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GEOCITY: A COMPUTER CODE FOR CALCULATING COSTS OF DISTRICT HEATING USING GEOTHERMAL RESOURCES

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SUMMARY

GEOCITY is a computer simulation model developed to study the economics of district heating using geothermal energy. GEOCITY calculates the cost of district heating based on climate, population, resource characteristics, and financing conditions. The principal input variables are minimum temperature, heating degree days, population size and density, resource temperature and distance from load center, and the interest rate. From this input data the model designs the transmission and district heating systems. From this design, GEOCITY calculates the capital and operating costs for the entire system, including the production and disposal of the geothermal water.

GEOCITY consists of two major submodels: the geothermal reservoir model and the distribution system model. The distribution system model calculates the cost of heat by simulating the design and the operation of the district heating system. The reservoir model calculates the cost of energy by simulating the discovery, development and operation of a geothermal resource and the transmission of this energy to a distribution center. The submodels can be used independently; that is, the distribution model will accept any source of hot water and the reservoir model will deliver energy to meet any demand.

The distribution system model can simulate many designs for hot water heating systems. These alternative designs include various configurations of heat pumps and/or heat exchangers; different piping system design practices; and the use of different materials for pipe, insulation, and casing.

GEOCITY can simulate nearly any financial and tax structure through varying the rates of return on equity and debt, the debt-equity ratios, and tax rates. Both private enterprise and municipal utility systems can be simulated. The reservoir model and the distribution model may have the same or differing financial structures and costs of capital. The distribution system and reservoir life can be varied over a long period, currently up to 50 years.

GEOCITY calculates the cost of energy based on the principle that the present worth of the revenues will be equal to the present worth of the expenses including investment return over the economic life of the distribution system and/or reservoir. The present worth factor is determined by the capital structure and rates of return on invested capital for the organization.

The models have been designed to enable extensive sensitivity studies to determine the relative effect of different economic and technical parameters, assumptions, and uncertainties on the cost of providing heat. The GEOCITY program can be used to:

- determine the economic incentives for specific research and development programs;
- determine potential economic impacts of uncertainties in resource conditions and technology;
- identify major cost components;
- assess the economic incentive for district heating at specific locations; and
- provide a systematic method for comparing district heating system designs.

Combined with resource assessment, climatic, and demographic information, GEOCITY can be used to define the potential supply curve (price/quanity relationship) for geothermal energy. This supply curve forms the basis for: 1) assessing the potential role of geothermal energy in competition with other sources of energy, and 2) estimating potential economic incentives for new research and development programs.

INTRODUCTION

District heating is an area where low quality energy (geothermal heat) can replace high quality energy (fossil fuels and electricity). Geothermal energy is a potentially extensive and inexhaustible energy source. A large fraction of the known geothermal resources consist of medium to low temperature water. The energy available in this water may be efficiently exploited with district heating systems. Economic exploitation depends on the design of the distribution systems and the characteristics of the city, climate and geothermal resource.

Since wide variations are expected in cities, climates and geothermal sources, a computer program called GEOCITY has been developed to systematically calculate the potential cost of district heating using geothermal power. GEOCITY combines engineering design, engineering economy and economic simulation. This provides the capability to evaluate the impacts of heating costs, variations in economic and technical factors, resource conditions, climate, and demographic factors. System components are designed using accepted engineering practice; some component designs are optimized. This report describes GEOCITY; after an overview of the program, the various components are described in detail.

GEOCITY is an offshoot of the GEOCOST computer program,[1] which calculates the cost of generating electricity from geothermal resources. The reservoir model in GEOCITY is taken directly from GEOCOST. The distribution model is derived from a solar energy district heating model obtained from Sandia Laboratories.[a] The GEOCITY program comprises the entire production, distribution, and waste disposal system for geothermal district heating applications, but does not include the cost of radiators, convectors, or other in-house heating systems.

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[a] B.W. Marshell of Sandia Laboratories generously provided a copy of the code he was developing.

