heating System for zone ABCDFHS.

A comparison between the cost of the different Geothermal District Heating Systems analyzed in this study is shown in Figure B-5.

Zone ABCDFHS

It was determined that when only the commercial users are supplied with geothermal district heating the minimum price of energy produced is 1.52 times the price of #2 oil with an initial capital cost of \$2.37 million expressed in 1981 dollars.

The price of energy from geothermal district heating will decrease to a minimum of 1.50 times the price of No. 2 oil when 60 residential users are added to the system. However, this will increase the initial capital cost to \$2.98 million expressed in 1981 dollars.

When the diesel engine heat recovery unit was added to the geothermal system with commercial and residential users, the additional investment of \$48,000 provided an additional accumulated revenue (net present value) of approximately \$250,000. This is based on the assumption that the cost of geothermal energy is 1.50 times the price of No. 2 oil.

Zone EJLMO

For the commercial/residential scenario, it was determined that the minimum price of energy is 1.60 times the price of No. 2 oil with an initial capital cost of \$1.96 million expressed in 1981 dollars.

5.4 SENSITIVITY ANALYSIS

An analysis for zone ABCDFHS was performed to determine the sensitivity of the geothermal district heating cost to various production well flow rates and various well head water temperatures.

Figure B-6 of Appendix B shows that for any combination of flow rates between 150 and 300 gpm and wellhead temperatures between 140F and 170F that result in a discounted average cost of less than 17.5 \$/million Btu, the geothermal District Heating System is competitive with individual oil heating systems.

It was further determined that only commercial users should be provided with geothermal heating if the production well has a maximum flow rate of 200 gpm at any wellhead temperature or 250 gpm at maximum 150F. Residential users should be added to the system if the production well could provide 250 gpm at wellhead temperatures above 150F or more than 300 gpm at any wellhead temperatures.

6.0 CONCLUSIONS

A district heating system is feasible for Berlin based on:

- 1) The economic criteria established for this study
- 2) The estimated costs for equipment and installation
- 3) The expected temperature, capacity and life of the geothermal wells.
- 4) The identified users joining the system at the start of operation.

The study has shown that Geothermal District Heating is competitive with existing individual oil fired systems when the delivered price, in dollars per million btu, is less than 1.82 times the price of No. 2 oil as delivered to the user. For the two zones analyzed in this study the price of energy is between 1.50 and 1.60 times the price of No. 2 oil. Therefore there is a potential savings to the user of 12 percent to 17.6 percent compared to the cost of No. 2 oil. As the cost of oil goes up, the potential savings by using a geothermal source District Heating System will increase.

The break-even points for the two zones can be seen in the computer print outs in Appendix A. For both zones it occurs in the eighteenth year of operation based on the minimum system selling costs with 8 percent rate of return. If other uses can be found for the water extracted from the ground, such as recovery of minerals, then the cost of delivered geothermal energy should go down.

The addition of a diesel engine heat recovery unit will also reduce system cost and the break-even point will occur earlier.

To proceed further it would require a detailed energy audit of each potential user and some detailed engineering studies of the proposed systems and the drilling and assessment of a well to confirm the basic assumptions of the GRITS model and of this report. The identified potential users must be willing to commit to joining the system at the start of operation.

7.0 REFERENCES

1. Saleem, Z.A., and W. Mott, December, 1980. Eastern Geothermal Drilling Project, Lewes, Delaware in "Geothermal Energy and the Eastern U.S.", Fifth Technical Information Interchange Meeting, the John Hopkins University, Applied Physics Laboratory Report No. QM-80-185.
2. Anderson, J.L., 1948, Cretaceous and Tertiary Subsurface Geology, Maryland Department of Geology, Mines, and Water Resources Bulletin No. 2.
3. Brown, P.M., J.A. Miller, and F.M. Swain, 1972, Structural and Stratigraphic Framework and Spatial Distribution of Permeability of the Atlantic Coastal Plain, North Carolina to New York: U.S. Geological Survey Professional Paper 796.
4. Robbins, E.I., W.J. Perry, Jr., and J.A. Doyle, June, 1975, Palynological and Stratigraphic Investigations of Four Deep Wells in the Salisbury Embayment of the Atlantic Coastal Plain, U.S. Geological Survey Open File Report, No. 75-307.
5. Lambiase, J., December 1980, Atlantic Coastal Plain Geological Targeting and Evaluation Progress Report, The John Hopkins University, Applied Physics Laboratory Report No. QM-80-185.
6. Schubert, C.E., August, 1981. Ocean City, Maryland, Geothermal Energy Evaluation, the John Hopkins University, Applied Physics Laboratory Report No. QM-81-109
7. Radford, L., L. B. Cob, and R. L. McCoy, January, 1980, Atlantic Coast Plain Geothermal Drilling Program, DOE/Crisfield Airport No. 1 Well, Somerset County, Maryland, Final Report, Part 1; Drilling and Completion, Gruy Federal Inc., DOE/ET/28373-1pt. 1.
8. Trapp, H., 1982, Personal Communication with Z. Saleem.
9. Maxim, September 2, 1982, Personal Communication with A. Stepanian
10. American Society of Heating, Refrigeratin and Air Conditioning Engineers (ASHRAE), "1981 Handbook of Fundamentals," ASHRAE, Atlanta, GA.
11. Bernow, S.S., and R.A. Rosen, "An Assessment Of The Potential For District Heating In Four Major Eastern Cities," Argonne National Laboratory Informal Report No. ANL/ICES-TM-11 (August 1978).
12. Kroll, P., and S.M. Kane, "Geothermal Energy Market Study On The Atlantic Coastal Plain: GRITS (Version 9): Model Description and User's Guide," JHU/APL, QM-81-112, MCGER-81-002(APML 1982).
13. Santini, D.J., A.A. Davis and S.M. Marder, "Economic and TEchnical Analysis of Retrofit to Cogenerating District Energy Systems: North Central Cities," Argonne National Laboratory Report No. ANL/CNSV-TM-11 (June 1979).
14. Santini, D.J., and A.A. Davis, "A Test Case For The Potential Applilcation of District Energy Systems Using Thermal Energy Cogenerated At Existing Electric Power Plants", Argonne National Laboratory Informal Report No. ANL/ICES-TM-13 (January 1978).

APPENDIX A

GRITS PROGRAM COMPUTER PRINT-OUTS

A-1

COMMERCIAL SCENARIO

(0% RATE OF RETURN)

ZONE ABCDFHS

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)
(Base period for costs is 2nd Quarter, 1981)
Residential-Commercial Scenario Parameters
(All sets of options will be listed)

Program Operating Conditions

0 Standard geothermal system
2 Output file name:
4 Title of scenario: (displayed above, if any)
5 Residential-Commercial service chosen.
8 Data files will not be generated.
9 System will be sized according to DEMAND conditions.
Do you wish to change any of these options now (Yes/No)? N
Resource Condition Parameters

42 Number of production wells: 1
12 Depth of upwell (feet): 6000.
11 Wellhead water temp. (deg. Fahr.)
linear function used with:
initial water temp.= 160.0
annual drop in temp.= 0.0
21 Reject temperature (deg. Fahr.): 110.0
43 Number of reinjection wells: 1
23 Depth of reinjection well (feet): 3000.
<press "RETURN" to continue>
26 Drawdown of upwell (percent)
determined from aquifer characteristics:
Pumping cycle: Space heating application
Transmissivity= 0.500 sq.cm./sec.
Aq.Stor.Coef.= 0.003900; Well Radius=12.0 in.
32 Maximum flow per well (gpm)
linear function used with:
initial flow= 300.00
annual change= 0.00
38 Transport distance (miles) carrying flow of...
1 wells' flow to distn. system: 1.500
1 wells' flow to reinj. well: 0.520

Do you wish to change any of these options now (Yes/No)? N
Residential-Commercial Demand Condition Parameters

10 Area under consideration: BERLIN
14 System design temp. (deg. Fahr.): 38
28 Min. ambient temperature (deg. Fahr.): -20.
35 Fraction of distribution system installed:
in year 2 =100.000%
<press "RETURN" to continue>
(Residential-Specific)
52 Ultimate number of households: 0.
<press "RETURN" to continue>

COMMERCIAL SCENARIO
(0% Rate of Return)

(Commercial-Specific)

- # 45 Number of types of commercial buildings: 7
- # 46 Avg. floor space for each commercial building of
type 1 :	3.000 thousand sq. ft.
type 2 :	19.200 thousand sq. ft.
type 3 :	75.000 thousand sq. ft.
type 4 :	49.000 thousand sq. ft.
type 5 :	5.000 thousand sq. ft.
type 6 :	5.000 thousand sq. ft.
type 7 :	6.000 thousand sq. ft.
- # 47 Average heat demand for
- | Buildings of | Space Heat
(Btu/sqft/deg/day) | Hot Water Heat
(Btu/sqft/day) |
|--------------|----------------------------------|----------------------------------|
| type 1: | 16.3 | 9.0 |
| type 2: | 6.5 | 9.0 |
| type 3: | 22.3 | 9.0 |
| type 4: | 16.1 | 9.0 |
| type 5: | 72.4 | 640.0 |
| type 6: | 14.5 | 410.6 |
| type 7: | 25.8 | 9.0 |
- # 48 Number of commercial buildings of
type 1 :	40
type 2 :	1
type 3 :	1
type 4 :	1
type 5 :	1
type 6 :	1
type 7 :	1
- # 51 Rate of commercial market penetration
linear function used with:
initial percentage= 100.00
annual change = 0.00
- # 50 Length of commercial distrib. sys: 0.00 miles
- # 49 Avg cost per hookup of a commer. bldg: \$ 1524.
- Do you wish to change any of these options now (Yes/No)? N

Financial Condition Parameters

- # 40 Economic accounting method: NPV & Disc Avg Cost
- # 36 System selling price (\$/mil. Btu):
selling price is a multiple of:
fossil fuel price, factor= 1.41
- # 33 Study period: 22 years; Intervals of 1 year
- # 41 Resource assessment period 2 yrs
Ann'l resource assess. cost(\$thous): 50.
- # 16 Well cost adjustment factor: 0.894
Adj. total cost of wells(\$thou): 1100.000
- # 17 Heat exch. cost adjustment factor: 1.000
Adj tot cost of heat exchs(\$thou): 35.506 (* projected *)
- # 24 Storage tank capacity: 0.0 hours of flow
- <press "RETURN" to continue>

COMMERCIAL SCENARIO
(0% Rate of Return)

#	Capital Equipment	Amort. Per.	Phys. Life
# 15	Wells	30. yrs*	30. yrs
	Piping system	30. yrs*	30. yrs
	Heat exchanger	10. yrs*	10. yrs
	Pumps	10. yrs*	10. yrs
	Hookups	30. yrs*	30. yrs
	Peaking boiler	30. yrs*	30. yrs
	Storage tank	0. yrs*	30. yrs

*(reduced as needed to end in study period)

<press "RETURN" to continue>

37 Discount rate (percent): 4.00

27 Interest rate (percent): 12.00

25 Cost calculations are in REAL dollars

Inflation rate (percent): 8.00

20 Cost of electricity (cts/kwh)

compounding function used with:

initial elec. price= 5.60

percent annual change= 3.00

29 Fossil fuel cost (\$/mil. Btu)

compounding function used with:

initial foss. fuel price= 7.580

percent annual change= 3.000

44 Oper. & maint. cost (% of capital): 1.00%

30 Boiler cost(\$/100K Btu/hr): 2000.00

22 Distrib sys pipe cost(\$thou/mi): 250.000

<press "RETURN" to continue>

Residential-commercial option in effect.

The scenario has a resource assessment period of 2 years.

Time horizon is 22 years, with costs calculated every 1 year

Dollar values are in real dollars.

System will be sized to meet the specified demand conditions.

The system will be a hybrid geothermal system.

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

* * Cost of Initial Capital Equipment * *

Wells:	\$	1100.000	thousand
Distribution system:	\$	0.000	thousand
Heat exchangers:	\$	28.619	thousand
Pumps:	\$	64.446	thousand
Hookups:	\$	70.104	thousand
Peaking boiler:	\$	248.117	thousand
Transport system:	\$	854.899	thousand
Storage tank:	\$	0.000	thousand

* Total *	\$	2366.185	thousand

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	2366.185
Net Present Value (\$ thou.): \$	3.725
Discounted Average Cost (\$/mil. Btu): \$	14.647
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	6.453
Break-even point in year 21	
Total Savings in Operating Costs(thou):\$	3958.871
Payback achieved in year 15	

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 0

Peak total flow (gpm):	0.00
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	0.00
Total system Btu's (millions):	0.00
Pumping energy:	0.000 million kwh
Coefficient of performance:	0.00
Percentage geothermal utilization:	0.00
Percentage service geothermal:	0.00

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	0.000
Distribution system costs:	0.000
Heat exchanger costs:	0.000
Original pump costs:	0.000
Hookup costs:	0.000
Pump overhaul costs:	0.000
Annual pumping costs:	0.000
Peaking boiler costs:	0.000
Fossil fuel costs:	0.000
Transport costs:	0.000
Storage tank costs:	0.000
Operation and maintenance costs:	0.000
Resource assessment costs:	50.000

<Press "RETURN" to continue>

Total annual wellhead costs:	50.000
Total annual system costs:	50.000
Wellhead cost per geo mil. Btu(\$):	*****
System cost per mil. Btu(\$):	*****
Revenue (\$ thousands):	0.000
Net revenue (\$ thousands):	-50.000
Oper cost saved this yr(\$thou):	0.000
Oper cost saved so far(\$thou):	0.000

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 1

Peak total flow (gpm):	0.00
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	0.00
Total system Btu's (millions):	0.00
Pumping energy:	0.000 million kwh
Coefficient of performance:	0.00
Percentage geothermal utilization:	0.00
Percentage service geothermal:	0.00

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	0.000
Distribution system costs:	0.000
Heat exchanger costs:	0.000
Original pump costs:	0.000
Hookup costs:	0.000
Pump overhaul costs:	0.000
Annual pumping costs:	0.000
Peaking boiler costs:	0.000
Fossil fuel costs:	0.000
Transport costs:	0.000
Storage tank costs:	0.000
Operation and maintenance costs:	0.000
Resource assessment costs:	50.000

<Press "RETURN" to continue>

Total annual wellhead costs:	50.000
Total annual system costs:	50.000
Wellhead cost per geo mil. Btu(\$):	*****
System cost per mil. Btu(\$):	*****
Revenue (\$ thousands):	0.000
Net revenue (\$ thousands):	-50.000
Oper cost saved this yr(\$thou):	0.000
Oper cost saved so far(\$thou):	0.000

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 2

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.640 million kwh
Coefficient of performance:	8.77
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	147.267
Distribution system costs:	0.000
Heat exchanger costs:	5.065
Original pump costs:	11.406
Hookup costs:	11.279
Pump overhaul costs:	9.536
Annual pumping costs:	38.026
Peaking boiler costs:	33.218
Fossil fuel costs:	25.381
Transport costs:	114.453
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	180.956
Total annual system costs:	419.293
Wellhead cost per geo mil. Btu(\$):	9.45
System cost per mil. Btu(\$):	19.48
Revenue (\$ thousands):	244.083
Net revenue (\$ thousands):	-175.209
Oper cost saved this yr(\$thou):	143.165
Oper cost saved so far(\$thou):	143.165

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 3

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.640 million kwh
Coefficient of performance:	8.77
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	136.358
Distribution system costs:	0.000
Heat exchanger costs:	4.690
Original pump costs:	10.561
Hookup costs:	10.444
Pump overhaul costs:	9.536
Annual pumping costs:	39.167
Peaking boiler costs:	30.757
Fossil fuel costs:	26.143
Transport costs:	105.975
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	169.103
Total annual system costs:	397.292
Wellhead cost per geo mil. Btu(\$):	8.83
System cost per mil. Btu(\$):	18.46
Revenue (\$ thousands):	251.406
Net revenue (\$ thousands):	-145.886
Oper cost saved this yr(\$thou):	148.170
Oper cost saved so far(\$thou):	291.335

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 4

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.652 million kwh
Coefficient of performance:	8.60
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	126.257
Distribution system costs:	0.000
Heat exchanger costs:	4.342
Original pump costs:	9.779
Hookup costs:	9.670
Pump overhaul costs:	9.536
Annual pumping costs:	41.118
Peaking boiler costs:	28.479
Fossil fuel costs:	26.927
Transport costs:	98.125
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	158.128
Total annual system costs:	377.895
Wellhead cost per geo mil. Btu(\$):	8.26
System cost per mil. Btu(\$):	17.55
Revenue (\$ thousands):	258.948
Net revenue (\$ thousands):	-118.947
Oper cost saved this yr(\$thou):	152.549
Oper cost saved so far(\$thou):	443.884

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 5

Peak total flow (gpm):	231.86
Number of households:	10.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.652 million kwh
Coefficient of performance:	8.60
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	116.905
Distribution system costs:	0.000
Heat exchanger costs:	4.021
Original pump costs:	9.054
Hookup costs:	8.954
Pump overhaul costs:	9.536
Annual pumping costs:	42.352
Peaking boiler costs:	26.369
Fossil fuel costs:	27.735
Transport costs:	90.856
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	147.966
Total annual system costs:	359.444
Wellhead cost per geo mil. Btu(\$):	7.73
System cost per mil. Btu(\$):	16.70
Revenue (\$ thousands):	266.716
Net revenue (\$ thousands):	-92.727
Oper cost saved this yr(\$thou):	157.835
Oper cost saved so far(\$thou):	601.719

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 11

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.671 million kwh
Coefficient of performance:	8.37
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	73.670
Distribution system costs:	0.000
Heat exchanger costs:	2.534
Original pump costs:	5.706
Hookup costs:	5.642
Pump overhaul costs:	9.536
Annual pumping costs:	52.018
Peaking boiler costs:	16.617
Fossil fuel costs:	33.117
Transport costs:	57.255
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	100.988
Total annual system costs:	279.757
Wellhead cost per geo mil. Btu(\$):	5.27
System cost per mil. Btu(\$):	13.00
Revenue (\$ thousands):	318.473
Net revenue (\$ thousands):	38.717
Oper cost saved this yr(\$thou):	191.608
Oper cost saved so far(\$thou):	1663.021

COMMERCIAL SCENARIO

(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 12

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.675 million kwh
Coefficient of performance:	8.32
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	68.213
Distribution system costs:	0.000
Heat exchanger costs:	5.065
Original pump costs:	11.406
Hookup costs:	5.224
Pump overhaul costs:	9.536
Annual pumping costs:	53.893
Peaking boiler costs:	15.386
Fossil fuel costs:	34.110
Transport costs:	53.014
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	101.902
Total annual system costs:	279.510
Wellhead cost per geo mil. Btu(\$):	5.32
System cost per mil. Btu(\$):	12.98
Revenue (\$ thousands):	328.028
Net revenue (\$ thousands):	48.518
Oper cost saved this yr(\$thou):	197.751
Oper cost saved so far(\$thou):	1860.772

A-1
COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 13

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.675 million kwh
Coefficient of performance:	8.32
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	63.160
Distribution system costs:	0.000
Heat exchanger costs:	4.690
Original pump costs:	10.561
Hookup costs:	4.837
Pump overhaul costs:	9.536
Annual pumping costs:	55.510
Peaking boiler costs:	14.246
Fossil fuel costs:	35.134
Transport costs:	49.087
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	95.905
Total annual system costs:	270.423
Wellhead cost per geo mil. Btu(\$):	5.01
System cost per mil. Btu(\$):	12.56
Revenue (\$ thousands):	337.868
Net revenue (\$ thousands):	67.445
Oper cost saved this yr(\$thou):	204.393
Oper cost saved so far(\$thou):	2065.165

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 14

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.678 million kwh
Coefficient of performance:	8.28
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	58.482
Distribution system costs:	0.000
Heat exchanger costs:	4.342
Original pump costs:	9.779
Hookup costs:	4.479
Pump overhaul costs:	9.536
Annual pumping costs:	57.461
Peaking boiler costs:	13.191
Fossil fuel costs:	36.188
Transport costs:	45.451
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	90.352
Total annual system costs:	262.570
Wellhead cost per geo mil. Btu(\$):	4.72
System cost per mil. Btu(\$):	12.20
Revenue (\$ thousands):	348.004
Net revenue (\$ thousands):	85.434
Oper cost saved this yr(\$thou):	210.949
Oper cost saved so far(\$thou):	2276.115

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 19

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.684 million kwh
Coefficient of performance:	8.21
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	39.802
Distribution system costs:	0.000
Heat exchanger costs:	2.955
Original pump costs:	6.655
Hookup costs:	3.048
Pump overhaul costs:	9.536
Annual pumping costs:	67.159
Peaking boiler costs:	8.978
Fossil fuel costs:	41.951
Transport costs:	30.933
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	68.181
Total annual system costs:	234.680
Wellhead cost per geo mil. Btu(\$):	3.56
System cost per mil. Btu(\$):	10.90
Revenue (\$ thousands):	403.433
Net revenue (\$ thousands):	168.752
Oper cost saved this yr(\$thou):	247.770
Oper cost saved so far(\$thou):	3439.141

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 20

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.686 million kwh
Coefficient of performance:	8.18
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	36.853
Distribution system costs:	0.000
Heat exchanger costs:	2.737
Original pump costs:	6.162
Hookup costs:	2.823
Pump overhaul costs:	9.536
Annual pumping costs:	69.412
Peaking boiler costs:	8.313
Fossil fuel costs:	43.210
Transport costs:	28.642
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	64.682
Total annual system costs:	231.349
Wellhead cost per geo mil. Btu(\$):	3.38
System cost per mil. Btu(\$):	10.75
Revenue (\$ thousands):	415.536
Net revenue (\$ thousands):	184.186
Oper cost saved this yr(\$thou):	255.675
Oper cost saved so far(\$thou):	3694.816

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 21

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.686 million kwh
Coefficient of performance:	8.18
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	34.123
Distribution system costs:	0.000
Heat exchanger costs:	2.534
Original pump costs:	5.706
Hookup costs:	2.613
Pump overhaul costs:	9.536
Annual pumping costs:	71.495
Peaking boiler costs:	7.697
Fossil fuel costs:	44.506
Transport costs:	26.520
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	61.442
Total annual system costs:	228.393
Wellhead cost per geo mil. Btu(\$):	3.21
System cost per mil. Btu(\$):	10.61
Revenue (\$ thousands):	428.002
Net revenue (\$ thousands):	199.609
(Break-even point achieved in this year)	
Oper cost saved this yr(\$thou):	264.055
Oper cost saved so far(\$thou):	3958.871

Summary of Finances Over Life of Project

Capital Cost (\$ thousands):	2366.185
Net Present Value (\$ thous.):	3.725
Discounted Avg Cost (\$/mil.Btu):	14.647
Disc.Avg.Wellhead Cost(\$/mil.Btu):	6.453
Break-even point achieved in year 21	
Tot. Oper. Cost Savings(\$thou):	3958.871
Payback achieved in year 15	

COMMERCIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)
 (Base period for costs is 2nd Quarter, 1981)

Option? 7

At what detail should the results be printed at the terminal:
 (output to file, if any, is unaffected)

1-only final net present value or discounted average cost

2-annual summary for each calculated year

3-full details for each calculated year

4-full details for selected years

Type in number to begin execution: 2

For year 0:

Average system cost per million Btu: \$*****	
Total annual system cost (\$ thou.): \$	50.000
Average wellhead cost per million geo Btu: \$*****	
Total annual wellhead cost (\$ thou.): \$	50.000
Total annual system revenue (\$ thou.): \$	0.000
Net annual system revenue (\$ thou.): \$	-50.000
Savings in operating costs this yr(thou):\$	0.000
Savings in operating costs so far(thou):\$	0.000

For year 1:

Average system cost per million Btu: \$*****	
Total annual system cost (\$ thou.): \$	50.000
Average wellhead cost per million geo Btu: \$*****	
Total annual wellhead cost (\$ thou.): \$	50.000
Total annual system revenue (\$ thou.): \$	0.000
Net annual system revenue (\$ thou.): \$	-50.000
Savings in operating costs this yr(thou):\$	0.000
Savings in operating costs so far(thou):\$	0.000

For year 2:

Average system cost per million Btu: \$	19.48
Total annual system cost (\$ thou.): \$	419.293
Average wellhead cost per million geo Btu: \$	9.45
Total annual wellhead cost (\$ thou.): \$	180.956
Total annual system revenue (\$ thou.): \$	244.083
Net annual system revenue (\$ thou.): \$	-175.209
Savings in operating costs this yr(thou):\$	143.165
Savings in operating costs so far(thou):\$	143.165

COMMERCIAL SCENARIO
(0% Rate of Return)

For year 3:

Average system cost per million Btu: \$	18.46
Total annual system cost (\$ thou.): \$	397.292
Average wellhead cost per million geo Btu: \$	8.83
Total annual wellhead cost (\$ thou.): \$	169.103
Total annual system revenue (\$ thou.): \$	251.406
Net annual system revenue (\$ thou.): \$	-145.886
Savings in operating costs this yr(thou):\$	148.170
Savings in operating costs so far(thou):\$	291.335

For year 4:

Average system cost per million Btu: \$	17.55
Total annual system cost (\$ thou.): \$	377.895
Average wellhead cost per million geo Btu: \$	8.26
Total annual wellhead cost (\$ thou.): \$	158.128
Total annual system revenue (\$ thou.): \$	258.948
Net annual system revenue (\$ thou.): \$	-118.947
Savings in operating costs this yr(thou):\$	152.549
Savings in operating costs so far(thou):\$	443.884

For year 5:

Average system cost per million Btu: \$	16.70
Total annual system cost (\$ thou.): \$	359.444
Average wellhead cost per million geo Btu: \$	7.73
Total annual wellhead cost (\$ thou.): \$	147.966
Total annual system revenue (\$ thou.): \$	266.716
Net annual system revenue (\$ thou.): \$	-92.727
Savings in operating costs this yr(thou):\$	157.835
Savings in operating costs so far(thou):\$	601.719

For year 6:

Average system cost per million Btu: \$	15.94
Total annual system cost (\$ thou.): \$	343.106
Average wellhead cost per million geo Btu: \$	7.23
Total annual wellhead cost (\$ thou.): \$	138.557
Total annual system revenue (\$ thou.): \$	274.718
Net annual system revenue (\$ thou.): \$	-68.388
Savings in operating costs this yr(thou):\$	162.746
Savings in operating costs so far(thou):\$	764.465

For year 7:

Average system cost per million Btu: \$	15.22
Total annual system cost (\$ thou.): \$	327.719
Average wellhead cost per million geo Btu: \$	6.78
Total annual wellhead cost (\$ thou.): \$	129.845
Total annual system revenue (\$ thou.): \$	282.960
Net annual system revenue (\$ thou.): \$	-44.759
Savings in operating costs this yr(thou):\$	168.338
Savings in operating costs so far(thou):\$	932.803

COMMERCIAL SCENARIO
(0% Rate of Return)

For year 8:

Average system cost per million Btu: \$	14.59
Total annual system cost (\$ thou.): \$	314.120
Average wellhead cost per million geo Btu: \$	6.36
Total annual wellhead cost (\$ thou.): \$	121.778
Total annual system revenue (\$ thou.): \$	291.448
Net annual system revenue (\$ thou.): \$	-22.672
Savings in operating costs this yr(thou):\$	173.676
Savings in operating costs so far(thou):\$	1106.479

For year 9:

Average system cost per million Btu: \$	14.00
Total annual system cost (\$ thou.): \$	301.384
Average wellhead cost per million geo Btu: \$	5.97
Total annual wellhead cost (\$ thou.): \$	114.308
Total annual system revenue (\$ thou.): \$	300.192
Net annual system revenue (\$ thou.): \$	-1.193
Savings in operating costs this yr(thou):\$	179.596
Savings in operating costs so far(thou):\$	1286.076

For year 10:

Average system cost per million Btu: \$	13.48
Total annual system cost (\$ thou.): \$	290.191
Average wellhead cost per million geo Btu: \$	5.61
Total annual wellhead cost (\$ thou.): \$	107.392
Total annual system revenue (\$ thou.): \$	309.198
Net annual system revenue (\$ thou.): \$	19.007
Savings in operating costs this yr(thou):\$	185.338
Savings in operating costs so far(thou):\$	1471.413

For year 11:

Average system cost per million Btu: \$	13.00
Total annual system cost (\$ thou.): \$	279.757
Average wellhead cost per million geo Btu: \$	5.27
Total annual wellhead cost (\$ thou.): \$	100.988
Total annual system revenue (\$ thou.): \$	318.473
Net annual system revenue (\$ thou.): \$	38.717
Savings in operating costs this yr(thou):\$	191.608
Savings in operating costs so far(thou):\$	1663.021

For year 12:

Average system cost per million Btu: \$	12.98
Total annual system cost (\$ thou.): \$	279.510
Average wellhead cost per million geo Btu: \$	5.32
Total annual wellhead cost (\$ thou.): \$	101.902
Total annual system revenue (\$ thou.): \$	328.028
Net annual system revenue (\$ thou.): \$	48.518
Savings in operating costs this yr(thou):\$	197.751
Savings in operating costs so far(thou):\$	1860.772

COMMERCIAL SCENARIO
(0% Rate of Return)

For year 13:

Average system cost per million Btu: \$	12.56
Total annual system cost (\$ thou.): \$	270.423
Average wellhead cost per million geo Btu: \$	5.01
Total annual wellhead cost (\$ thou.): \$	95.905
Total annual system revenue (\$ thou.): \$	337.868
Net annual system revenue (\$ thou.): \$	67.445
Savings in operating costs this yr(thou):\$	204.393
Savings in operating costs so far(thou):\$	2065.165

For year 14:

Average system cost per million Btu: \$	12.20
Total annual system cost (\$ thou.): \$	262.570
Average wellhead cost per million geo Btu: \$	4.72
Total annual wellhead cost (\$ thou.): \$	90.352
Total annual system revenue (\$ thou.): \$	348.004
Net annual system revenue (\$ thou.): \$	85.434
Savings in operating costs this yr(thou):\$	210.949
Savings in operating costs so far(thou):\$	2276.115

For year 15:

Average system cost per million Btu: \$	11.86
Total annual system cost (\$ thou.): \$	255.326
Average wellhead cost per million geo Btu: \$	4.45
Total annual wellhead cost (\$ thou.): \$	85.211
Total annual system revenue (\$ thou.): \$	358.445
Net annual system revenue (\$ thou.): \$	103.119
Savings in operating costs this yr(thou):\$	217.988
Savings in operating costs so far(thou):\$	2494.103

Payback achieved in this year.

For year 16:

Average system cost per million Btu: \$	11.58
Total annual system cost (\$ thou.): \$	249.176
Average wellhead cost per million geo Btu: \$	4.20
Total annual wellhead cost (\$ thou.): \$	80.450
Total annual system revenue (\$ thou.): \$	369.198
Net annual system revenue (\$ thou.): \$	120.022
Savings in operating costs this yr(thou):\$	224.972
Savings in operating costs so far(thou):\$	2719.075

For year 17:

Average system cost per million Btu: \$	11.31
Total annual system cost (\$ thou.): \$	243.545
Average wellhead cost per million geo Btu: \$	3.97
Total annual wellhead cost (\$ thou.): \$	76.042
Total annual system revenue (\$ thou.): \$	380.274
Net annual system revenue (\$ thou.): \$	136.729
Savings in operating costs this yr(thou):\$	232.431
Savings in operating costs so far(thou):\$	2951.506

COMMERCIAL SCENARIO
(0% Rate of Return)

For year 18:

Average system cost per million Btu: \$	11.10
Total annual system cost (\$ thou.): \$	238.892
Average wellhead cost per million geo Btu: \$	3.76
Total annual wellhead cost (\$ thou.): \$	71.960
Total annual system revenue (\$ thou.): \$	391.682
Net annual system revenue (\$ thou.): \$	152.790
Savings in operating costs this yr(thou):\$	239.864
Savings in operating costs so far(thou):\$	3191.371

For year 19:

Average system cost per million Btu: \$	10.90
Total annual system cost (\$ thou.): \$	234.680
Average wellhead cost per million geo Btu: \$	3.56
Total annual wellhead cost (\$ thou.): \$	68.181
Total annual system revenue (\$ thou.): \$	403.433
Net annual system revenue (\$ thou.): \$	168.752
Savings in operating costs this yr(thou):\$	247.770
Savings in operating costs so far(thou):\$	3439.141

For year 20:

Average system cost per million Btu: \$	10.75
Total annual system cost (\$ thou.): \$	231.349
Average wellhead cost per million geo Btu: \$	3.38
Total annual wellhead cost (\$ thou.): \$	64.682
Total annual system revenue (\$ thou.): \$	415.536
Net annual system revenue (\$ thou.): \$	184.186
Savings in operating costs this yr(thou):\$	255.675
Savings in operating costs so far(thou):\$	3694.816

For year 21:

Average system cost per million Btu: \$	10.61
Total annual system cost (\$ thou.): \$	228.393
Average wellhead cost per million geo Btu: \$	3.21
Total annual wellhead cost (\$ thou.): \$	61.442
Total annual system revenue (\$ thou.): \$	428.002
Net annual system revenue (\$ thou.): \$	199.609
Break-even point achieved in this year.	
Savings in operating costs this yr(thou):\$	264.055
Savings in operating costs so far(thou):\$	3958.871

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	2366.185
Net Present Value (\$ thou.): \$	3.725
Discounted Average Cost (\$/mil. Btu): \$	14.647
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	6.453
Break-even point in year 21	
Total Savings in Operating Costs(thou):\$	3958.871
Payback achieved in year 15	

A-2

COMMERCIAL SCENARIO

(8% RATE OF RETURN)

ZONE ABCDFHS

COMMERCIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)
(Base period for costs is 2nd Quarter, 1981)

Residential-Commercial Scenario Parameters

Financial Condition Parameters

```
# 40 Economic accounting method: NPV & Disc Avg Cost
# 36 System selling price ($/mil. Btu):
      selling price is a multiple of:
      fossil fuel price, factor=      1.52
# 33 Study period: 22 years; Intervals of 1 year
# 41 Resource assessment period      2 yrs
      Ann'l resource assess. cost($thous): 50.
# 16 Well cost adjustment factor:    0.894
      Adj. total cost of wells($thou): 1100.000
# 17 Heat exch. cost adjustment factor: 1.000
      Adj tot cost of heat exchs($thou): 35.506 (* projected *)
# 24 Storage tank capacity: 0.0 hours of flow
<press "RETURN" to continue>
# 15 Capital Equipment Amort. Per. Phys. Life
      Wells      30. yrs*      30. yrs
      Piping system 30. yrs*      30. yrs
      Heat exchanger 10. yrs*      10. yrs
      Pumps      10. yrs*      10. yrs
      Hookups    30. yrs*      30. yrs
      Peaking boiler 30. yrs*      30. yrs
      Storage tank 0. yrs*      30. yrs
      *(reduced as needed to end in study period)
<press "RETURN" to continue>
# 37 Discount rate (percent):      4.00
# 27 Interest rate (percent):      12.00
# 25 Cost calculations are in REAL dollars.
      Inflation rate (percent):      8.00
# 20 Cost of electricity (cts/kwh)
      compounding function used with:
      initial elec. price= 5.60
      percent annual change= 3.00
# 29 Fossil fuel cost ($/mil. Btu)
      compounding function used with:
      initial foss. fuel price= 7.580
      percent annual change= 3.000
# 44 Oper. & maint. cost (% of capital): 1.00%
# 30 Boiler cost($/100K Btu/hr): 2000.00
# 22 Distrib sys pipe cost($thou/mi): 250.000
<press "RETURN" to continue>
```

Residential-commercial option in effect.

The scenario has a resource assessment period of 2 years.
Time horizon is 22 years, with costs calculated every 1 year
Dollar values are in real dollars.
System will be sized to meet the specified demand conditions.
The system will be a hybrid geothermal system.

COMMERCIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

*** * Cost of Initial Capital Equipment * ***

Wells:	\$	1100.000	thousand
Distribution system:	\$	0.000	thousand
Heat exchangers:	\$	28.619	thousand
Pumps:	\$	64.446	thousand
Hookups:	\$	70.104	thousand
Peaking boiler:	\$	248.117	thousand
Transport system:	\$	854.899	thousand
Storage tank:	\$	0.000	thousand
<hr/>			
* Total *	\$	2366.185	thousand

Summary of Finances Over Life of Project

Capital Cost (excl replacement) (\$thou):	\$	2366.185
Net Present Value (\$ thou.):	\$	334.225
Discounted Average Cost (\$/mil. Btu):	\$	14.647
Discounted Avg Wellhead Cost (\$/mil. Btu):	\$	6.453
Break-even point in year 18		
Total Savings in Operating Costs (thou):	\$	3958.871
Payback achieved in year 15		

COMMERCIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 2

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.640 million kwh
Coefficient of performance:	8.77
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	147.267
Distribution system costs:	0.000
Heat exchanger costs:	5.065
Original pump costs:	11.406
Hookup costs:	11.279
Pump overhaul costs:	9.536
Annual pumping costs:	38.026
Peaking boiler costs:	33.218
Fossil fuel costs:	25.381
Transport costs:	114.453
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	180.956
Total annual system costs:	419.293
Wellhead cost per geo mil. Btu(\$):	9.45
System cost per mil. Btu(\$):	19.48
Revenue (\$ thousands):	263.645
Net revenue (\$ thousands):	-155.648
Oper cost saved this yr(\$thou):	143.165
Oper cost saved so far(\$thou):	143.165

COMMERCIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 3

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.640 million kwh
Coefficient of performance:	8.77
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	136.358
Distribution system costs:	0.000
Heat exchanger costs:	4.690
Original pump costs:	10.561
Hookup costs:	10.444
Pump overhaul costs:	9.536
Annual pumping costs:	39.167
Peaking boiler costs:	30.757
Fossil fuel costs:	26.143
Transport costs:	105.975
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	169.103
Total annual system costs:	397.292
Wellhead cost per geo mil. Btu(\$):	8.83
System cost per mil. Btu(\$):	18.46
Revenue (\$ thousands):	271.554
Net revenue (\$ thousands):	-125.738
Oper cost saved this yr(\$thou):	148.170
Oper cost saved so far(\$thou):	291.335

COMMERCIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 4

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.652 million kwh
Coefficient of performance:	8.60
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	126.257
Distribution system costs:	0.000
Heat exchanger costs:	4.342
Original pump costs:	9.779
Hookup costs:	9.670
Pump overhaul costs:	9.536
Annual pumping costs:	41.118
Peaking boiler costs:	28.479
Fossil fuel costs:	26.927
Transport costs:	98.125
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	158.128
Total annual system costs:	377.895
Wellhead cost per geo mil. Btu(\$):	8.26
System cost per mil. Btu(\$):	17.55
Revenue (\$ thousands):	279.701
Net revenue (\$ thousands):	-98.195
Oper cost saved this yr(\$thou):	152.549
Oper cost saved so far(\$thou):	443.884

COMMERCIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 21

Peak total flow (gpm):	231.86
Number of households:	0.
Length of distribution system:	0.00 miles
Total residential Btu's (millions):	0.00
Total geothermal Btu's (millions):	19153.49
Total system Btu's (millions):	21526.60
Pumping energy:	0.686 million kwh
Coefficient of performance:	8.18
Percentage geothermal utilization:	37.72
Percentage service geothermal:	88.98

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	34.123
Distribution system costs:	0.000
Heat exchanger costs:	2.534
Original pump costs:	5.706
Hookup costs:	2.613
Pump overhaul costs:	9.536
Annual pumping costs:	71.495
Peaking boiler costs:	7.697
Fossil fuel costs:	44.506
Transport costs:	26.520
Storage tank costs:	0.000
Operation and maintenance costs:	23.662
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	61.442
Total annual system costs:	228.393
Wellhead cost per geo mil. Btu(\$):	3.21
System cost per mil. Btu(\$):	10.61
Revenue (\$ thousands):	462.302
Net revenue (\$ thousands):	233.910
Oper cost saved this yr(\$thou):	264.055
Oper cost saved so far(\$thou):	3958.871

COMMERCIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (1983 IS START OF STUDY PERIOD)
(Base period for costs is 2nd Quarter, 1981)

Option? 7

At what detail should the results be printed at the terminal:

(output to file, if any, is unaffected)

1-only final net present value or discounted average cost

2-annual summary for each calculated year

3-full details for each calculated year

4-full details for selected years

Type in number to begin execution: 2

For year 0:

Average system cost per million Btu:	*****
Total annual system cost (\$ thou.):	\$ 50.000
Average wellhead cost per million geo Btu:	*****
Total annual wellhead cost (\$ thou.):	\$ 50.000
Total annual system revenue (\$ thou.):	\$ 0.000
Net annual system revenue (\$ thou.):	\$ -50.000
Savings in operating costs this yr(thou):	\$ 0.000
Savings in operating costs so far(thou):	\$ 0.000

For year 1:

Average system cost per million Btu:	*****
Total annual system cost (\$ thou.):	\$ 50.000
Average wellhead cost per million geo Btu:	*****
Total annual wellhead cost (\$ thou.):	\$ 50.000
Total annual system revenue (\$ thou.):	\$ 0.000
Net annual system revenue (\$ thou.):	\$ -50.000
Savings in operating costs this yr(thou):	\$ 0.000
Savings in operating costs so far(thou):	\$ 0.000

For year 2:

Average system cost per million Btu:	\$ 19.48
Total annual system cost (\$ thou.):	\$ 419.293
Average wellhead cost per million geo Btu:	\$ 9.45
Total annual wellhead cost (\$ thou.):	\$ 180.956
Total annual system revenue (\$ thou.):	\$ 263.645
Net annual system revenue (\$ thou.):	\$ -155.648
Savings in operating costs this yr(thou):	\$ 143.165
Savings in operating costs so far(thou):	\$ 143.165

COMMERCIAL SCENARIO
(8% Rate of Return)

For year 3:

Average system cost per million Btu: \$	18.46
Total annual system cost (\$ thou.): \$	397.292
Average wellhead cost per million geo Btu: \$	8.83
Total annual wellhead cost (\$ thou.): \$	169.103
Total annual system revenue (\$ thou.): \$	271.554
Net annual system revenue (\$ thou.): \$	-125.738
Savings in operating costs this yr(thou):\$	148.170
Savings in operating costs so far(thou):\$	291.335

For year 4:

Average system cost per million Btu: \$	17.55
Total annual system cost (\$ thou.): \$	377.895
Average wellhead cost per million geo Btu: \$	8.26
Total annual wellhead cost (\$ thou.): \$	158.128
Total annual system revenue (\$ thou.): \$	279.701
Net annual system revenue (\$ thou.): \$	-98.195
Savings in operating costs this yr(thou):\$	152.549
Savings in operating costs so far(thou):\$	443.884

For year 5:

Average system cost per million Btu: \$	16.70
Total annual system cost (\$ thou.): \$	359.444
Average wellhead cost per million geo Btu: \$	7.73
Total annual wellhead cost (\$ thou.): \$	147.966
Total annual system revenue (\$ thou.): \$	288.092
Net annual system revenue (\$ thou.): \$	-71.352
Savings in operating costs this yr(thou):\$	157.835
Savings in operating costs so far(thou):\$	601.719

For year 6:

Average system cost per million Btu: \$	15.94
Total annual system cost (\$ thou.): \$	343.106
Average wellhead cost per million geo Btu: \$	7.23
Total annual wellhead cost (\$ thou.): \$	138.557
Total annual system revenue (\$ thou.): \$	296.734
Net annual system revenue (\$ thou.): \$	-46.372
Savings in operating costs this yr(thou):\$	162.746
Savings in operating costs so far(thou):\$	764.465

For year 7:

Average system cost per million Btu: \$	15.22
Total annual system cost (\$ thou.): \$	327.719
Average wellhead cost per million geo Btu: \$	6.78
Total annual wellhead cost (\$ thou.): \$	129.845
Total annual system revenue (\$ thou.): \$	305.636
Net annual system revenue (\$ thou.): \$	-22.082
Savings in operating costs this yr(thou):\$	168.338
Savings in operating costs so far(thou):\$	932.803

COMMERCIAL SCENARIO
(8% Rate of Return)

For year 8:

Average system cost per million Btu: \$	14.59
Total annual system cost (\$ thou.): \$	314.120
Average wellhead cost per million geo Btu: \$	6.36
Total annual wellhead cost (\$ thou.): \$	121.778
Total annual system revenue (\$ thou.): \$	314.806
Net annual system revenue (\$ thou.): \$	0.686
Savings in operating costs this yr(thou):\$	173.676
Savings in operating costs so far(thou):\$	1106.477

For year 9:

Average system cost per million Btu: \$	14.00
Total annual system cost (\$ thou.): \$	301.384
Average wellhead cost per million geo Btu: \$	5.97
Total annual wellhead cost (\$ thou.): \$	114.308
Total annual system revenue (\$ thou.): \$	324.250
Net annual system revenue (\$ thou.): \$	22.865
Savings in operating costs this yr(thou):\$	179.596
Savings in operating costs so far(thou):\$	1286.076

For year 10:

Average system cost per million Btu: \$	13.48
Total annual system cost (\$ thou.): \$	290.191
Average wellhead cost per million geo Btu: \$	5.61
Total annual wellhead cost (\$ thou.): \$	107.392
Total annual system revenue (\$ thou.): \$	333.977
Net annual system revenue (\$ thou.): \$	43.786
Savings in operating costs this yr(thou):\$	185.338
Savings in operating costs so far(thou):\$	1471.413

For year 11:

Average system cost per million Btu: \$	13.00
Total annual system cost (\$ thou.): \$	279.757
Average wellhead cost per million geo Btu: \$	5.27
Total annual wellhead cost (\$ thou.): \$	100.988
Total annual system revenue (\$ thou.): \$	343.996
Net annual system revenue (\$ thou.): \$	64.240
Savings in operating costs this yr(thou):\$	191.608
Savings in operating costs so far(thou):\$	1663.021

For year 12:

Average system cost per million Btu: \$	12.98
Total annual system cost (\$ thou.): \$	279.510
Average wellhead cost per million geo Btu: \$	5.32
Total annual wellhead cost (\$ thou.): \$	101.902
Total annual system revenue (\$ thou.): \$	354.316
Net annual system revenue (\$ thou.): \$	74.807
Savings in operating costs this yr(thou):\$	197.751
Savings in operating costs so far(thou):\$	1860.772

COMMERCIAL SCENARIO
(8% Rate of Return)

For year 13:

Average system cost per million Btu: \$	12.56
Total annual system cost (\$ thou.): \$	270.423
Average wellhead cost per million geo Btu: \$	5.01
Total annual wellhead cost (\$ thou.): \$	95.905
Total annual system revenue (\$ thou.): \$	364.946
Net annual system revenue (\$ thou.): \$	94.523
Savings in operating costs this yr(thou):\$	204.393
Savings in operating costs so far(thou):\$	2065.165

For year 14:

Average system cost per million Btu: \$	12.20
Total annual system cost (\$ thou.): \$	262.570
Average wellhead cost per million geo Btu: \$	4.72
Total annual wellhead cost (\$ thou.): \$	90.352
Total annual system revenue (\$ thou.): \$	375.894
Net annual system revenue (\$ thou.): \$	113.324
Savings in operating costs this yr(thou):\$	210.949
Savings in operating costs so far(thou):\$	2276.115

For year 15:

Average system cost per million Btu: \$	11.86
Total annual system cost (\$ thou.): \$	255.326
Average wellhead cost per million geo Btu: \$	4.45
Total annual wellhead cost (\$ thou.): \$	85.211
Total annual system revenue (\$ thou.): \$	387.171
Net annual system revenue (\$ thou.): \$	131.845
Savings in operating costs this yr(thou):\$	217.988
Savings in operating costs so far(thou):\$	2494.103
Payback achieved in this year.	

For year 16:

Average system cost per million Btu: \$	11.58
Total annual system cost (\$ thou.): \$	249.176
Average wellhead cost per million geo Btu: \$	4.20
Total annual wellhead cost (\$ thou.): \$	80.450
Total annual system revenue (\$ thou.): \$	398.786
Net annual system revenue (\$ thou.): \$	149.610
Savings in operating costs this yr(thou):\$	224.972
Savings in operating costs so far(thou):\$	2719.075

For year 17:

Average system cost per million Btu: \$	11.31
Total annual system cost (\$ thou.): \$	243.545
Average wellhead cost per million geo Btu: \$	3.97
Total annual wellhead cost (\$ thou.): \$	76.042
Total annual system revenue (\$ thou.): \$	410.750
Net annual system revenue (\$ thou.): \$	167.205
Savings in operating costs this yr(thou):\$	232.431
Savings in operating costs so far(thou):\$	2951.506

COMMERCIAL SCENARIO
(8% Rate of Return)

For year 18:

Average system cost per million Btu: \$	11.10
Total annual system cost (\$ thou.): \$	238.892
Average wellhead cost per million geo Btu: \$	3.76
Total annual wellhead cost (\$ thou.): \$	71.960
Total annual system revenue (\$ thou.): \$	423.072
Net annual system revenue (\$ thou.): \$	184.180
Break-even point achieved in this year.	
Savings in operating costs this yr(thou):\$	239.864
Savings in operating costs so far(thou):\$	3191.371

For year 19:

Average system cost per million Btu: \$	10.90
Total annual system cost (\$ thou.): \$	234.680
Average wellhead cost per million geo Btu: \$	3.56
Total annual wellhead cost (\$ thou.): \$	68.181
Total annual system revenue (\$ thou.): \$	435.764
Net annual system revenue (\$ thou.): \$	201.084
Savings in operating costs this yr(thou):\$	247.770
Savings in operating costs so far(thou):\$	3439.141

For year 20:

Average system cost per million Btu: \$	10.75
Total annual system cost (\$ thou.): \$	231.349
Average wellhead cost per million geo Btu: \$	3.38
Total annual wellhead cost (\$ thou.): \$	64.682
Total annual system revenue (\$ thou.): \$	448.837
Net annual system revenue (\$ thou.): \$	217.488
Savings in operating costs this yr(thou):\$	255.675
Savings in operating costs so far(thou):\$	3694.816

For year 21:

Average system cost per million Btu: \$	10.61
Total annual system cost (\$ thou.): \$	228.393
Average wellhead cost per million geo Btu: \$	3.21
Total annual wellhead cost (\$ thou.): \$	61.442
Total annual system revenue (\$ thou.): \$	462.302
Net annual system revenue (\$ thou.): \$	233.910
Savings in operating costs this yr(thou):\$	264.055
Savings in operating costs so far(thou):\$	3958.871

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	2366.185
Net Present Value (\$ thou.): \$	334.225
Discounted Average Cost (\$/mil. Btu): \$	14.647
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	6.453
Break-even point in year 18	
Total Savings in Operating Costs(thou):\$	3958.871
Payback achieved in year 15	

A-3

COMMERCIAL-RESIDENTIAL SCENARIO

(0% RATE OF RETURN)

ZONE ABCDFHS

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)
 (Base period for costs is 2nd Quarter, 1981)
 Residential-Commercial Scenario Parameters
 (All sets of options will be listed)

Program Operating Conditions

-
- # 0 Standard geothermal system
 # 2 Output file name:
 # 4 Title of scenario: (displayed above, if any)
 # 5 Residential-Commercial service chosen.
 # 8 Data files will not be generated.
 # 9 System will be sized according to RESOURCE conditions.

Do you wish to change any of these options now (Yes/No)? N

Resource Condition Parameters

-
- # 42 Number of production wells: 1
 # 12 Depth of upwell (feet): 6000.
 # 11 Wellhead water temp. (deg. Fahr.)
 linear function used with:
 initial water temp.= 160.0
 annual drop in temp.= 0.0
 # 21 Reject temperature (deg. Fahr.): 110.0
 # 43 Number of reinjection wells: 1
 # 23 Depth of reinjection well (feet): 3000.
 <press "RETURN" to continue>
 # 26 Drawdown of upwell (percent)
 determined from aquifer characteristics:
 Pumping cycle: Space heating application
 Transmissivity= 0.500 sq.cm./sec.
 Aq.Stor.Coeff.= 0.003900; Well Radius=12.0 in.
 # 32 Maximum flow per well (gpm)
 linear function used with:
 initial flow= 300.00
 annual change= 0.00
 # 38 Transport distance (miles) carrying flow of...
 1 wells' flow to distn. system: 1.500
 1 wells' flow to reinj. well: 0.520

Do you wish to change any of these options now (Yes/No)? N

Residential-Commercial Demand Condition Parameters

-
- # 10 Area under consideration: BERLIN
 # 14 System design temp. (deg. Fahr.): 40
 # 28 Min. ambient temperature (deg. Fahr.): -20.
 # 35 Fraction of distribution system installed:
 in year 2 =100.000%

<press "RETURN" to continue>

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

(Residential-Specific)

13 Percentages of housing types on system:

Housing type	(%)	(Btu/hr/deg)
1-single family suburban:	100.000	1200.
2-single family dense:	0.000	1200.
3-townhouse:	0.000	780.
4-garden apts.:	0.000	420.
5-high rise:	0.000	348.

34 Market saturation (%): 50.00

19 Rate of residential market penetration
linear function used with:
initial percentage= 100.00
annual change = 0.00

18 Hookup cost per household:

Housing type	(\$)
1-single family suburban:	1500.00
2-single family dense:	1500.00
3-townhouse:	1500.00
4-garden apts.:	400.00
5-high rise:	400.00

Avg hookup cost per household: 1500.00

39 Domestic hot water(mil.Btu/yr/hh): 20.10

<press "RETURN" to continue>

(Commercial-Specific)

45 Number of types of commercial buildings: 7

46 Avg. floor space for each commercial building of

type	sq. ft.
type 1 :	3.000 thousand
type 2 :	19.200 thousand
type 3 :	75.000 thousand
type 4 :	49.000 thousand
type 5 :	5.000 thousand
type 6 :	5.000 thousand
type 7 :	6.000 thousand

47 Average heat demand for

Buildings of	Space Heat (Btu/sqft/deg/day)	Hot Water Heat (Btu/sqft/day)
type 1:	16.3	9.0
type 2:	6.5	9.0
type 3:	22.3	9.0
type 4:	16.1	9.0
type 5:	72.4	640.0
type 6:	14.5	410.6
type 7:	25.8	9.0

48 Number of commercial buildings of

type	count
type 1 :	40
type 2 :	1
type 3 :	1
type 4 :	1
type 5 :	1
type 6 :	1
type 7 :	1

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

51 Rate of commercial market penetration
linear function used with:
initial percentage= 100.00
annual change = 0.00

50 Length of commercial distrib. sys: 0.00 miles
49 Avg cost per hookup of a commer. bldg: \$ 1524.
Do you wish to change any of these options now (Yes/No)? N
Financial Condition Parameters

40 Economic accounting method: NPV & Disc Avg Cost
36 System selling price (\$/mil. Btu):
selling price is a multiple of:
fossil fuel price, factor= 1.38

33 Study period: 22 years; Intervals of 1 year
41 Resource assessment period 2 yrs
Ann'l resource assess. cost(\$thous): 50.
16 Well cost adjustment factor: 0.894
Adj. total cost of wells(\$thou): 1100.000
17 Heat exch. cost adjustment factor: 1.000
Adj tot cost of heat exchs(\$thou): 35.506
24 Storage tank capacity: 0.0 hours of flow
<press "RETURN" to continue>

# 15	Capital Equipment	Amort. Per.	Phys. Life
	Wells	30. yrs*	30. yrs
	Piping system	30. yrs*	30. yrs
	Heat exchanger	10. yrs*	10. yrs
	Pumps	10. yrs*	10. yrs
	Hookups	30. yrs*	30. yrs
	Peaking boiler	30. yrs*	30. yrs
	Storage tank	0. yrs*	30. yrs

*(reduced as needed to end in study period)
<press "RETURN" to continue>

37 Discount rate (percent): 4.00
27 Interest rate (percent): 12.00
25 Cost calculations are in REAL dollars
Inflation rate (percent): 8.00

20 Cost of electricity (cts/kwh)
compounding function used with:
initial elec. price= 5.60
percent annual change= 3.00

29 Fossil fuel cost (\$/mil. Btu)
compounding function used with:
initial foss. fuel price= 7.580
percent annual change= 3.000

44 Oper. & maint. cost (% of capital): 1.00%
30 Boiler cost(\$/100K Btu/hr): 2000.00
22 Distrib sys pipe cost(\$thou/mi): 250.000
<press "RETURN" to continue>

Residential-commercial option in effect.
The scenario has a resource assessment period of 2 years.
Time horizon is 22 years, with costs calculated every 1 year
Dollar values are in real dollars.
System will be sized according to resource conditions.
The system will be a hybrid geothermal system.