GEOCITY OVERVIEW

The GEOCITY program consists of design models and deterministic cost models which simulate the construction and operation of a district heating system using a geothermal resource. The design models develop system components based on the characteristics of the resource, climate, city and buildings heated. Capital costs for the components are then determined from cost models. Other cost models provide operating costs. Accounting routines generate the cash flow from capital and operating costs and other economic factors, e.g., taxes, interest rate and rate of return. Using discounted cash flow analysis, GEOCITY calculates the unit cost for district heating. The input data are the wellhead fluid conditions, density and area of zones within the city, description of heat demand of buildings within each zone, climatic conditions and piping system design. GEOCITY includes an economic and technical data file consisting of design parameters and cost and tax data. The code user may use the built-in data or supply any desired changes.

The flow chart for GEOCITY is shown in Figure 1. The two main elements of the program are the reservoir and distribution systems models. Linkage between these two models is provided by the fluid transmission and distribution system demand submodels. Total fluid demand at wellhead conditions is computed in the demand submodel. The transmission submodel calculates the number of wells required, pipe lengths, and diameters, pumping requirements and the temperature and pressure loss between the reservoir and the distribution system. The program iterates between the distribution system demand submodel, which calculates the additional flow required under the degraded fluid conditions, and the fluid transmission submodel, which provides the additional flow requirements by adding wells and determines the new temperature and pressure drop. Iteration continues until the flow to the distribution system converges within preset criteria.

After the required total fluid flow is established, the cash flow associated with the exploration, development, and operation of the reservoir from the beginning of exploration through the life of the distribution system is determined. From the cash flow, the required revenue from energy sales and

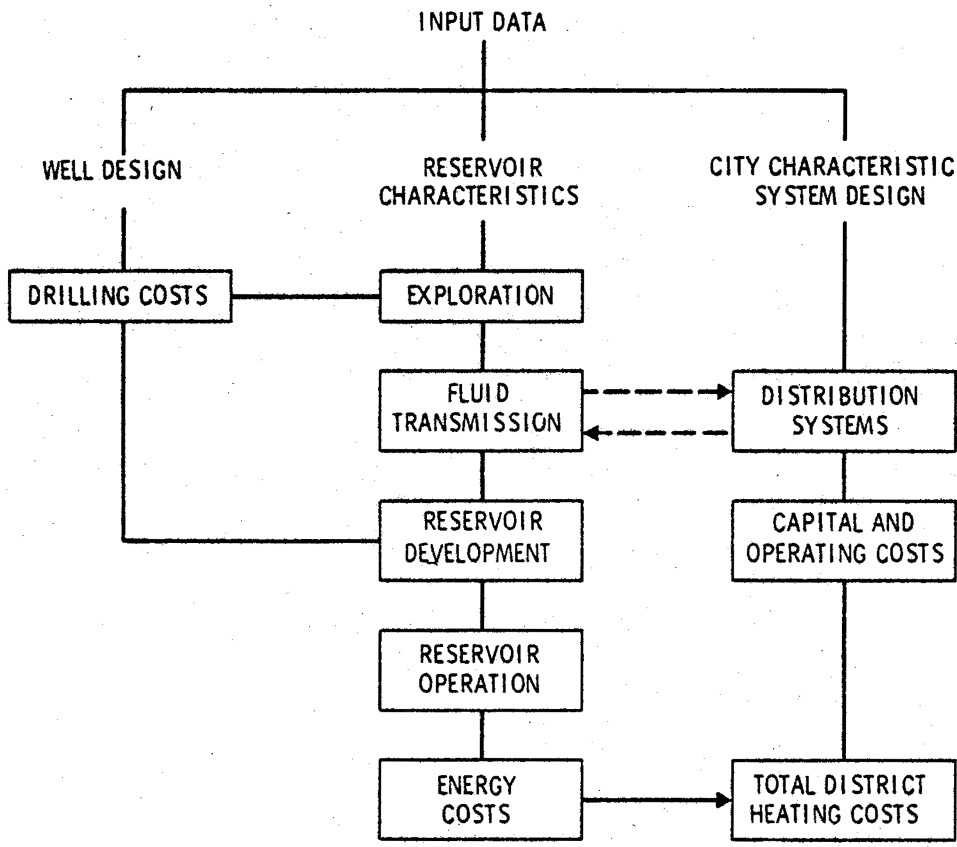


FIGURE 1. Economic Model for Geothermal District Heating Systems

the unit cost of energy from the reservoir are determined. The GEOCITY program solves for the unit cost of energy by equating the present worth of the revenues and expenses over the useful life of the distribution system.