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

* * Cost of Initial Capital Equipment * *

Wells:	\$	1100.000	thousand
Distribution system:	\$	311.333	thousand
Heat exchangers:	\$	35.495	thousand
Pumps:	\$	82.291	thousand
Hookups:	\$	160.104	thousand
Peaking boiler:	\$	342.975	thousand
Transport system:	\$	948.287	thousand
Storage tank:	\$	0.000	thousand

* Total *	\$	2980.484	thousand

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	2980.484
Net Present Value (\$ thou.):	\$ 2.529
Discounted Average Cost (\$/mil. Btu): \$	14.383
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	5.165
Break-even point in year 21	
Total Savings in Operating Costs(thou):\$	5264.861
Payback achieved in year 14	

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 2

Peak total flow (gpm):	279.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	0.934 million kwh
Coefficient of performance:	8.12
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	147.267
Distribution system costs:	50.090
Heat exchanger costs:	6.282
Original pump costs:	14.564
Hookup costs:	25.759
Pump overhaul costs:	15.815
Annual pumping costs:	55.517
Peaking boiler costs:	45.917
Fossil fuel costs:	43.478
Transport costs:	126.956
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	192.229
Total annual system costs:	561.450
Wellhead cost per geo mil. Btu(\$):	7.43
System cost per mil. Btu(\$):	18.75
Revenue (\$ thousands):	333.268
Net revenue (\$ thousands):	-228.182
Oper cost saved this yr(\$thou):	191.465
Oper cost saved so far(\$thou):	191.465

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 3

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	0.934 million kwh
Coefficient of performance:	8.12
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	136.358
Distribution system costs:	46.380
Heat exchanger costs:	5.817
Original pump costs:	13.485
Hookup costs:	23.851
Pump overhaul costs:	15.815
Annual pumping costs:	57.183
Peaking boiler costs:	42.516
Fossil fuel costs:	44.783
Transport costs:	117.551
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	180.028
Total annual system costs:	533.543
Wellhead cost per geo mil. Btu(\$):	6.96
System cost per mil. Btu(\$):	17.82
Revenue (\$ thousands):	343.266
Net revenue (\$ thousands):	-190.277
Oper cost saved this yr(\$thou):	198.103
Oper cost saved so far(\$thou):	389.568

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 4

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25979.13
Total system Btu's (millions):	29944.28
Pumping energy:	0.955 million kwh
Coefficient of performance:	7.94
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	126.257
Distribution system costs:	42.944
Heat exchanger costs:	5.386
Original pump costs:	12.486
Hookup costs:	22.084
Pump overhaul costs:	15.815
Annual pumping costs:	60.196
Peaking boiler costs:	39.366
Fossil fuel costs:	46.126
Transport costs:	108.844
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	168.731
Total annual system costs:	509.310
Wellhead cost per geo mil. Btu(\$):	6.52
System cost per mil. Btu(\$):	17.01
Revenue (\$ thousands):	353.564
Net revenue (\$ thousands):	-155.746
Oper cost saved this yr(\$thou):	203.642
Oper cost saved so far(\$thou):	593.210

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 12

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	0.993 million kwh
Coefficient of performance:	7.64
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	68.213
Distribution system costs:	23.202
Heat exchanger costs:	6.282
Original pump costs:	14.564
Hookup costs:	11.931
Pump overhaul costs:	15.815
Annual pumping costs:	79.275
Peaking boiler costs:	21.268
Fossil fuel costs:	58.431
Transport costs:	58.805
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	113.176
Total annual system costs:	387.591
Wellhead cost per geo mil. Btu(\$):	4.37
System cost per mil. Btu(\$):	12.94
Revenue (\$ thousands):	447.884
Net revenue (\$ thousands):	60.293
Oper cost saved this yr(\$thou):	262.898
Oper cost saved so far(\$thou):	2479.970

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 13

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	0.993 million kwh
Coefficient of performance:	7.64
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	63.160
Distribution system costs:	21.483
Heat exchanger costs:	5.917
Original pump costs:	13.485
Hookup costs:	11.048
Pump overhaul costs:	15.815
Annual pumping costs:	81.653
Peaking boiler costs:	19.693
Fossil fuel costs:	60.184
Transport costs:	54.449
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	106.830
Total annual system costs:	376.591
Wellhead cost per geo mil. Btu(\$):	4.13
System cost per mil. Btu(\$):	12.58
Revenue (\$ thousands):	461.321
Net revenue (\$ thousands):	84.729
Oper cost saved this yr(\$thou):	271.679
Oper cost saved so far(\$thou):	2751.649

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 14

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	0.999 million kwh
Coefficient of performance:	7.60
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	58.482
Distribution system costs:	19.892
Heat exchanger costs:	5.386
Original pump costs:	12.486
Hookup costs:	10.229
Pump overhaul costs:	15.815
Annual pumping costs:	84.581
Peaking boiler costs:	18.234
Fossil fuel costs:	61.989
Transport costs:	50.416
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	100.955
Total annual system costs:	367.314
Wellhead cost per geo mil. Btu(\$):	3.90
System cost per mil. Btu(\$):	12.27
Revenue (\$ thousands):	475.160
Net revenue (\$ thousands):	107.846
Oper cost saved this yr(\$thou):	290.246
Oper cost saved so far(\$thou):	3031.895
Payback achieved in this year.	

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 19

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	1.008 million kwh
Coefficient of performance:	7.53
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	39.802
Distribution system costs:	13.538
Heat exchanger costs:	3.666
Original pump costs:	8.498
Hookup costs:	6.962
Pump overhaul costs:	15.815
Annual pumping costs:	98.967
Peaking boiler costs:	12.410
Fossil fuel costs:	71.863
Transport costs:	34.312
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	77.496
Total annual system costs:	335.636
Wellhead cost per geo mil. Btu(\$):	2.99
System cost per mil. Btu(\$):	11.21
Revenue (\$ thousands):	550.841
Net revenue (\$ thousands):	215.205
Oper cost saved this yr(\$thou):	328.714
Oper cost saved so far(\$thou):	4575.653

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 20

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	1.012 million kwh
Coefficient of performance:	7.50
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	36.853
Distribution system costs:	12.535
Heat exchanger costs:	3.394
Original pump costs:	7.869
Hookup costs:	6.446
Pump overhaul costs:	15.815
Annual pumping costs:	102.335
Peaking boiler costs:	11.491
Fossil fuel costs:	74.019
Transport costs:	31.771
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	73.794
Total annual system costs:	332.331
Wellhead cost per geo mil. Btu(\$):	2.85
System cost per mil. Btu(\$):	11.10
Revenue (\$ thousands):	567.366
Net revenue (\$ thousands):	235.035
Oper cost saved this yr(\$thou):	339.071
Oper cost saved so far(\$thou):	4914.724

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 21

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	1.012 million kwh
Coefficient of performance:	7.50
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	34.123
Distribution system costs:	11.607
Heat exchanger costs:	3.143
Original pump costs:	7.286
Hookup costs:	5.969
Pump overhaul costs:	15.815
Annual pumping costs:	105.405
Peaking boiler costs:	10.640
Fossil fuel costs:	76.239
Transport costs:	29.417
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	70.366
Total annual system costs:	329.447
Wellhead cost per geo mil. Btu(\$):	2.72
System cost per mil. Btu(\$):	11.00
Revenue (\$ thousands):	584.387
Net revenue (\$ thousands):	254.940
(Break-even point achieved in this year)	
Oper cost saved this yr(\$thou):	350.137

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

7
At what detail should the results be printed at the terminal:
(output to file, if any, is unaffected)
1-only final net present value or discounted average cost
2-annual summary for each calculated year
3-full details for each calculated year
4-full details for selected years
Type in number to begin execution: 2

For year 0:
Average system cost per million Btu: \$*****
Total annual system cost (\$ thou.): \$ 50.000
Average wellhead cost per million geo Btu: \$*****
Total annual wellhead cost (\$ thou.): \$ 50.000
Total annual system revenue (\$ thou.): \$ 0.000
Net annual system revenue (\$ thou.): \$ -50.000
Savings in operating costs this yr(thou):\$ 0.000
Savings in operating costs so far(thou):\$ 0.000

For year 1:
Average system cost per million Btu: \$*****
Total annual system cost (\$ thou.): \$ 50.000
Average wellhead cost per million geo Btu: \$*****
Total annual wellhead cost (\$ thou.): \$ 50.000
Total annual system revenue (\$ thou.): \$ 0.000
Net annual system revenue (\$ thou.): \$ -50.000
Savings in operating costs this yr(thou):\$ 0.000
Savings in operating costs so far(thou):\$ 0.000

For year 2:
Average system cost per million Btu: \$ 18.75
Total annual system cost (\$ thou.): \$ 561.450
Average wellhead cost per million geo Btu: \$ 7.43
Total annual wellhead cost (\$ thou.): \$ 192.229
Total annual system revenue (\$ thou.): \$ 333.268
Net annual system revenue (\$ thou.): \$ -228.182
Savings in operating costs this yr(thou):\$ 191.465
Savings in operating costs so far(thou):\$ 191.465

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

For year 3:

Average system cost per million Btu: \$	17.82
Total annual system cost (\$ thou.): \$	533.543
Average wellhead cost per million geo Btu: \$	6.96
Total annual wellhead cost (\$ thou.): \$	180.028
Total annual system revenue (\$ thou.): \$	343.266
Net annual system revenue (\$ thou.): \$	-190.277
Savings in operating costs this yr(thou):\$	199.103
Savings in operating costs so far(thou):\$	389.568

For year 4:

Average system cost per million Btu: \$	17.01
Total annual system cost (\$ thou.): \$	509.310
Average wellhead cost per million geo Btu: \$	6.52
Total annual wellhead cost (\$ thou.): \$	168.731
Total annual system revenue (\$ thou.): \$	353.564
Net annual system revenue (\$ thou.): \$	-155.746
Savings in operating costs this yr(thou):\$	203.642
Savings in operating costs so far(thou):\$	593.210

For year 5:

Average system cost per million Btu: \$	16.23
Total annual system cost (\$ thou.): \$	486.028
Average wellhead cost per million geo Btu: \$	6.12
Total annual wellhead cost (\$ thou.): \$	158.270
Total annual system revenue (\$ thou.): \$	364.171
Net annual system revenue (\$ thou.): \$	-121.857
Savings in operating costs this yr(thou):\$	210.646
Savings in operating costs so far(thou):\$	803.855

For year 6:

Average system cost per million Btu: \$	15.55
Total annual system cost (\$ thou.): \$	465.697
Average wellhead cost per million geo Btu: \$	5.74
Total annual wellhead cost (\$ thou.): \$	148.584
Total annual system revenue (\$ thou.): \$	375.096
Net annual system revenue (\$ thou.): \$	-90.601
Savings in operating costs this yr(thou):\$	216.965
Savings in operating costs so far(thou):\$	1020.820

For year 7:

Average system cost per million Btu: \$	14.91
Total annual system cost (\$ thou.): \$	446.412
Average wellhead cost per million geo Btu: \$	5.39
Total annual wellhead cost (\$ thou.): \$	139.616
Total annual system revenue (\$ thou.): \$	386.349
Net annual system revenue (\$ thou.): \$	-60.063
Savings in operating costs this yr(thou):\$	224.368
Savings in operating costs so far(thou):\$	1245.188

COMMERCIAL-RESIDENTIAL SCENARIO
(0% Rate of Return)

For year 8:

Average system cost per million Btu: \$	14.35
Total annual system cost (\$ thou.): \$	429.617
Average wellhead cost per million geo Btu: \$	5.07
Total annual wellhead cost (\$ thou.): \$	131.312
Total annual system revenue (\$ thou.): \$	397.939
Net annual system revenue (\$ thou.): \$	-31.677
Savings in operating costs this yr(thou):\$	231.288
Savings in operating costs so far(thou):\$	1476.476

For year 9:

Average system cost per million Btu: \$	13.82
Total annual system cost (\$ thou.): \$	413.799
Average wellhead cost per million geo Btu: \$	4.78
Total annual wellhead cost (\$ thou.): \$	123.623
Total annual system revenue (\$ thou.): \$	409.878
Net annual system revenue (\$ thou.): \$	-3.921
Savings in operating costs this yr(thou):\$	239.120
Savings in operating costs so far(thou):\$	1715.596

For year 10:

Average system cost per million Btu: \$	13.36
Total annual system cost (\$ thou.): \$	400.128
Average wellhead cost per million geo Btu: \$	4.50
Total annual wellhead cost (\$ thou.): \$	116.504
Total annual system revenue (\$ thou.): \$	422.174
Net annual system revenue (\$ thou.): \$	22.046
Savings in operating costs this yr(thou):\$	246.592
Savings in operating costs so far(thou):\$	1962.188

For year 11:

Average system cost per million Btu: \$	12.93
Total annual system cost (\$ thou.): \$	387.325
Average wellhead cost per million geo Btu: \$	4.25
Total annual wellhead cost (\$ thou.): \$	109.912
Total annual system revenue (\$ thou.): \$	434.839
Net annual system revenue (\$ thou.): \$	47.514
Savings in operating costs this yr(thou):\$	254.884
Savings in operating costs so far(thou):\$	2217.071

For year 12:

Average system cost per million Btu: \$	12.94
Total annual system cost (\$ thou.): \$	387.591
Average wellhead cost per million geo Btu: \$	4.37
Total annual wellhead cost (\$ thou.): \$	113.176
Total annual system revenue (\$ thou.): \$	447.884
Net annual system revenue (\$ thou.): \$	60.293
Savings in operating costs this yr(thou):\$	262.898
Savings in operating costs so far(thou):\$	2479.970

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

For year 13:

Average system cost per million Btu: \$	12.58
Total annual system cost (\$ thou.): \$	376.591
Average wellhead cost per million geo Btu: \$	4.13
Total annual wellhead cost (\$ thou.): \$	106.830
Total annual system revenue (\$ thou.): \$	461.321
Net annual system revenue (\$ thou.): \$	84.729
Savings in operating costs this yr(thou):\$	271.679
Savings in operating costs so far(thou):\$	2751.649

For year 14:

Average system cost per million Btu: \$	12.27
Total annual system cost (\$ thou.): \$	367.314
Average wellhead cost per million geo Btu: \$	3.90
Total annual wellhead cost (\$ thou.): \$	100.955
Total annual system revenue (\$ thou.): \$	475.160
Net annual system revenue (\$ thou.): \$	107.846
Savings in operating costs this yr(thou):\$	280.246
Savings in operating costs so far(thou):\$	3031.895

Payback achieved in this year.

For year 15:

Average system cost per million Btu: \$	11.98
Total annual system cost (\$ thou.): \$	358.739
Average wellhead cost per million geo Btu: \$	3.69
Total annual wellhead cost (\$ thou.): \$	95.515
Total annual system revenue (\$ thou.): \$	489.415
Net annual system revenue (\$ thou.): \$	130.676
Savings in operating costs this yr(thou):\$	289.547
Savings in operating costs so far(thou):\$	3321.442

For year 16:

Average system cost per million Btu: \$	11.75
Total annual system cost (\$ thou.): \$	351.700
Average wellhead cost per million geo Btu: \$	3.50
Total annual wellhead cost (\$ thou.): \$	90.478
Total annual system revenue (\$ thou.): \$	504.098
Net annual system revenue (\$ thou.): \$	152.397
Savings in operating costs this yr(thou):\$	298.685
Savings in operating costs so far(thou):\$	3620.127

For year 17:

Average system cost per million Btu: \$	11.53
Total annual system cost (\$ thou.): \$	345.257
Average wellhead cost per million geo Btu: \$	3.32
Total annual wellhead cost (\$ thou.): \$	85.814
Total annual system revenue (\$ thou.): \$	519.221
Net annual system revenue (\$ thou.): \$	173.964
Savings in operating costs this yr(thou):\$	308.539
Savings in operating costs so far(thou):\$	3928.666

COMMERCIAL-RESIDENTIAL SCENARIO

(0% Rate of Return)

For year 18:

Average system cost per million Btu: \$	11.36
Total annual system cost (\$ thou.): \$	340.195
Average wellhead cost per million geo Btu: \$	3.15
Total annual wellhead cost (\$ thou.): \$	81.495
Total annual system revenue (\$ thou.): \$	534.797
Net annual system revenue (\$ thou.): \$	194.602
Savings in operating costs this yr(thou):\$	318.272
Savings in operating costs so far(thou):\$	4246.938

For year 19:

Average system cost per million Btu: \$	11.21
Total annual system cost (\$ thou.): \$	335.636
Average wellhead cost per million geo Btu: \$	2.99
Total annual wellhead cost (\$ thou.): \$	77.496
Total annual system revenue (\$ thou.): \$	550.841
Net annual system revenue (\$ thou.): \$	215.205
Savings in operating costs this yr(thou):\$	328.714
Savings in operating costs so far(thou):\$	4575.653

For year 20:

Average system cost per million Btu: \$	11.10
Total annual system cost (\$ thou.): \$	332.331
Average wellhead cost per million geo Btu: \$	2.85
Total annual wellhead cost (\$ thou.): \$	73.794
Total annual system revenue (\$ thou.): \$	567.366
Net annual system revenue (\$ thou.): \$	235.035
Savings in operating costs this yr(thou):\$	339.071
Savings in operating costs so far(thou):\$	4914.724

For year 21:

Average system cost per million Btu: \$	11.00
Total annual system cost (\$ thou.): \$	329.447
Average wellhead cost per million geo Btu: \$	2.72
Total annual wellhead cost (\$ thou.): \$	70.366
Total annual system revenue (\$ thou.): \$	584.387
Net annual system revenue (\$ thou.): \$	254.940
Break-even point achieved in this year.	
Savings in operating costs this yr(thou):\$	350.137
Savings in operating costs so far(thou):\$	5264.861

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	2980.484
Net Present Value (\$ thou.): \$	2.529
Discounted Average Cost (\$/mil. Btu): \$	14.383
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	5.165
Break-even point in year 21	
Total Savings in Operating Costs(thou):\$	5264.861
Payback achieved in year 14	

A-4

COMMERCIAL-RESIDENTIAL SCENARIO

(8% RATE OF RETURN)

ZONE ABCDFHS

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)
(Base period for costs is 2nd Quarter, 1981)

Residential-Commercial Scenario Parameters

Financial Condition Parameters

40 Economic accounting method: NPV & Disc Avg Cost

36 System selling price (\$/mil. Btu):

selling price is a multiple of:

fossil fuel price, factor= 1.50

33 Study period: 22 years; Intervals of 1 year

41 Resource assessment period 2 yrs

Ann'l resource assess. cost(\$thou): 50.

16 Well cost adjustment factor: 0.894

Adj. total cost of wells(\$thou): 1100.000

17 Heat exch. cost adjustment factor: 1.000

Adj tot cost of heat exchs(\$thou): 35.506

24 Storage tank capacity: 0.0 hours of flow

<press "RETURN" to continue>

15 Capital Equipment Amort. Per. Phys. Life

Wells 30. yrs* 30. yrs

Piping system 30. yrs* 30. yrs

Heat exchanger 10. yrs* 10. yrs

Pumps 10. yrs* 10. yrs

Hookups 30. yrs* 30. yrs

Peaking boiler 30. yrs* 30. yrs

Storage tank 0. yrs* 30. yrs

*(reduced as needed to end in study period)

<press "RETURN" to continue>

37 Discount rate (percent): 4.00

27 Interest rate (percent): 12.00

25 Cost calculations are in REAL dollars

Inflation rate (percent): 8.00

20 Cost of electricity (cts/kwh)

compounding function used with:

initial elec. price= 5.60

percent annual change= 3.00

29 Fossil fuel cost (\$/mil. Btu)

compounding function used with:

initial foss. fuel price= 7.580

percent annual change= 3.000

44 Oper. & maint. cost (% of capital): 1.00%

30 Boiler cost(\$/100K Btu/hr): 2000.00

22 Distrib sys pipe cost(\$thou/mi): 250.000

<press "RETURN" to continue>

Residential-commercial option in effect.

The scenario has a resource assessment period of 2 years.

Time horizon is 22 years, with costs calculated every 1 year

Dollar values are in real dollars.

System will be sized according to resource conditions.

The system will be a hybrid geothermal system.

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

* * Cost of Initial Capital Equipment * *

Wells:	\$	1100.000	thousand
Distribution system:	\$	311.333	thousand
Heat exchangers:	\$	35.495	thousand
Pumps:	\$	82.291	thousand
Hookups:	\$	160.104	thousand
Peaking boiler:	\$	342.975	thousand
Transport system:	\$	948.287	thousand
Storage tank:	\$	0.000	thousand
<hr/>			
* Total *	\$	2980.484	thousand

Summary of Finances Over Life of Project

Capital Cost (excl replacement) (\$thou):	\$	2980.484
Net Present Value (\$ thou.):	\$	458.198
Discounted Average Cost (\$/mil. Btu):	\$	14.383
Discounted Avg Wellhead Cost (\$/mil. Btu):	\$	5.165
Break-even point in year	18	
Total Savings in Operating Costs (thou):	\$	5264.861
Payback achieved in year	14	

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 21

Peak total flow (gpm):	299.88
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	25879.13
Total system Btu's (millions):	29944.28
Pumping energy:	1.012 million kwh
Coefficient of performance:	7.50
Percentage geothermal utilization:	39.41
Percentage service geothermal:	86.42

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	34.123
Distribution system costs:	11.607
Heat exchanger costs:	3.143
Original pump costs:	7.286
Hookup costs:	5.969
Pump overhaul costs:	15.815
Annual pumping costs:	105.405
Peaking boiler costs:	10.640
Fossil fuel costs:	76.239
Transport costs:	29.417
Storage tank costs:	0.000
Operation and maintenance costs:	29.805
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	70.366
Total annual system costs:	329.447
Wellhead cost per geo mil. Btu(\$):	2.72
System cost per mil. Btu(\$):	11.00
Revenue (\$ thousands):	631.679
Net revenue (\$ thousands):	302.232
Oper cost saved this yr(\$thou):	350.137
Oper cost saved so far(\$thou):	5264.861

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Option? 7

At what detail should the results be printed at the terminal:
(output to file, if any, is unaffected)

- 1-only final net present value or discounted average cost
- 2-annual summary for each calculated year
- 3-full details for each calculated year
- 4-full details for selected years

Type in number to begin execution: 2

For year 0:

Average system cost per million Btu: \$*****	
Total annual system cost (\$ thou.): \$	50.000
Average wellhead cost per million geo Btu: \$*****	
Total annual wellhead cost (\$ thou.): \$	50.000
Total annual system revenue (\$ thou.): \$	0.000
Net annual system revenue (\$ thou.): \$	-50.000
Savings in operating costs this yr(thou):\$	0.000
Savings in operating costs so far(thou):\$	0.000

For year 1:

Average system cost per million Btu: \$*****	
Total annual system cost (\$ thou.): \$	50.000
Average wellhead cost per million geo Btu: \$*****	
Total annual wellhead cost (\$ thou.): \$	50.000
Total annual system revenue (\$ thou.): \$	0.000
Net annual system revenue (\$ thou.): \$	-50.000
Savings in operating costs this yr(thou):\$	0.000
Savings in operating costs so far(thou):\$	0.000

For year 2:

Average system cost per million Btu: \$	18.75
Total annual system cost (\$ thou.): \$	561.450
Average wellhead cost per million geo Btu: \$	7.43
Total annual wellhead cost (\$ thou.): \$	192.229
Total annual system revenue (\$ thou.): \$	360.238
Net annual system revenue (\$ thou.): \$	-201.212
Savings in operating costs this yr(thou):\$	191.465
Savings in operating costs so far(thou):\$	191.465

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

For year 3:

Average system cost per million Btu: \$	17.82
Total annual system cost (\$ thou.): \$	533.543
Average wellhead cost per million geo Btu: \$	6.96
Total annual wellhead cost (\$ thou.): \$	180.028
Total annual system revenue (\$ thou.): \$	371.045
Net annual system revenue (\$ thou.): \$	-162.498
Savings in operating costs this yr(thou):\$	198.103
Savings in operating costs so far(thou):\$	389.568

For year 4:

Average system cost per million Btu: \$	17.01
Total annual system cost (\$ thou.): \$	509.310
Average wellhead cost per million geo Btu: \$	6.52
Total annual wellhead cost (\$ thou.): \$	168.731
Total annual system revenue (\$ thou.): \$	382.176
Net annual system revenue (\$ thou.): \$	-127.134
Savings in operating costs this yr(thou):\$	203.642
Savings in operating costs so far(thou):\$	593.210

For year 5:

Average system cost per million Btu: \$	16.23
Total annual system cost (\$ thou.): \$	486.028
Average wellhead cost per million geo Btu: \$	6.12
Total annual wellhead cost (\$ thou.): \$	158.270
Total annual system revenue (\$ thou.): \$	393.641
Net annual system revenue (\$ thou.): \$	-92.387
Savings in operating costs this yr(thou):\$	210.646
Savings in operating costs so far(thou):\$	803.855

For year 6:

Average system cost per million Btu: \$	15.55
Total annual system cost (\$ thou.): \$	465.697
Average wellhead cost per million geo Btu: \$	5.74
Total annual wellhead cost (\$ thou.): \$	148.584
Total annual system revenue (\$ thou.): \$	405.451
Net annual system revenue (\$ thou.): \$	-60.246
Savings in operating costs this yr(thou):\$	216.965
Savings in operating costs so far(thou):\$	1020.820

For year 7:

Average system cost per million Btu: \$	14.91
Total annual system cost (\$ thou.): \$	446.412
Average wellhead cost per million geo Btu: \$	5.39
Total annual wellhead cost (\$ thou.): \$	139.616
Total annual system revenue (\$ thou.): \$	417.614
Net annual system revenue (\$ thou.): \$	-28.798
Savings in operating costs this yr(thou):\$	224.368
Savings in operating costs so far(thou):\$	1245.188

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

For year 8:

Average system cost per million Btu: \$	14.35
Total annual system cost (\$ thou.): \$	429.617
Average wellhead cost per million geo Btu: \$	5.07
Total annual wellhead cost (\$ thou.): \$	131.312
Total annual system revenue (\$ thou.): \$	430.143
Net annual system revenue (\$ thou.): \$	0.526
Savings in operating costs this yr(thou):\$	231.288
Savings in operating costs so far(thou):\$	1476.476

For year 9:

Average system cost per million Btu: \$	13.82
Total annual system cost (\$ thou.): \$	413.799
Average wellhead cost per million geo Btu: \$	4.78
Total annual wellhead cost (\$ thou.): \$	123.623
Total annual system revenue (\$ thou.): \$	443.047
Net annual system revenue (\$ thou.): \$	29.248
Savings in operating costs this yr(thou):\$	239.120
Savings in operating costs so far(thou):\$	1715.596

For year 10:

Average system cost per million Btu: \$	13.36
Total annual system cost (\$ thou.): \$	400.128
Average wellhead cost per million geo Btu: \$	4.50
Total annual wellhead cost (\$ thou.): \$	116.504
Total annual system revenue (\$ thou.): \$	456.338
Net annual system revenue (\$ thou.): \$	56.211
Savings in operating costs this yr(thou):\$	246.592
Savings in operating costs so far(thou):\$	1962.188

For year 11:

Average system cost per million Btu: \$	12.93
Total annual system cost (\$ thou.): \$	387.325
Average wellhead cost per million geo Btu: \$	4.25
Total annual wellhead cost (\$ thou.): \$	109.912
Total annual system revenue (\$ thou.): \$	470.028
Net annual system revenue (\$ thou.): \$	82.703
Savings in operating costs this yr(thou):\$	254.884
Savings in operating costs so far(thou):\$	2217.071

For year 12:

Average system cost per million Btu: \$	12.94
Total annual system cost (\$ thou.): \$	387.591
Average wellhead cost per million geo Btu: \$	4.37
Total annual wellhead cost (\$ thou.): \$	113.176
Total annual system revenue (\$ thou.): \$	484.129
Net annual system revenue (\$ thou.): \$	96.538
Savings in operating costs this yr(thou):\$	262.898
Savings in operating costs so far(thou):\$	2479.970

COMMERCIAL-RESIDENTIAL SCENARIO

(8% Rate of Return)

For year 13:

Average system cost per million Btu: \$	12.58
Total annual system cost (\$ thou.): \$	376.591
Average wellhead cost per million geo Btu: \$	4.13
Total annual wellhead cost (\$ thou.): \$	106.830
Total annual system revenue (\$ thou.): \$	498.653
Net annual system revenue (\$ thou.): \$	122.062
Savings in operating costs this yr(thou):\$	271.679
Savings in operating costs so far(thou):\$	2751.649

For year 14:

Average system cost per million Btu: \$	12.27
Total annual system cost (\$ thou.): \$	367.314
Average wellhead cost per million geo Btu: \$	3.90
Total annual wellhead cost (\$ thou.): \$	100.955
Total annual system revenue (\$ thou.): \$	513.613
Net annual system revenue (\$ thou.): \$	146.298
Savings in operating costs this yr(thou):\$	280.246
Savings in operating costs so far(thou):\$	3031.895

Payback achieved in this year.

For year 15:

Average system cost per million Btu: \$	11.98
Total annual system cost (\$ thou.): \$	358.739
Average wellhead cost per million geo Btu: \$	3.69
Total annual wellhead cost (\$ thou.): \$	95.515
Total annual system revenue (\$ thou.): \$	529.021
Net annual system revenue (\$ thou.): \$	170.282
Savings in operating costs this yr(thou):\$	289.547
Savings in operating costs so far(thou):\$	3321.442

For year 16:

Average system cost per million Btu: \$	11.75
Total annual system cost (\$ thou.): \$	351.700
Average wellhead cost per million geo Btu: \$	3.50
Total annual wellhead cost (\$ thou.): \$	90.478
Total annual system revenue (\$ thou.): \$	544.892
Net annual system revenue (\$ thou.): \$	193.191
Savings in operating costs this yr(thou):\$	298.685
Savings in operating costs so far(thou):\$	3620.127

For year 17:

Average system cost per million Btu: \$	11.53
Total annual system cost (\$ thou.): \$	345.257
Average wellhead cost per million geo Btu: \$	3.32
Total annual wellhead cost (\$ thou.): \$	85.814
Total annual system revenue (\$ thou.): \$	561.239
Net annual system revenue (\$ thou.): \$	215.982
Savings in operating costs this yr(thou):\$	308.539
Savings in operating costs so far(thou):\$	3928.666

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

For year 18:

Average system cost per million Btu: \$	11.36
Total annual system cost (\$ thou.): \$	340.195
Average wellhead cost per million geo Btu: \$	3.15
Total annual wellhead cost (\$ thou.): \$	81.495
Total annual system revenue (\$ thou.): \$	578.076
Net annual system revenue (\$ thou.): \$	237.880
Break-even point achieved in this year.	
Savings in operating costs this yr(thou):\$	318.272
Savings in operating costs so far(thou):\$	4246.938

For year 19:

Average system cost per million Btu: \$	11.21
Total annual system cost (\$ thou.): \$	335.636
Average wellhead cost per million geo Btu: \$	2.99
Total annual wellhead cost (\$ thou.): \$	77.496
Total annual system revenue (\$ thou.): \$	595.418
Net annual system revenue (\$ thou.): \$	259.782
Savings in operating costs this yr(thou):\$	328.714
Savings in operating costs so far(thou):\$	4575.653

For year 20:

Average system cost per million Btu: \$	11.10
Total annual system cost (\$ thou.): \$	332.331
Average wellhead cost per million geo Btu: \$	2.85
Total annual wellhead cost (\$ thou.): \$	73.794
Total annual system revenue (\$ thou.): \$	613.280
Net annual system revenue (\$ thou.): \$	280.949
Savings in operating costs this yr(thou):\$	339.071
Savings in operating costs so far(thou):\$	4914.724

For year 21:

Average system cost per million Btu: \$	11.00
Total annual system cost (\$ thou.): \$	329.447
Average wellhead cost per million geo Btu: \$	2.72
Total annual wellhead cost (\$ thou.): \$	70.366
Total annual system revenue (\$ thou.): \$	631.679
Net annual system revenue (\$ thou.): \$	302.232
Savings in operating costs this yr(thou):\$	350.137
Savings in operating costs so far(thou):\$	5264.861

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	2980.484
Net Present Value (\$ thou.): \$	458.198
Discounted Average Cost (\$/mil. Btu): \$	14.383
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	5.165
Break-even point in year 18	
Total Savings in Operating Costs(thou):\$	5264.861
Payback achieved in year 14	

A-5

COMMERCIAL-RESIDENTIAL SCENARIO
GEOTHERMAL MODE WITH HEAT RECOVERY
FROM DIESEL GENERATOR EXHAUST
ZONE ABCDFHS

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

- BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)
 (Base period for costs is 2nd Quarter, 1981)
 Residential-Commercial Scenario Parameters
 (All sets of options will be listed)

Program Operating Conditions

0 Standard geothermal system
 # 2 Output file name:
 # 4 Title of scenario: (displayed above, if any)
 # 5 Residential-Commercial service chosen.
 # 8 Data files will not be generated.
 # 9 System will be sized according to DEMAND conditions.
 Do you wish to change any of these options now (Yes/No)? N
 Resource Condition Parameters

42 Number of production wells: 1
 # 12 Depth of upwell (feet): 6000.
 # 11 Wellhead water temp. (deg. Fahr.)
 linear function used with:
 initial water temp.= 168.7
 annual drop in temp.= 0.0
 # 21 Reject temperature (deg. Fahr.): 110.0
 # 43 Number of reinjection wells: 1
 # 23 Depth of reinjection well (feet): 3000.
 <press "RETURN" to continue>
 # 26 Drawdown of upwell (percent)
 determined from aquifer characteristics:
 Pumping cycle: Space heating application
 Transmissivity= 0.500 sq.cm./sec.
 Aq.Stor.Coef.= 0.003900; Well Radius=12.0 in.
 # 32 Maximum flow per well (gpm)
 linear function used with:
 initial flow= 300.00
 annual change= 0.00
 # 38 Transport distance (miles) carrying flow of...
 1 wells' flow to distn. system: 1.500
 1 wells' flow to reinj. well: 0.520

Do you wish to change any of these options now (Yes/No)? N
 Residential-Commercial Demand Condition Parameters

10 Area under consideration: BERLIN
 # 14 System design temp. (deg. Fahr.): 36
 # 28 Min. ambient temperature (deg. Fahr.): -25.
 # 35 Fraction of distribution system installed:
 in year 2 =100.000%
 <press "RETURN" to continue>

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

(Residential-Specific)

52 Ultimate number of households: 60.

13 Percentages of housing types on system:

Housing type	(%)	(Btu/hr/deg)
1-single family suburban:	100.000	1200.
2-single family dense:	0.000	1200.
3-townhouse:	0.000	780.
4-garden apts.:	0.000	420.
5-high rise:	0.000	348.

34 Market saturation (%): 50.00

19 Rate of residential market penetration
 linear function used with:
 initial percentage= 100.00
 annual change = 0.00

18 Hookup cost per household:

Housing type	(\$)
1-single family suburban:	1500.00
2-single family dense:	1500.00
3-townhouse:	1500.00
4-garden apts.:	400.00
5-high rise:	400.00

Avg hookup cost per household: 1500.00

39 Domestic hot water(mil.Btu/yr/hh): 20.10

<press "RETURN" to continue>

(Commercial-Specific)

45 Number of types of commercial buildings: 7

46 Avg. floor space for each commercial building of

type 1 :	3.000 thousand sq. ft.
type 2 :	19.200 thousand sq. ft.
type 3 :	75.000 thousand sq. ft.
type 4 :	49.000 thousand sq. ft.
type 5 :	5.000 thousand sq. ft.
type 6 :	5.000 thousand sq. ft.
type 7 :	6.000 thousand sq. ft.