The distribution system model designs a piping network for each zone within a city and calculates fluid conditions in each segment of the piping network. Capital and operating cost models are then used to determine the cash flow for the construction and operation of the distribution system. The revenue to the reservoir model is the energy cost to the distribution system and is included in the cash flow for the distribution system. From the distribution system cash flow, the required revenue and unit cost of heat are determined.

The GEOCITY program allows specifying any debt-equity ratio, any rate of return on equity, and any rate of interest on bonds. Either municipal utility or private enterprise financing and accounting can be selected. The program incurs debt and equity at the specified ratio when expenses exceed revenues, and repays debt and equity in the same ratio when revenues exceed expenses. At the end of each project, debt and equity are exactly repaid and the project exactly earns the specified rate of return.

The reservoir and distribution systems models are discussed in more detail in later sections. The distribution system capital and operating cost models are described in Appendix A. The residential zones included in the GEOCITY data file are described in Appendix B. Appendix C includes an example case showing typical input and output from the program.

DISTRIBUTION SYSTEM MODEL

The distribution system model simulates the design, construction, and operation of a district heating distribution system. For this simulation, hot water is purchased from the operator of the geothermal reservoir. The distribution system model includes submodels which 1) design a distribution system for a city by considering building densities, heat demands, and climatic data; 2) calculate head and heat losses for the system; 3) estimate equipment and material requirements; and 4) estimate construction, operating and maintenance costs.

A city consists of districts with relatively homogeneous heat demand density. Each district is defined by describing the heat and hot water demand of typical building units, the density of buildings, the area of the district and two parameters describing the shape of this district. From this information, a piping network is designed. Heat demand data and climatic data are used to determine the water requirements for each building. Working down the piping network, water requirements are used as a basis in selecting the economic pipe size for each segment of the network. Material requirements, heat losses, and head losses are determined for each segment of the piping network. Construction, material and operating costs, and costs for pumps, meters, and control equipment are derived based on the distribution system design.

Each component of the distribution systems model is described in the following paragraphs. The logical relationships between the model components are illustrated in Figure 2.

CITY DEFINITION

The city is defined by its distance from the geothermal reservoir, its climatic characteristics, and the number of districts within the city. The input parameters which may be used in describing the city are listed in Table 1. Most of the details needed for design of the actual piping system are derived from the definitions of the districts. The distance from the reservoir to the city is used in designing the fluid transmission line and

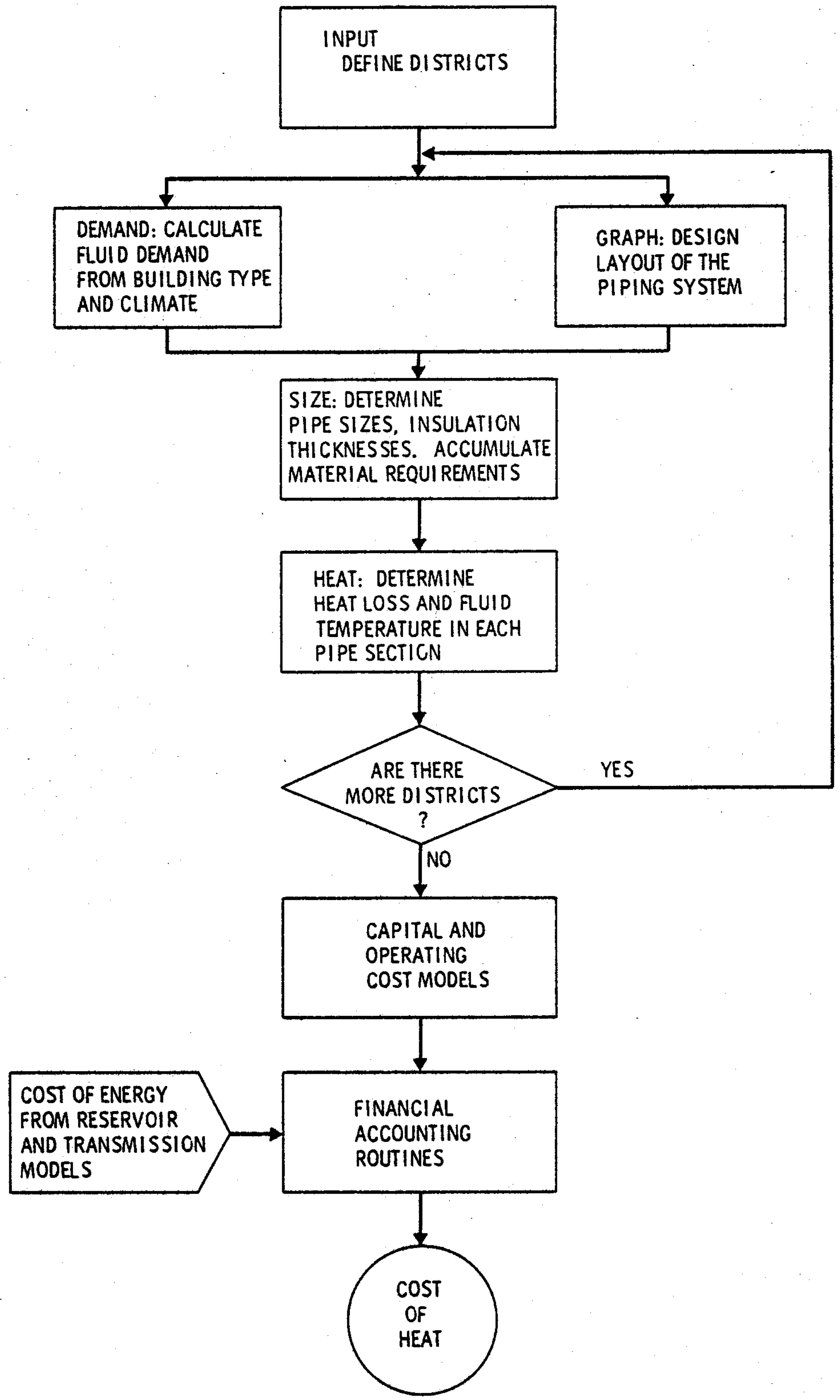


FIGURE 2. Logical Relationship of the Elements of the Distribution System Model

TABLE 1. City Definition Input Parameters

Climatic Parameters	City Parameters
Actual degree days	Distance to reservoir from city
Design degree days	Number of districts in city
Maximum degree days	
Minimum temperature	
Design temperature	

calculating the fluid temperature and pressure entering the distribution system. The climatic parameters are used in determining the distribution of the demand, peak demand, average demand, the load factor, and supplemental heat requirements.

DEFINITION OF DISTRICTS

A city is described by disaggregating it into districts. A district is a contiguous area consisting of buildings of relatively similar heat demand and uniform density. Districts are defined by the input parameters listed in Table 2.

TABLE 2. Input Parameters Describing the Districts for a District Heating System

District Definition Parameters	District Type Parameters
Type of district	Density of units
Area of district	Peak heat demand per unit
Width of district	Hot water demand per unit
Length of district	Reject temperature
Length of the main	Diversity factor
Elevation of district above the distribution center	Number of residents per unit
Demand growth rate during system life	

Districts are the basic element of the distribution system model. Fluid requirements are computed, and the piping networks are designed for each district. Material requirements and costs are also calculated for each district and are totaled for the city.

District type parameters determine the heat demand density and fluid requirements to individual buildings, while district definition parameters define the area, shape, and location of the districts. Several districts may be of the same type. Each type of district is defined only once, and the type designation is included in the district definition parameter list. For example, several suburban residential areas may have the same density, peak heat demand and hot water requirements. These could be defined by a single suburban district type. Then each district would be defined by including this suburban district type in the district parameter list.

Five district types, representing typical residential areas, have been identified and defined. These district types are described in Table 3. Most residential areas in the United States can be described by one of these district types. Variations of the district types in Table 3 or additional district types can also be defined through input. Bases and assumptions for the defined district types are included in Appendix B.

TABLE 3. Description of the Five Residential District Types Used by the Distribution System Model[a]

District Type	Density (Buildings/ sq. mile)	Building Peak Heat Demand (MBtu/hr)	Building Hot Water Demand (gallons/ day)	Reject Temperature[b] (°F)	Per Unit	Number of Residences Per Unit	Floor Area (sq. ft/ Residence)
Suburban	2560	.053	60	100	3.2	1	1620
High Density Single Family	4480	.034	55	100	3.2	1	1000
Garden Apartments	293	1.38	3030	100	162	60	990
Townhouses or Rowhouses	373	.9	1515	100	81	30	1012
High Rise Apartments	385	1.728	5400	100	324	108	780

(a) Any of these values may be changed through input.
(b) Heat demand is based on 65°F inside temperature, -5°F outside temperature and a 15 mph wind.