47 Average heat demand for

Buildings of	Space Heat (Btu/sqft/deg/day)	Hot Water Heat (Btu/sqft/day)
type 1:	16.3	9.0
type 2:	6.5	9.0
type 3:	22.3	9.0
type 4:	16.1	9.0
type 5:	72.4	640.0
type 6:	14.5	410.6
type 7:	25.8	9.0

48 Number of commercial buildings of

type 1 :	40
type 2 :	1
type 3 :	1
type 4 :	1
type 5 :	1
type 6 :	1
type 7 :	1

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
RECOVERY FROM DIESEL GENERATOR EXHAUST

51 Rate of commercial market penetration
 linear function used with:
 initial percentage= 100.00
 annual change = 0.00
 # 50 Length of commercial distrib. sys: 0.00 miles
 # 49 Avg cost per hookup of a commer. bldg: \$ 1524.
 Do you wish to change any of these options now (Yes/No)? N
 Financial Condition Parameters

40 Economic accounting method: NPV & Disc Avg Cost
 # 36 System selling price (\$/mil. Btu):
 selling price is a multiple of:
 fossil fuel price, factor= 1.50
 # 33 Study period: 22 years; Intervals of 1 year
 # 41 Resource assessment period 2 yrs
 Ann'l resource assess. cost(\$thous): 50.
 # 16 Well cost adjustment factor: 0.894
 Adj. total cost of wells(\$thou): 1100.000
 # 17 Heat exch. cost adjustment factor: 2.182
 Adj tot cost of heat exchs(\$thou): 88.608 (* projected *)
 # 24 Storage tank capacity: 0.0 hours of flow
 <press "RETURN" to continue>

15 Capital Equipment Amort. Per. Phys. Life
 Wells 30. yrs* 30. yrs
 Piping system 30. yrs* 30. yrs
 Heat exchanger 10. yrs* 10. yrs
 Pumps 10. yrs* 10. yrs
 Hookups 30. yrs* 30. yrs
 Peaking boiler 30. yrs* 30. yrs
 Storage tank 0. yrs* 30. yrs
 *(reduced as needed to end in study period)

<press "RETURN" to continue>
 # 37 Discount rate (percent): 4.00
 # 27 Interest rate (percent): 12.00
 # 25 Cost calculations are in REAL dollars
 Inflation rate (percent): 8.00

20 Cost of electricity (cts/kwh)
 compounding function used with:
 initial elec. price= 5.60
 percent annual change= 3.00

29 Fossil fuel cost (\$/mil. Btu)
 compounding function used with:
 initial foss. fuel price= 7.580
 percent annual change= 3.000

44 Oper. & maint. cost (% of capital): 1.00%
 # 30 Boiler cost(\$/100K Btu/hr): 2000.00
 # 22 Distrib sys pipe cost(\$thou/mi): 250.000

<press "RETURN" to continue>

Residential-commercial option in effect.

The scenario has a resource assessment period of 2 years.
 Time horizon is 22 years, with costs calculated every 1 year
 Dollar values are in real dollars.
 System will be sized to meet the specified demand conditions.
 The system will be a hybrid geothermal system.

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

* * Cost of Initial Capital Equipment * *

Wells:	\$	1100.000	thousand
Distribution system:	\$	311.333	thousand
Heat exchangers:	\$	87.219	thousand
Pumps:	\$	84.304	thousand
Hookups:	\$	160.104	thousand
Peaking boiler:	\$	348.691	thousand
Transport system:	\$	941.247	thousand
Storage tank:	\$	0.000	thousand
<hr/>			
* Total *	\$	3032.899	thousand

Summary of Finances Over Life of Project

Capital Cost (\$ thousands):	3032.899
Net Present Value (\$ thous.):	712.707
Discounted Avg Cost (\$/mil.Btu):	13.733
Disc.Avg.Wellhead Cost(\$/mil.Btu):	5.094
Break-even point achieved in year	16
Tot. Oper. Cost Savings(\$thou):	5804.269
Payback achieved in year	13

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 2

Peak total flow (gpm):	294.39
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	27519.79
Total system Btu's (millions):	29944.28
Pumping energy:	0.887 million kwh
Coefficient of performance:	9.09
Percentage geothermal utilization:	36.36
Percentage service geothermal:	91.90

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	147.267
Distribution system costs:	50.090
Heat exchanger costs:	15.436
Original pump costs:	14.921
Hookup costs:	25.759
Pump overhaul costs:	15.300
Annual pumping costs:	52.714
Peaking boiler costs:	46.682
Fossil fuel costs:	25.931
Transport costs:	126.013
Storage tank costs:	0.000
Operation and maintenance costs:	30.329
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	201.018
Total annual system costs:	550.442
Wellhead cost per geo mil. Btu(\$):	7.30
System cost per mil. Btu(\$):	18.38
Revenue (\$ thousands):	360.238
Net revenue (\$ thousands):	-190.205
Oper cost saved this yr(\$thou):	211.291
Oper cost saved so far(\$thou):	211.291

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 3

Peak total flow (gpm):	294.39
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	27519.79
Total system Btu's (millions):	29944.28
Pumping energy:	0.887 million kwh
Coefficient of performance:	9.09
Percentage geothermal utilization:	36.36
Percentage service geothermal:	91.90

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	136.358
Distribution system costs:	46.380
Heat exchanger costs:	14.293
Original pump costs:	13.815
Hookup costs:	23.851
Pump overhaul costs:	15.300
Annual pumping costs:	54.296
Peaking boiler costs:	43.224
Fossil fuel costs:	26.709
Transport costs:	116.679
Storage tank costs:	0.000
Operation and maintenance costs:	30.329
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	188.161
Total annual system costs:	521.234
Wellhead cost per geo mil. Btu(\$):	6.84
System cost per mil. Btu(\$):	17.41
Revenue (\$ thousands):	371.045
Net revenue (\$ thousands):	-150.189
Oper cost saved this yr(\$thou):	218.539
Oper cost saved so far(\$thou):	429.830

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 4

Peak total flow (gpm):	294.39
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	27519.79
Total system Btu's (millions):	29944.28
Pumping energy:	0.907 million kwh
Coefficient of performance:	8.89
Percentage geothermal utilization:	36.36
Percentage service geothermal:	91.90

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	126.257
Distribution system costs:	42.944
Heat exchanger costs:	13.234
Original pump costs:	12.792
Hookup costs:	22.084
Pump overhaul costs:	15.300
Annual pumping costs:	57.175
Peaking boiler costs:	40.023
Fossil fuel costs:	27.510
Transport costs:	108.036
Storage tank costs:	0.000
Operation and maintenance costs:	30.329
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	176.256
Total annual system costs:	495.685
Wellhead cost per geo mil. Btu(\$):	6.40
System cost per mil. Btu(\$):	16.55
Revenue (\$ thousands):	382.176
Net revenue (\$ thousands):	-113.509
Oper cost saved this yr(\$thou):	224.755
Oper cost saved so far(\$thou):	654.585

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 21

Peak total flow (gpm):	294.39
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	27519.79
Total system Btu's (millions):	29944.28
Pumping energy:	0.962 million kwh
Coefficient of performance:	8.39
Percentage geothermal utilization:	36.36
Percentage service geothermal:	91.90

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	34.123
Distribution system costs:	11.607
Heat exchanger costs:	7.722
Original pump costs:	7.464
Hookup costs:	5.969
Pump overhaul costs:	15.300
Annual pumping costs:	100.197
Peaking boiler costs:	10.817
Fossil fuel costs:	45.470
Transport costs:	29.199
Storage tank costs:	0.000
Operation and maintenance costs:	30.329
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	74.727
Total annual system costs:	298.197
Wellhead cost per geo mil. Btu(\$):	2.72
System cost per mil. Btu(\$):	9.96
Revenue (\$ thousands):	631.679
Net revenue (\$ thousands):	333.482
Oper cost saved this yr(\$thou):	385.590
Oper cost saved so far(\$thou):	5804.269

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

7

At what detail should the results be printed at the terminal:
 (output to file, if any, is unaffected)
 1-only final net present value or discounted average cost
 2-annual summary for each calculated year
 3-full details for each calculated year
 4-full details for selected years
 Type in number to begin execution: 2

For year 0:

Average system cost per million Btu: *****	
Total annual system cost (\$ thou.): \$	50.000
Average wellhead cost per million geo Btu: *****	
Total annual wellhead cost (\$ thou.): \$	50.000
Total annual system revenue (\$ thou.): \$	0.000
Net annual system revenue (\$ thou.): \$	-50.000
Savings in operating costs this yr(thou):\$	0.000
Savings in operating costs so far(thou):\$	0.000

For year 1:

Average system cost per million Btu: *****	
Total annual system cost (\$ thou.): \$	50.000
Average wellhead cost per million geo Btu: *****	
Total annual wellhead cost (\$ thou.): \$	50.000
Total annual system revenue (\$ thou.): \$	0.000
Net annual system revenue (\$ thou.): \$	-50.000
Savings in operating costs this yr(thou):\$	0.000
Savings in operating costs so far(thou):\$	0.000

For year 2:

Average system cost per million Btu: \$	18.38
Total annual system cost (\$ thou.): \$	550.442
Average wellhead cost per million geo Btu: \$	7.30
Total annual wellhead cost (\$ thou.): \$	201.018
Total annual system revenue (\$ thou.): \$	360.238
Net annual system revenue (\$ thou.): \$	-190.205
Savings in operating costs this yr(thou):\$	211.291
Savings in operating costs so far(thou):\$	211.291

For year 3:

Average system cost per million Btu: \$	17.41
Total annual system cost (\$ thou.): \$	521.234
Average wellhead cost per million geo Btu: \$	6.84
Total annual wellhead cost (\$ thou.): \$	188.161
Total annual system revenue (\$ thou.): \$	371.045
Net annual system revenue (\$ thou.): \$	-150.189
Savings in operating costs this yr(thou):\$	218.539
Savings in operating costs so far(thou):\$	429.830

COMMERCIAL-RESIDENTIAL SCENARIO
GEO THERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

For year 4:

Average system cost per million Btu: \$	16.55
Total annual system cost (\$ thou.): \$	495.685
Average wellhead cost per million geo Btu: \$	6.40
Total annual wellhead cost (\$ thou.): \$	176.256
Total annual system revenue (\$ thou.): \$	382.176
Net annual system revenue (\$ thou.): \$	-113.509
Savings in operating costs this yr(thou):\$	224.755
Savings in operating costs so far(thou):\$	654.585

For year 5:

Average system cost per million Btu: \$	15.73
Total annual system cost (\$ thou.): \$	471.161
Average wellhead cost per million geo Btu: \$	6.00
Total annual wellhead cost (\$ thou.): \$	165.232
Total annual system revenue (\$ thou.): \$	393.641
Net annual system revenue (\$ thou.): \$	-77.520
Savings in operating costs this yr(thou):\$	232.407
Savings in operating costs so far(thou):\$	886.992

For year 6:

Average system cost per million Btu: \$	15.01
Total annual system cost (\$ thou.): \$	449.580
Average wellhead cost per million geo Btu: \$	5.63
Total annual wellhead cost (\$ thou.): \$	155.026
Total annual system revenue (\$ thou.): \$	405.451
Net annual system revenue (\$ thou.): \$	-44.129
Savings in operating costs this yr(thou):\$	239.427
Savings in operating costs so far(thou):\$	1126.419

For year 7:

Average system cost per million Btu: \$	14.33
Total annual system cost (\$ thou.): \$	429.098
Average wellhead cost per million geo Btu: \$	5.29
Total annual wellhead cost (\$ thou.): \$	145.575
Total annual system revenue (\$ thou.): \$	417.614
Net annual system revenue (\$ thou.): \$	-11.483
Savings in operating costs this yr(thou):\$	247.520
Savings in operating costs so far(thou):\$	1373.940

For year 8:

Average system cost per million Btu: \$	13.73
Total annual system cost (\$ thou.): \$	411.095
Average wellhead cost per million geo Btu: \$	4.97
Total annual wellhead cost (\$ thou.): \$	136.825
Total annual system revenue (\$ thou.): \$	430.143
Net annual system revenue (\$ thou.): \$	19.047
Savings in operating costs this yr(thou):\$	255.176
Savings in operating costs so far(thou):\$	1629.115

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

For year 9:

Average system cost per million Btu: \$	13.16
Total annual system cost (\$ thou.): \$	394.110
Average wellhead cost per million geo Btu: \$	4.68
Total annual wellhead cost (\$ thou.): \$	128.722
Total annual system revenue (\$ thou.): \$	443.047
Net annual system revenue (\$ thou.): \$	48.937
Savings in operating costs this yr(thou):\$	263.741
Savings in operating costs so far(thou):\$	1892.856

For year 10:

Average system cost per million Btu: \$	12.67
Total annual system cost (\$ thou.): \$	379.259
Average wellhead cost per million geo Btu: \$	4.40
Total annual wellhead cost (\$ thou.): \$	121.220
Total annual system revenue (\$ thou.): \$	456.338
Net annual system revenue (\$ thou.): \$	77.079
Savings in operating costs this yr(thou):\$	271.988
Savings in operating costs so far(thou):\$	2164.845

For year 11:

Average system cost per million Btu: \$	12.20
Total annual system cost (\$ thou.): \$	365.305
Average wellhead cost per million geo Btu: \$	4.15
Total annual wellhead cost (\$ thou.): \$	114.274
Total annual system revenue (\$ thou.): \$	470.028
Net annual system revenue (\$ thou.): \$	104.723
Savings in operating costs this yr(thou):\$	281.058
Savings in operating costs so far(thou):\$	2445.902

For year 12:

Average system cost per million Btu: \$	12.34
Total annual system cost (\$ thou.): \$	369.511
Average wellhead cost per million geo Btu: \$	4.43
Total annual wellhead cost (\$ thou.): \$	121.964
Total annual system revenue (\$ thou.): \$	484.129
Net annual system revenue (\$ thou.): \$	114.618
Savings in operating costs this yr(thou):\$	289.892
Savings in operating costs so far(thou):\$	2735.795

For year 13:

Average system cost per million Btu: \$	11.92
Total annual system cost (\$ thou.): \$	356.987
Average wellhead cost per million geo Btu: \$	4.18
Total annual wellhead cost (\$ thou.): \$	114.963
Total annual system revenue (\$ thou.): \$	498.653
Net annual system revenue (\$ thou.): \$	141.666
Savings in operating costs this yr(thou):\$	299.499
Savings in operating costs so far(thou):\$	3035.294
Payback achieved in this year.	

COMMERCIAL-RESIDENTIAL SCENARIO
GEOHERMAL MODE WITH HEAT
RECOVERY FROM DIESEL GENERATOR EXHAUST

For year 14:

Average system cost per million Btu: \$	11.56
Total annual system cost (\$ thou.): \$	346.196
Average wellhead cost per million geo Btu: \$	3.94
Total annual wellhead cost (\$ thou.): \$	108.480
Total annual system revenue (\$ thou.): \$	513.613
Net annual system revenue (\$ thou.): \$	167.417
Savings in operating costs this yr(thou):\$	308.933
Savings in operating costs so far(thou):\$	3344.227

For year 15:

Average system cost per million Btu: \$	11.23
Total annual system cost (\$ thou.): \$	336.146
Average wellhead cost per million geo Btu: \$	3.72
Total annual wellhead cost (\$ thou.): \$	102.477
Total annual system revenue (\$ thou.): \$	529.021
Net annual system revenue (\$ thou.): \$	192.875
Savings in operating costs this yr(thou):\$	319.111
Savings in operating costs so far(thou):\$	3663.338

For year 16:

Average system cost per million Btu: \$	10.94
Total annual system cost (\$ thou.): \$	327.634
Average wellhead cost per million geo Btu: \$	3.52
Total annual wellhead cost (\$ thou.): \$	96.919
Total annual system revenue (\$ thou.): \$	544.892
Net annual system revenue (\$ thou.): \$	217.258
Break-even point achieved in this year.	
Savings in operating costs this yr(thou):\$	329.167
Savings in operating costs so far(thou):\$	3992.505

For year 17:

Average system cost per million Btu: \$	10.68
Total annual system cost (\$ thou.): \$	319.747
Average wellhead cost per million geo Btu: \$	3.33
Total annual wellhead cost (\$ thou.): \$	91.773
Total annual system revenue (\$ thou.): \$	561.238
Net annual system revenue (\$ thou.): \$	241.492
Savings in operating costs this yr(thou):\$	339.952
Savings in operating costs so far(thou):\$	4332.457

For year 18:

Average system cost per million Btu: \$	10.46
Total annual system cost (\$ thou.): \$	313.237
Average wellhead cost per million geo Btu: \$	3.16
Total annual wellhead cost (\$ thou.): \$	87.008
Total annual system revenue (\$ thou.): \$	575.076
Net annual system revenue (\$ thou.): \$	264.839
Savings in operating costs this yr(thou):\$	350.658
Savings in operating costs so far(thou):\$	4683.115

COMMERCIAL-RESIDENTIAL SCENARIO
GEO THERMAL MODE WITH HEAT
 RECOVERY FROM DIESEL GENERATOR EXHAUST

For year 19:

Average system cost per million Btu: \$	10.26
Total annual system cost (\$ thou.): \$	307.250
Average wellhead cost per million geo Btu: \$	3.00
Total annual wellhead cost (\$ thou.): \$	82.595
Total annual system revenue (\$ thou.): \$	595.418
Net annual system revenue (\$ thou.): \$	288.168
Savings in operating costs this yr(thou):\$	362.088
Savings in operating costs so far(thou):\$	5045.203

For year 20:

Average system cost per million Btu: \$	10.10
Total annual system cost (\$ thou.): \$	302.506
Average wellhead cost per million geo Btu: \$	2.85
Total annual wellhead cost (\$ thou.): \$	78.510
Total annual system revenue (\$ thou.): \$	613.280
Net annual system revenue (\$ thou.): \$	310.775
Savings in operating costs this yr(thou):\$	373.476
Savings in operating costs so far(thou):\$	5418.679

For year 21:

Average system cost per million Btu: \$	9.96
Total annual system cost (\$ thou.): \$	298.197
Average wellhead cost per million geo Btu: \$	2.72
Total annual wellhead cost (\$ thou.): \$	74.727
Total annual system revenue (\$ thou.): \$	631.679
Net annual system revenue (\$ thou.): \$	333.482
Savings in operating costs this yr(thou):\$	385.590
Savings in operating costs so far(thou):\$	5804.269

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	3032.899
Net Present Value (\$ thou.): \$	712.707
Discounted Average Cost (\$/mil. Btu): \$	13.733
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	5.094
Break-even point in year 16	
Total Savings in Operating Costs(thou):\$	5804.269
Payback achieved in year 13	

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COMMERCIAL-RESIDENTIAL SCENARIO

FOSSIL-FUEL MODE ONLY

(8% RATE OF RETURN

ZONE ABCDFHS

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)
 (Base period for costs is 2nd Quarter, 1981)
 Residential-Commercial Scenario Parameters
 (All sets of options will be listed)

Program Operating Conditions

0 "Fossil-Fuel-Only" system--ignore geothermal
 # 2 Output file name:
 # 4 Title of scenario: (displayed above, if any)
 # 5 Residential-Commercial service chosen.
 # 8 Data files will not be generated.
 # 9 System will be sized according to DEMAND conditions.