TOTAL FLUID REQUIREMENTS

Fluid requirements are calculated for each district as a function of peak heat demand, density, area, specified temperature drop, climate and sanitary hot water requirements. The total city requirement is the sum of the district requirements. It is assumed that 1/7 of the total daily hot water consumption occurs at the same time as the hourly peak heat demand, i.e., in morning or afternoon when people turn up thermostats and use hot water for washing and meal preparation.

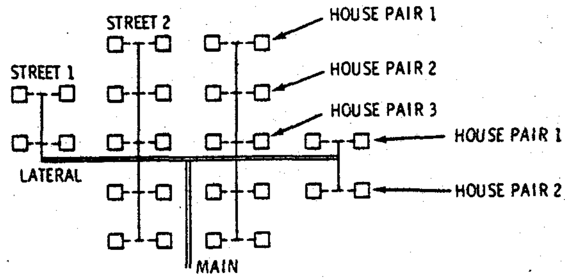
Initially, fluid requirements are calculated using the wellhead temperature. The reservoir and transmission line is then designed to meet the fluid demand. The fluid degradation (temperature and pressure) in the transmission line is calculated, and the fluid requirements are recalculated using the degraded temperature. If the new demand changes by more than the given percentage (2%), the reservoir and transmission line are redesigned using the new fluid demand. This is repeated until the convergence criterion is satisfied.

PIPING NETWORK DESIGN

The piping network is based on a rectangular grid system in which a building is associated with each grid point. The number of buildings is the product of the density and the area for the district. Buildings are assigned to grid points a row at a time until all of the buildings have been assigned. The ratio of rows to columns is the same as the ratio of length to width specified in the input district descriptions. Each pair of columns is then assigned to a street pipe. If there is an odd column left, two short streets are created, one on each side of the rectangle. A lateral pipe connecting all of the street pipes is created at the midpoint of the streets. At the midpoint of the lateral a main is created which joins the district to the other districts. An example network design and output from GEOCITY are illustrated in Figure 3.

Pipe Design and Material Requirements

Starting at the building farthest from the main, the fluid requirements for that point are calculated and pipe size is determined. Proceeding to



LAYOUT IS FOR A DISTRICT WITH 28 BUILDINGS; THE PIPING NETWORK IS SYMMETRICAL ABOUT THE MAIN AND THE LATERAL. BELOW IS A SAMPLE OUTPUT FROM GEOCITY DESCRIBING THIS NETWORK.

DISTRIBUTION SYSTEM OF DISTRICT 3 SINGLE PIPE SYSTEM

HOUSE DESCRIPTION		FLOW RATE (lb/sec)	HEAT LOSS (BTU/sec)	TEMPERATURE (F) SUPPLY	TEMPERATURE (F) RETURN	HEAD LOSS feet	NOMINAL DIA (in.)	INSUL (in.)
HOUSE		2.0	- 0.2	194	123	8.86	2.00	2.0
STREET DESCRIPTION								
STREET	HOUSE							
1	1	4.1	- 0.2	195	---	17.32	2.00	3.0
	2	8.2	- 3.0	195	---	6.19	3.00	2.5
	3	10.2	0	195	---	0	3.00	2.0
LATERAL DESCRIPTION								
LATERAL	STREET							
1	1	8.2	- 5.0	195	---	12.05	3.00	3.5
	2	28.7	- 3.3	195	---	17.20	4.00	3.0
MAIN DESCRIPTION								
MAIN		57.3	-13.1	195	---	7.38	14.00	3.5

FIGURE 3. Example Layout and Piping Network for a District, with Program Output Describing the Network

the next pipe intersection toward the main, total fluid flow for that intersection is computed and the pipe is sized. Due to the high degree of symmetry in the network, only a few pipe intersections need to be considered to size the whole pipe network. For example, in Figure 2 the pipe for the network is sized by considering only seven sections. Optimal pipe diameter is selected for each section by minimizing the sum of the annualized capital cost of pipe, insulation, casing, valves, fittings, pumps and trenching and the annual costs of heat loss and pumping power costs. The optimization scheme is a simple search of a restricted set of feasible pipe sizes. Insulation thickness is optimized by considering the value of lost heat, cost of insulation, and increased casing costs.

Many material and configuration options for pipe, conduit, and insulation are possible. These design options are summarized in Table 4.

Material requirements including pipe, insulation, casing, valves, fittings and meters are accumulated at each pipe intersection. The design options determine which capital cost models are used for the respective system components. Detailed discussion of the capital cost models for the system components is included in Appendix A. Input parameters used to design the piping network are listed in Table 5.

TABLE 4. Design Options for Distribution System Model

Pipe Options

1. Two pipes, supply insulated only
2. Two pipes, bundle insulated
3. Two pipes, both insulated separately
4. Two pipes, each insulated and in separate conduit
5. Two pipes, supply insulated, each in separate conduit
6. Single pipe, insulated

Pipe Material Options

1. Carbon steel, schedule 40
2. Fiberglass reinforced plastic

Insulation Options

1. Calcium silicate
2. Polyurethane foam

Conduit Options

1. Steel, prefabricated, Class A
2. Plastic (PVC), prefabricated
3. Concrete, field constructed

TABLE 5. Piping System Design Parameters

Design Parameters
Pipe Option
Pipe Material Option
Insulation Option
Conduit Option
Annular Air Space Size
Burial Depth
Thermal Conductivities of:
• Pipe
• Ground
• Insulation
Ground Temperature
Age Factor for Pipe Roughness
Combined Motor and Pump Efficiency

Temperature Calculations

Heat loss and temperatures are calculated for each pipe section starting at the main and following the pipes to the points farthest from the main. If the system includes a return pipe, heat losses and temperatures are also calculated for every return pipe segment. Parameters used in the heat loss calculations are listed with the design parameters in Table 5. Heat loss calculations assume a single straight pipe buried in soil, with insulation, an annular air space and casing. It is assumed that the soil temperature remains undisturbed at a radius equal to the pipe burial depth.

Capital and Operating Costs

Capital and operating costs for the accounts listed in Table 6 are computed from cost models. Detailed discussion of these cost models is in Appendix A. A discounted cash flow accounting scheme is used to calculate the price of heat. The price of heat is determined so that the bonds and/or the specified return on equity are exactly satisfied at the end of the project life. The geothermal reservoir and transmission system can be operated as a separate entity from the district heating system. In this case, the district heating system purchases heat from the reservoir and transmission line operator. Alternatively, the entire system can be treated as an integral unit.

TABLE 6. Capital and Operating Cost Accounts for the Distribution System Model

Capital Cost Accounts

Pipe	Fittings
Insulation	Metering and Control Equipment
Casing	Buildings
Valves	House Retrofit (optional)
Meters	Heat Pump (optional)
Pumps	Storage (optional)
Expansion Loops	Heat Exchanger (optional)
Trenches	Engineering and Administration

Operating Cost Accounts

Operating Expenses	State Income Tax
Maintenance	Property Tax and Insurance
Pump Operation	Federal Income Tax
Meter Readers	Heat Pump Operation (optional)
Bond Interest	Heat Exchanger Operation (optional)
Gross Revenue Tax	Supplemental Heat Cost

Input parameters for the economic analysis are listed in Table 7. The leakage, supplemental heat cost, and cost of electricity are used by the operating cost models. Trenching difficulty, building retrofit, and heat pump capital costs modify the capital cost accounts. Based on the number of years of construction and operation, annual cash flows are determined. Using a discounted cash flow analysis, the cost of heat to meet the required taxes, rate of return, and bond interest payments is calculated. State taxes are deducted from Federal taxes. The discount rate is determined from the rate of return on equity, bond interest rate, and the capital structure. Plant capital costs, including interim capital replacements, are recovered through the depreciation account.

Special Options and Capabilities

Options and adjustment factors have been incorporated into the distribution system model to make it useful for specialized studies and situations. Using these options one can study the effects of 1) designing capacity to meet different growth rates in demand, 2) using heat pumps or heat exchangers, and 3) designing different storage capacities. Parameters for the special options are summarized in Table 8. A short discussion of each of the available options follows.