Do you wish to change any of these options now (Yes/No)? N
 Resource Condition Parameters

38 Transport distance (miles): 1.50

Do you wish to change any of these options now (Yes/No)? N
 Residential-Commercial Demand Condition Parameters

10 Area under consideration: BERLIN
 # 14 System design temp. (deg. Fahr.): 40
 # 28 Min. ambient temperature (deg. Fahr.): 16.
 # 35 Fraction of distribution system installed:
 in year 2 = 100.000%

<press "RETURN" to continue>

(Residential-Specific)

52 Ultimate number of households: 60.
 # 13 Percentages of housing types on system:
 Housing type (%) (Btu/hr/deg)
 1-single family suburban: 100.000 1200.
 2-single family dense: 0.000 1200.
 3-townhouse: 0.000 780.
 4-garden apts.: 0.000 420.
 5-high rise: 0.000 348.

34 Market saturation (%): 50.00

19 Rate of residential market penetration

linear function used with:
 initial percentage= 100.00
 annual change = 0.00

18 Hookup cost per household:

Housing type (\$)
 1-single family suburban: 1500.00
 2-single family dense: 1500.00
 3-townhouse: 1500.00
 4-garden apts.: 400.00
 5-high rise: 400.00

Avg hookup cost per household: 1500.00

39 Domestic hot water (mil. Btu/yr/hh): 20.10

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

(Commercial-Specific)

- # 45 Number of types of commercial buildings: 7
- # 46 Avg. floor space for each commercial building of
type 1 :	3.000 thousand sq. ft.
type 2 :	19.200 thousand sq. ft.
type 3 :	75.000 thousand sq. ft.
type 4 :	49.000 thousand sq. ft.
type 5 :	5.000 thousand sq. ft.
type 6 :	5.000 thousand sq. ft.
type 7 :	6.000 thousand sq. ft.
- # 47 Average heat demand for
- | Buildings of | Space Heat
(Btu/sqft/deg/day) | Hot Water Heat
(Btu/sqft/day) |
|--------------|----------------------------------|----------------------------------|
| type 1: | 16.3 | 9.0 |
| type 2: | 6.5 | 9.0 |
| type 3: | 22.3 | 9.0 |
| type 4: | 16.1 | 9.0 |
| type 5: | 72.4 | 640.0 |
| type 6: | 14.5 | 410.6 |
| type 7: | 25.8 | 9.0 |
- # 48 Number of commercial buildings of
type 1 :	40
type 2 :	1
type 3 :	1
type 4 :	1
type 5 :	1
type 6 :	1
type 7 :	1
- # 51 Rate of commercial market penetration
 linear function used with:
 initial percentage= 100.00
 annual change = 0.00
- # 50 Length of commercial distrib. sys: 0.00 miles
- # 49 Avg cost per hookup of a commer. bldg: \$ 1524.
- Do you wish to change any of these options now (Yes/No)? N

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

Financial Condition Parameters

```
# 40 Economic accounting method: NPV & Disc Avg Cost
# 36 System selling price ($/mil. Btu):
      compounding function used with:
      initial selling price= 16.37
      annual change (percent): 3.00
# 33 Study period: 22 years; Intervals of 1 year
# 41 Resource assessment period 2 yrs
      Ann'l resource assess. cost($thous): 50.
# 16 Well cost adjustment factor: 0.894
      Adj. total cost of wells($thou): 1100.000
# 17 Heat exch. cost adjustment factor: 1.000
      Adj tot cost of heat exchs($thou): 35.506 (* projected *)
# 24 Storage tank capacity: 0.0 hours of flow
<press "RETURN" to continue>
# 15 Capital Equipment Amort. Per. Phys. Life
      Wells 30. yrs* 30. yrs
      Piping system 30. yrs* 30. yrs
      Heat exchanger 10. yrs* 10. yrs
      Pumps 10. yrs* 10. yrs
      Hookups 30. yrs* 30. yrs
      Peaking boiler 30. yrs* 30. yrs
      Storage tank 0. yrs* 30. yrs
      *(reduced as needed to end in study period)
<press "RETURN" to continue>
# 37 Discount rate (percent): 4.00
# 27 Interest rate (percent): 12.00
# 25 Cost calculations are in REAL dollars
      Inflation rate (percent): 8.00
# 20 Cost of electricity (cts/kwh)
      compounding function used with:
      initial elec. price= 5.60
      percent annual change= 3.00
# 29 Fossil fuel cost ($/mil. Btu)
      compounding function used with:
      initial foss. fuel price= 7.580
      percent annual change= 3.000
# 44 Oper. & maint. cost (% of capital): 1.00%
# 30 Boiler cost($/100K Btu/hr): 2000.00
# 22 Distrib sys pipe cost($thou/mi): 250.000
<press "RETURN" to continue>
```

Residential-commercial option in effect.

The scenario has a resource assessment period of 2 years.

Time horizon is 22 years, with costs calculated every 1 year

Dollar values are in real dollars.

System will be sized to meet the specified demand conditions.

The system will be a fossil-fuel-only system (no geothermal.)

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

* * Cost of Initial Capital Equipment * *

Wells:	\$	0.000 thousand
Distribution system:	\$	311.333 thousand
Heat exchangers:	\$	0.000 thousand
Pumps:	\$	11.548 thousand
Hookups:	\$	160.104 thousand
Peaking boiler:	\$	287.132 thousand
Transport system:	\$	1229.466 thousand
Storage tank:	\$	0.000 thousand
<hr/>		
* Total *	\$	1999.583 thousand

Summary of Finances Over Life of Project

Capital Cost (\$ thousands):	1999.583
Net Present Value (\$ thous.):	661.905
Discounted Avg Cost (\$/mil.Btu):	20.767
Disc.Avg.Wellhead Cost(\$/mil.Btu):	*****
Break-even point achieved in year	15
Tot. Oper. Cost Savings(\$thou):	-738.607
Payback not achieved.	

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 2

Peak total flow (gpm):	957.11
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	0.00
Total system Btu's (millions):	29944.28
Pumping energy:	0.212 million kwh
Coefficient of performance:	*****
Percentage geothermal utilization:	0.00
Percentage service geothermal:	0.00

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	0.000
Distribution system costs:	50.090
Heat exchanger costs:	0.000
Original pump costs:	2.044
Hookup costs:	25.759
Pump overhaul costs:	0.173
Annual pumping costs:	12.605
Peaking boiler costs:	38.441
Fossil fuel costs:	320.265
Transport costs:	164.599
Storage tank costs:	0.000
Operation and maintenance costs:	19.996
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:*****	
Total annual system costs:	633.972
Wellhead cost per geo mil. Btu(\$):*****	
System cost per mil. Btu(\$):	21.17
Revenue (\$ thousands):	520.136
Net revenue (\$ thousands):	-113.837
Oper cost saved this yr(\$thou):	-32.600
Oper cost saved so far(\$thou):	-32.600

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 3

Peak total flow (gpm):	957.11
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	0.00
Total system Btu's (millions):	29944.28
Pumping energy:	0.212 million kwh
Coefficient of performance:	*****
Percentage geothermal utilization:	0.00
Percentage service geothermal:	0.00

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	0.000
Distribution system costs:	46.380
Heat exchanger costs:	0.000
Original pump costs:	1.892
Hookup costs:	23.851
Pump overhaul costs:	0.173
Annual pumping costs:	12.983
Peaking boiler costs:	35.593
Fossil fuel costs:	329.873
Transport costs:	152.407
Storage tank costs:	0.000
Operation and maintenance costs:	19.996
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:*****	
Total annual system costs:	623.148
Wellhead cost per geo mil. Btu(\$):*****	
System cost per mil. Btu(\$):	20.81
Revenue (\$ thousands):	535.740
Net revenue (\$ thousands):	-87.409
Oper cost saved this yr(\$thou):	-32.979
Oper cost saved so far(\$thou):	-65.579

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 4

Peak total flow (gpm):	957.11
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	0.00
Total system Btu's (millions):	29944.28
Pumping energy:	0.212 million kwh
Coefficient of performance:	*****
Percentage geothermal utilization:	0.00
Percentage service geothermal:	0.00

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	0.000
Distribution system costs:	42.944
Heat exchanger costs:	0.000
Original pump costs:	1.752
Hookup costs:	22.084
Pump overhaul costs:	0.173
Annual pumping costs:	13.372
Peaking boiler costs:	32.957
Fossil fuel costs:	339.769
Transport costs:	141.118
Storage tank costs:	0.000
Operation and maintenance costs:	19.996
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:*****	
Total annual system costs:	614.166
Wellhead cost per geo mil. Btu(\$):*****	
System cost per mil. Btu(\$):	20.51
Revenue (\$ thousands):	551.812
Net revenue (\$ thousands):	-62.354
Oper cost saved this yr(\$thou):	-33.368
Oper cost saved so far(\$thou):	-98.947

COMMERCIAL-RESIDENTIAL SCENARIO
FOSSIL-FUEL MODE ONLY
 (8% Rate of Return)

BERLIN ZONE "A B C D F H S" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 21

Peak total flow (gpm):	957.11
Number of households:	60.
Length of distribution system:	1.25 miles
Total residential Btu's (millions):	8425.90
Total geothermal Btu's (millions):	0.00
Total system Btu's (millions):	29944.28
Pumping energy:	0.212 million kwh
Coefficient of performance:	*****
Percentage geothermal utilization:	0.00
Percentage service geothermal:	0.00

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	0.000
Distribution system costs:	11.607
Heat exchanger costs:	0.000
Original pump costs:	1.022
Hookup costs:	5.969
Pump overhaul costs:	0.173
Annual pumping costs:	22.102
Peaking boiler costs:	8.907
Fossil fuel costs:	561.586
Transport costs:	38.140
Storage tank costs:	0.000
Operation and maintenance costs:	19.996
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:*****	
Total annual system costs:	669.502
Wellhead cost per geo mil. Btu(\$):*****	
System cost per mil. Btu(\$):	22.36
Revenue (\$ thousands):	912.061
Net revenue (\$ thousands):	242.559
Oper cost saved this yr(\$thou):	-42.098
Oper cost saved so far(\$thou):	-738.607

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COMMERCIAL-RESIDENTIAL SCENARIO

(8% RATE OF RETURN

ZONE EJLMO

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Residential-Commercial Scenario Parameters

(All sets of options will be listed)

Program Operating Conditions

```
# 0 Standard geothermal system
# 2 Output file name:
# 4 Title of scenario: (displayed above, if any)
# 5 Residential-Commercial service chosen.
# 8 Data files will not be generated.
# 9 System will be sized according to DEMAND conditions.
```

Do you wish to change any of these options now (Yes/No)? N

Resource Condition Parameters

```
# 42 Number of production wells: 1
# 12 Depth of upwell (feet): 6000.
# 11 Wellhead water temp.(deg. Fahr.)
    linear function used with:
        initial water temp.= 160.0
        annual drop in temp.= 0.0
# 21 Reject temperature (deg. Fahr.): 110.0
# 43 Number of reinjection wells: 1
# 23 Depth of reinjection well (feet): 3000.
<press "RETURN" to continue>
# 26 Drawdown of upwell (percent)
    determined from aquifer characteristics:
        Pumping cycle: Space heating application
        Transmissivity= 0.500 sq.cm./sec.
        Aq.Stor.Coeff.= 0.003900; Well Radius=12.0 in.
# 32 Maximum flow per well (gpm)
    linear function used with:
        initial flow= 300.00
        annual change= 0.00
# 38 Transport distance (miles) carrying flow of...
    1 wells' flow to distn. system: 0.850
    1 wells' flow to reinj. well: 0.520
```

Do you wish to change any of these options now (Yes/No)? N

Residential-Commercial Demand Condition Parameters

```
# 10 Area under consideration: BERLIN
# 14 System design temp.(deg. Fahr.): 34
# 28 Min. ambient temperature (deg. Fahr.): -15.
# 35 Fraction of distribution system installed:
    in year 2 =100.000%
```

<press "RETURN" to continue>

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

(Residential-Specific)

```
# 52  Ultimate number of households:      15.
# 13  Percentages of housing types on system:
      Housing type      (%)      (Btu/hr/deg)
      1-single family suburban: 100.000      1200.
      2-single family dense:    0.000      1200.
      3-townhouse:              0.000      780.
      4-garden apts.:          0.000      420.
      5-high rise:              0.000      348.
# 34  Market saturation (%):              50.00
# 19  Rate of residential market penetration
      linear function used with:
        initial percentage= 100.00
        annual change      =   0.00
# 18  Hookup cost per household:
      Housing type      ($)
      1-single family suburban: 1500.00
      2-single family dense:    1500.00
      3-townhouse:              1500.00
      4-garden apts.:          400.00
      5-high rise:              400.00
      Avg hookup cost per household: 1500.00
# 39  Domestic hot water(mil.Btu/yr/hh):   20.10
<press "RETURN" to continue>
(Commercial-Specific)
# 45  Number of types of commercial buildings:  5
# 46  Avg. floor space for each commercial building of
      type 1 :    90.300 thousand sq. ft.
      type 2 :    6.560 thousand sq. ft.
      type 3 :   13.800 thousand sq. ft.
      type 4 :    9.100 thousand sq. ft.
      type 5 :    2.290 thousand sq. ft.
# 47  Average heat demand for
      Buildings      Space Heat      Hot Water Heat
      of      (Btu/sqft/deg/day)  (Btu/sqft/day)
      type 1:      10.8      48.1
      type 2:      15.3      9.0
      type 3:      34.4      9.0
      type 4:      17.1      9.0
      type 5:      17.1      9.0
# 48  Number of commercial buildings of
      type 1 :    1
      type 2 :    1
      type 3 :    1
      type 4 :    8
      type 5 :   10
# 51  Rate of commercial market penetration
      linear function used with:
        initial percentage= 100.00
        annual change      =   0.00
# 50  Length of commercial distrib. sys:    0.00 miles
# 49  Avg cost per hookup of a commer. bldg: $ 1524.
Do you wish to change any of these options now (Yes/No)? N
```

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

Financial Condition Parameters

```
# 40 Economic accounting method: NPV & Disc Avg Cost
# 36 System selling price ($/mil. Btu):
      selling price is a multiple of:
      fossil fuel price, factor=      1.60
# 33 Study period: 22 years; Intervals of      1 year
# 41 Resource assessment period      2 yrs
      Ann'l resource assess. cost($thous):      50.
# 16 Well cost adjustment factor:      0.894
      Adj. total cost of wells($thou): 1100.000
# 17 Heat exch. cost adjustment factor:      1.000
      Adj tot cost of heat exchs($thou): 35.506 (* projected *)
# 24 Storage tank capacity:      0.0 hours of flow
<press "RETURN" to continue>
# 15 Capital Equipment Amort. Per. Phys. Life
      Wells      30. yrs*      30. yrs
      Piping system      30. yrs*      30. yrs
      Heat exchanger      10. yrs*      10. yrs
      Pumps      10. yrs*      10. yrs
      Hookups      30. yrs*      30. yrs
      Peaking boiler      30. yrs*      30. yrs
      Storage tank      0. yrs*      30. yrs
      *(reduced as needed to end in study period)
<press "RETURN" to continue>
# 37 Discount rate (percent):      4.00
# 27 Interest rate (percent):      12.00
# 25 Cost calculations are in REAL dollars
      Inflation rate (percent):      8.00
# 20 Cost of electricity (cts/kwh)
      compounding function used with:
      initial elec. price=      5.60
      percent annual change=      3.00
# 29 Fossil fuel cost ($/mil. Btu)
      compounding function used with:
      initial foss. fuel price=      7.580
      percent annual change=      3.000
# 44 Oper. & maint. cost (% of capital):      1.00%
# 30 Boiler cost($/100K Btu/hr):      2000.00
# 22 Distrib sys pipe cost($thou/mi):      250.000
<press "RETURN" to continue>
```

Residential-commercial option in effect.

The scenario has a resource assessment period of 2 years.

Time horizon is 22 years, with costs calculated every 1 year

Dollar values are in real dollars..

System will be sized to meet the specified demand conditions.

The system will be a hybrid geothermal system.

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

* * Cost of Initial Capital Equipment * *

Wells:	\$	1100.000	thousand
Distribution system:	\$	77.833	thousand
Heat exchangers:	\$	24.287	thousand
Pumps:	\$	45.738	thousand
Hookups:	\$	54.504	thousand
Peaking boiler:	\$	147.583	thousand
Transport system:	\$	511.916	thousand
Storage tank:	\$	0.000	thousand
<hr/>			
* Total *	\$	1961.861	thousand

Summary of Finances Over Life of Project

Capital Cost (\$ thousands):	1961.861
Net Present Value (\$ thous.):	254.207
Discounted Avg Cost (\$/mil.Btu):	15.377
Disc. Avg. Wellhead Cost (\$/mil.Btu):	8.171
Break-even point achieved in year	18
Tot. Oper. Cost Savings (\$thou):	3100.946
Payback achieved in year	16

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 2

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.400 million kwh
Coefficient of performance:	10.63
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	147.267
Distribution system costs:	12.523
Heat exchanger costs:	4.298
Original pump costs:	8.095
Hookup costs:	8.769
Pump overhaul costs:	6.386
Annual pumping costs:	23.745
Peaking boiler costs:	19.758
Fossil fuel costs:	10.231
Transport costs:	68.535
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	175.103
Total annual system costs:	329.225
Wellhead cost per geo mil. Btu(\$):	12.08
System cost per mil. Btu(\$):	21.31
Revenue (\$ thousands):	198.802
Net revenue (\$ thousands):	-130.423
Oper cost saved this yr(\$thou):	111.660
Oper cost saved so far(\$thou):	111.660

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1963)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 3

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.400 million kwh
Coefficient of performance:	10.63
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	136.358
Distribution system costs:	11.595
Heat exchanger costs:	3.980
Original pump costs:	7.495
Hookup costs:	8.120
Pump overhaul costs:	6.386
Annual pumping costs:	24.458
Peaking boiler costs:	18.295
Fossil fuel costs:	10.537
Transport costs:	63.458
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	163.448
Total annual system costs:	310.300
Wellhead cost per geo mil. Btu(\$):	11.28
System cost per mil. Btu(\$):	20.08
Revenue (\$ thousands):	204.766
Net revenue (\$ thousands):	-105.534
Oper cost saved this yr(\$thou):	115.598
Oper cost saved so far(\$thou):	227.258

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 4

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.408 million kwh
Coefficient of performance:	10.41
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	126.257
Distribution system costs:	10.736
Heat exchanger costs:	3.685
Original pump costs:	6.940
Hookup costs:	7.518
Pump overhaul costs:	6.386
Annual pumping costs:	25.716
Peaking boiler costs:	16.940
Fossil fuel costs:	10.854
Transport costs:	58.757
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	152.656
Total annual system costs:	293.408
Wellhead cost per geo mil. Btu(\$):	10.53
System cost per mil. Btu(\$):	18.99
Revenue (\$ thousands):	210.909
Net revenue (\$ thousands):	-82.498
Oper cost saved this yr(\$thou):	119.130
Oper cost saved so far(\$thou):	346.368

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 12

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.423 million kwh
Coefficient of performance:	10.04
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	68.213
Distribution system costs:	5.800
Heat exchanger costs:	4.298
Original pump costs:	8.095
Hookup costs:	4.062
Pump overhaul costs:	6.386
Annual pumping costs:	33.796
Peaking boiler costs:	9.152
Fossil fuel costs:	13.749
Transport costs:	31.745
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	96.049
Total annual system costs:	204.914
Wellhead cost per geo mil. Btu(\$):	6.63
System cost per mil. Btu(\$):	13.26
Revenue (\$ thousands):	267.173
Net revenue (\$ thousands):	62.259
Oper cost saved this yr(\$thou):	154.925
Oper cost saved so far(\$thou):	1455.020

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 13

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.423 million kwh
Coefficient of performance:	10.04
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	63.160
Distribution system costs:	5.371
Heat exchanger costs:	3.980
Original pump costs:	7.495
Hookup costs:	3.761
Pump overhaul costs:	6.386
Annual pumping costs:	34.809
Peaking boiler costs:	8.474
Fossil fuel costs:	14.162
Transport costs:	29.393
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	90.250
Total annual system costs:	196.610
Wellhead cost per geo mil. Btu(\$):	6.23
System cost per mil. Btu(\$):	12.72
Revenue (\$ thousands):	275.189
Net revenue (\$ thousands):	78.579
Oper cost saved this yr(\$thou):	160.161
Oper cost saved so far(\$thou):	1615.181

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 14

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.426 million kwh
Coefficient of performance:	9.98
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs	(thousands of dollars):
Well costs:	58.482
Distribution system costs:	4.973
Heat exchanger costs:	3.685
Original pump costs:	6.940
Hookup costs:	3.482
Pump overhaul costs:	6.386
Annual pumping costs:	36.047
Peaking boiler costs:	7.846
Fossil fuel costs:	14.586
Transport costs:	27.216
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	84.880
Total annual system costs:	189.262
Wellhead cost per geo mil. Btu(\$):	5.86
System cost per mil. Btu(\$):	12.25
Revenue (\$ thousands):	283.444
Net revenue (\$ thousands):	94.182
Oper cost saved this yr(\$thou):	165.361
Oper cost saved so far(\$thou):	1780.543

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 19

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.429 million kwh
Coefficient of performance:	9.89
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	39.802
Distribution system costs:	3.384
Heat exchanger costs:	2.508
Original pump costs:	4.723
Hookup costs:	2.370
Pump overhaul costs:	6.386
Annual pumping costs:	42.157
Peaking boiler costs:	5.340
Fossil fuel costs:	16.910
Transport costs:	18.523
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	63.441
Total annual system costs:	161.722
Wellhead cost per geo mil. Btu(\$):	4.38
System cost per mil. Btu(\$):	10.47
Revenue (\$ thousands):	328.590
Net revenue (\$ thousands):	166.868
Oper cost saved this yr(\$thou):	194.455
Oper cost saved so far(\$thou):	2692.905

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 20

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.431 million kwh
Coefficient of performance:	9.86
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	36.853
Distribution system costs:	3.134
Heat exchanger costs:	2.322
Original pump costs:	4.373
Hookup costs:	2.194
Pump overhaul costs:	6.386
Annual pumping costs:	43.583
Peaking boiler costs:	4.944
Fossil fuel costs:	17.417
Transport costs:	17.151
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	60.057
Total annual system costs:	157.977
Wellhead cost per geo mil. Btu(\$):	4.14
System cost per mil. Btu(\$):	10.22
Revenue (\$ thousands):	338.447
Net revenue (\$ thousands):	180.470
Oper cost saved this yr(\$thou):	200.716
Oper cost saved so far(\$thou):	2893.621

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

BERLIN ZONE "E J L M O" (STUDY PERIOD STARTS IN 1983)

(Base period for costs is 2nd Quarter, 1981)

Results of Residential-Commercial Model for Year 21

Peak total flow (gpm):	190.57
Number of households:	15.
Length of distribution system:	0.31 miles
Total residential Btu's (millions):	2106.47
Total geothermal Btu's (millions):	14494.48
Total system Btu's (millions):	15451.03
Pumping energy:	0.431 million kwh
Coefficient of performance:	9.86
Percentage geothermal utilization:	34.73
Percentage service geothermal:	93.81

<Press "RETURN" to continue>

Annualized Costs (thousands of dollars):

Well costs:	34.123
Distribution system costs:	2.902
Heat exchanger costs:	2.150
Original pump costs:	4.049
Hookup costs:	2.032
Pump overhaul costs:	6.386
Annual pumping costs:	44.891
Peaking boiler costs:	4.578
Fossil fuel costs:	17.939
Transport costs:	15.880
Storage tank costs:	0.000
Operation and maintenance costs:	19.619
Resource assessment costs:	0.000

<Press "RETURN" to continue>

Total annual wellhead costs:	56.924
Total annual system costs:	154.550
Wellhead cost per geo mil. Btu(\$):	3.93
System cost per mil. Btu(\$):	10.00
Revenue (\$ thousands):	348.601
Net revenue (\$ thousands):	194.051
Oper cost saved this yr(\$thou):	207.326
Oper cost saved so far(\$thou):	3100.946

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

7
At what detail should the results be printed at the terminal:
(output to file, if any, is unaffected)
1-only final net present value or discounted average cost
2-annual summary for each calculated year
3-full details for each calculated year
4-full details for selected years
Type in number to begin execution: 2

For year 0:

Average system cost per million Btu:	*****
Total annual system cost (\$ thou.):	\$ 50.000
Average wellhead cost per million geo Btu:	*****
Total annual wellhead cost (\$ thou.):	\$ 50.000
Total annual system revenue (\$ thou.):	\$ 0.000
Net annual system revenue (\$ thou.):	\$ -50.000
Savings in operating costs this yr(thou):	\$ 0.000
Savings in operating costs so far(thou):	\$ 0.000

For year 1:

Average system cost per million Btu:	*****
Total annual system cost (\$ thou.):	\$ 50.000
Average wellhead cost per million geo Btu:	*****
Total annual wellhead cost (\$ thou.):	\$ 50.000
Total annual system revenue (\$ thou.):	\$ 0.000
Net annual system revenue (\$ thou.):	\$ -50.000
Savings in operating costs this yr(thou):	\$ 0.000
Savings in operating costs so far(thou):	\$ 0.000

For year 2:

Average system cost per million Btu:	\$ 21.31
Total annual system cost (\$ thou.):	\$ 329.225
Average wellhead cost per million geo Btu:	\$ 12.08
Total annual wellhead cost (\$ thou.):	\$ 175.103
Total annual system revenue (\$ thou.):	\$ 198.802
Net annual system revenue (\$ thou.):	\$ -130.423
Savings in operating costs this yr(thou):	\$ 111.660
Savings in operating costs so far(thou):	\$ 111.660

For year 3:

Average system cost per million Btu:	\$ 20.08
Total annual system cost (\$ thou.):	\$ 310.300
Average wellhead cost per million geo Btu:	\$ 11.28
Total annual wellhead cost (\$ thou.):	\$ 163.448
Total annual system revenue (\$ thou.):	\$ 204.766
Net annual system revenue (\$ thou.):	\$ -105.534
Savings in operating costs this yr(thou):	\$ 115.598
Savings in operating costs so far(thou):	\$ 227.258

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

For year 4:

Average system cost per million Btu: \$	18.99
Total annual system cost (\$ thou.): \$	293.408
Average wellhead cost per million geo Btu: \$	10.53
Total annual wellhead cost (\$ thou.): \$	152.656
Total annual system revenue (\$ thou.): \$	210.909
Net annual system revenue (\$ thou.): \$	-82.498
Savings in operating costs this yr(thou):\$	119.130
Savings in operating costs so far(thou):\$	346.388

For year 5:

Average system cost per million Btu: \$	17.95
Total annual system cost (\$ thou.): \$	277.406
Average wellhead cost per million geo Btu: \$	9.84
Total annual wellhead cost (\$ thou.): \$	142.664
Total annual system revenue (\$ thou.): \$	217.236
Net annual system revenue (\$ thou.): \$	-60.169
Savings in operating costs this yr(thou):\$	123.293
Savings in operating costs so far(thou):\$	469.681

For year 6:

Average system cost per million Btu: \$	17.03
Total annual system cost (\$ thou.): \$	263.065
Average wellhead cost per million geo Btu: \$	9.20
Total annual wellhead cost (\$ thou.): \$	133.411
Total annual system revenue (\$ thou.): \$	223.754
Net annual system revenue (\$ thou.): \$	-39.311
Savings in operating costs this yr(thou):\$	127.219
Savings in operating costs so far(thou):\$	596.900

For year 7:

Average system cost per million Btu: \$	16.15
Total annual system cost (\$ thou.): \$	249.580
Average wellhead cost per million geo Btu: \$	8.61
Total annual wellhead cost (\$ thou.): \$	124.845
Total annual system revenue (\$ thou.): \$	230.466
Net annual system revenue (\$ thou.): \$	-19.114
Savings in operating costs this yr(thou):\$	131.624
Savings in operating costs so far(thou):\$	728.525

For year 8:

Average system cost per million Btu: \$	15.37
Total annual system cost (\$ thou.): \$	237.501
Average wellhead cost per million geo Btu: \$	8.07
Total annual wellhead cost (\$ thou.): \$	116.912
Total annual system revenue (\$ thou.): \$	237.380
Net annual system revenue (\$ thou.): \$	-0.121
Savings in operating costs this yr(thou):\$	135.877
Savings in operating costs so far(thou):\$	864.401

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

For year 9:

Average system cost per million Btu: \$	14.64
Total annual system cost (\$ thou.): \$	226.188
Average wellhead cost per million geo Btu: \$	7.56
Total annual wellhead cost (\$ thou.): \$	109.568
Total annual system revenue (\$ thou.): \$	244.502
Net annual system revenue (\$ thou.): \$	18.314
Savings in operating costs this yr(thou):\$	140.542
Savings in operating costs so far(thou):\$	1004.943

For year 10:

Average system cost per million Btu: \$	13.99
Total annual system cost (\$ thou.): \$	216.084
Average wellhead cost per million geo Btu: \$	7.09
Total annual wellhead cost (\$ thou.): \$	102.767
Total annual system revenue (\$ thou.): \$	251.837
Net annual system revenue (\$ thou.): \$	35.752
Savings in operating costs this yr(thou):\$	145.105
Savings in operating costs so far(thou):\$	1150.048

For year 11:

Average system cost per million Btu: \$	13.37
Total annual system cost (\$ thou.): \$	206.647
Average wellhead cost per million geo Btu: \$	6.66
Total annual wellhead cost (\$ thou.): \$	96.470
Total annual system revenue (\$ thou.): \$	259.392
Net annual system revenue (\$ thou.): \$	52.744
Savings in operating costs this yr(thou):\$	150.047
Savings in operating costs so far(thou):\$	1300.096

For year 12:

Average system cost per million Btu: \$	13.26
Total annual system cost (\$ thou.): \$	204.914
Average wellhead cost per million geo Btu: \$	6.63
Total annual wellhead cost (\$ thou.): \$	96.049
Total annual system revenue (\$ thou.): \$	267.173
Net annual system revenue (\$ thou.): \$	62.259
Savings in operating costs this yr(thou):\$	154.925
Savings in operating costs so far(thou):\$	1455.020

For year 13:

Average system cost per million Btu: \$	12.72
Total annual system cost (\$ thou.): \$	196.610
Average wellhead cost per million geo Btu: \$	6.23
Total annual wellhead cost (\$ thou.): \$	90.250
Total annual system revenue (\$ thou.): \$	275.189
Net annual system revenue (\$ thou.): \$	78.579
Savings in operating costs this yr(thou):\$	160.161
Savings in operating costs so far(thou):\$	1615.181

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

For year 14:

Average system cost per million Btu: \$	12.25
Total annual system cost (\$ thou.): \$	189.262
Average wellhead cost per million geo Btu: \$	5.86
Total annual wellhead cost (\$ thou.): \$	84.880
Total annual system revenue (\$ thou.): \$	283.444
Net annual system revenue (\$ thou.): \$	94.182
Savings in operating costs this yr(thou):\$	165.361
Savings in operating costs so far(thou):\$	1780.543

For year 15:

Average system cost per million Btu: \$	11.81
Total annual system cost (\$ thou.): \$	182.438
Average wellhead cost per million geo Btu: \$	5.51
Total annual wellhead cost (\$ thou.): \$	79.908
Total annual system revenue (\$ thou.): \$	291.948
Net annual system revenue (\$ thou.): \$	109.509
Savings in operating costs this yr(thou):\$	170.911
Savings in operating costs so far(thou):\$	1951.454

For year 16:

Average system cost per million Btu: \$	11.42
Total annual system cost (\$ thou.): \$	176.457
Average wellhead cost per million geo Btu: \$	5.20
Total annual wellhead cost (\$ thou.): \$	75.305
Total annual system revenue (\$ thou.): \$	300.706
Net annual system revenue (\$ thou.): \$	124.249
Savings in operating costs this yr(thou):\$	176.448
Savings in operating costs so far(thou):\$	2127.901

Payback achieved in this year.

For year 17:

Average system cost per million Btu: \$	11.06
Total annual system cost (\$ thou.): \$	170.922
Average wellhead cost per million geo Btu: \$	4.90
Total annual wellhead cost (\$ thou.): \$	71.042
Total annual system revenue (\$ thou.): \$	309.727
Net annual system revenue (\$ thou.): \$	138.805
Savings in operating costs this yr(thou):\$	182.330
Savings in operating costs so far(thou):\$	2310.231

For year 18:

Average system cost per million Btu: \$	10.75
Total annual system cost (\$ thou.): \$	166.133
Average wellhead cost per million geo Btu: \$	4.63
Total annual wellhead cost (\$ thou.): \$	67.095
Total annual system revenue (\$ thou.): \$	319.019
Net annual system revenue (\$ thou.): \$	152.886

Break-even point achieved in this year.

Savings in operating costs this yr(thou):\$	188.219
Savings in operating costs so far(thou):\$	2498.450

COMMERCIAL-RESIDENTIAL SCENARIO
(8% Rate of Return)

For year 19:

Average system cost per million Btu: \$	10.47
Total annual system cost (\$ thou.): \$	161.722
Average wellhead cost per million geo Btu: \$	4.38
Total annual wellhead cost (\$ thou.): \$	63.441
Total annual system revenue (\$ thou.): \$	328.590
Net annual system revenue (\$ thou.): \$	166.868
Savings in operating costs this yr(thou):\$	194.455
Savings in operating costs so far(thou):\$	2692.905

For year 20:

Average system cost per million Btu: \$	10.22
Total annual system cost (\$ thou.): \$	157.977
Average wellhead cost per million geo Btu: \$	4.14
Total annual wellhead cost (\$ thou.): \$	60.057
Total annual system revenue (\$ thou.): \$	338.447
Net annual system revenue (\$ thou.): \$	180.470
Savings in operating costs this yr(thou):\$	200.716
Savings in operating costs so far(thou):\$	2893.621

For year 21:

Average system cost per million Btu: \$	10.00
Total annual system cost (\$ thou.): \$	154.550
Average wellhead cost per million geo Btu: \$	3.93
Total annual wellhead cost (\$ thou.): \$	56.924
Total annual system revenue (\$ thou.): \$	348.601
Net annual system revenue (\$ thou.): \$	194.051
Savings in operating costs this yr(thou):\$	207.326
Savings in operating costs so far(thou):\$	3100.946

Summary of Finances Over Life of Project

Capital Cost(excl replacement)(\$thou):\$	1961.861
Net Present Value (\$ thou.): \$	254.207
Discounted Average Cost (\$/mil. Btu): \$	15.377
Discounted Avg Wellhead Cost (\$/mil. Btu): \$	8.171
Break-even point in year 18	
Total Savings in Operating Costs(thou):\$	3100.946
Payback achieved in year 16	

APPENDIX B

GRAPHS OF ENERGY PRICES AND

SENSITIVITY ANALYSES

Figure B-1

Price Of Energy Over Life Of System
Zone ABCDFHS

("Geothermal" energy price is 1.52 times price of "100% efficient oil")

BERLIN DIST HEATING SYS - COMM/RESID

Figure B-2

Price Of Energy Over Life Of System
 Zone ABCDFHS

("Geothermal" energy price is 1.50 times price of "100% efficient oil")

ANNUAL COST COMPONENTS:
 1 - CAPITAL COST AMORTIZATION
 2 - OPERATION & MAINTENANCE COSTS
 3 - FOSSIL FUEL COSTS
 4 - PUMPING COSTS

Figure B-3

Distribution of Cash Flow Expressed In 1981 Dollars
 Zone ABCDFHS Commercial/Residential Scenario
 (8% Rate of Return)

- Note: 1. Geothermal Energy Price is 1.50 Times Price Of Oil
 2. Break Even Point Occurs In Year 18

BERLIN DIST HEATING SYS - COMM/RESID

OIL - 55% EFFICIENCY OIL COST
 GEO - GEOTHERMAL HEATING SYSTEM
 DAC - DISCOUNTED AVERAGE COST

Figure B-4

Price Of Energy Over Life Of System
 Zone EJLMO

(Geothermal energy price is 1.60 times price of "100% efficient oil")

Figure B-5

Comparison Between Geothermal Energy Prices

DISC \$/MILLION BTU

BERLIN DIST HEATING SYS - COST ANAL

EFFECT OF WELL FLOW RATE (GPM) AND TEMPERATURE ON SYSTEM COSTS, SUCH AS SYS SELLING COST AND DISC AVERAGE COST

ZONE ABCDFHS

Figure B-6