TABLE 7. Economic Input Parameters for the Distribution System Model

Percentage of Fluid Lost by Leakage	Property Insurance Rate
Cost of Electricity	Property Tax Rate
Supplemental Heat Cost	Bond Interest Rate
Trenching Difficulty Factor	Earning on Equity after Taxes Rate
Cost of Retrofitting Buildings	State Gross Revenue Tax Rate
Heat Pump Capital Cost	State Income Tax Rate
Number of Years of Construction	Federal Income Tax Rate
Number of Years of Operation	Fraction of Investment in Bonds
Depreciable Plant Life	Depreciation Option
Startup Year for Distribution System	• Straight Line
Interim Capital Replacement Rate	• Sum of Years Digits

TABLE 8. Parameters for Special Options

Growth

Total demand growth over study period (%) by district
Number of years in which growth occurs

Heat Pump Option by District

1 - heat pump at reservoir
2 - heat pumps on mains to districts
3 - heat pumps at individual buildings
4 - no heat pump

Temperature at heat pump outlet (°F)
Coefficient of performance
Heat pump capital cost

Heat Exchange Option

1 - heat exchanger
2 - no heat exchanger

Geothermal fluid temperature drop in heat exchanger
Circulating water temperature in
Circulating water temperature out

Storage Option

1 - storage as number of days demand
2 - storage as number of gallons
3 - no storage

Storage capacity (days or gallons depending on option)

When designing a district heating system, it is often desirable to design for growth in demand since it may be costly to replace pipes too small to meet future demand. The distribution system model will design the piping network for each district to 1) meet only current demand, 2) meet future demand including all pipes to future demand points, and 3) design only the mains and laterals with sufficient capacity to meet future growth. Total demand in each district may grow a different rate. If growth options are used, growth in annual operating, additional annual capital costs and growth in annual heat sales are factored into the accounting routines.

Geothermal resources of very low temperature (less than 120°F) may be used in conjunction with heat pumps. Use of heat pumps with a constant temperature source could lower the operating cost of the heat pump by allowing it to always operate in its most efficient range. Heat pumps may also be used to boost the water temperature for service to commercial or residential buildings. Three heat pump configurations are available; heat pumps can be located at the geothermal reservoir, at the main for each district or at each building. Capital costs must be supplied, but operating costs are calculated based on the input value of the coefficient of performance and the cost of electricity.

Heat exchangers are used because either the temperature of geothermal fluid needs to be reduced or the fluid's chemical composition makes it undesirable for use in a distribution system. A tube and shell heat exchanger is designed to meet the specified temperature changes. Capital costs are calculated as in GEOCOST.[2] It is assumed that the heat exchanger is located at the geothermal reservoir, but owned by the district heating system operator.

Storage capacity may be used to meet demand surges, emergencies, or to reduce the peak capacity requirements of the transmission line and reservoir. Storage options include specifying either the volumetric capacity or the number of days of demand. Capital costs and effects of storage on transmission line and reservoir are factored into the accounting routines.

Adjustment Factors

Adjustment factors have been included to allow a way of studying situations quite different from the norm. Available adjustment factors are listed in Table 9.

For areas with large elevation differences, it is possible to specify the relative elevation of each district, to be used when designing the pump and estimating the operating costs. Trench digging costs vary depending on terrain, ground conditions, current use and other buried utilities. The trench difficulty factor allows the user to adjust for cost-related factors.

TABLE 9. Adjustment Factors for Use with the Distribution System Model

- Elevation differences by district
- Trench difficulty factor
- Leakage
- Age factor for pipe roughness

The amount of leakage expected in the system can also be specified. Head losses in the distribution system are calculated based on the roughness of pipe that is about 10 years old. The roughness factors can be changed through input to handle other cases.

THE RESERVOIR MODEL

The reservoir model simulates a firm which explores for, discovers, develops, and operates a geothermal reservoir. The components of the energy costs supplied by the reservoir to the distribution system are computed and shown separately from the distribution system. This permits independent parametric analyses for the reservoir. The reservoir model includes submodels for simulating exploration and development costs, fluid transmission and disposal costs, drilling costs, and reservoir operating expenses.

EXPLORATION AND DEVELOPMENT

The exploration submodel simulates the process by which a geothermal resource would be identified and evaluated. The exploration model reduces the process to a series of discrete steps which have costs and success ratios assigned to them. These steps are 1) identification of target areas, 2) preliminary land check, 3) preliminary geologic reconnaissance, 4) detailed land check and geologic reconnaissance, 5) identification of drillable sites, 6) exploratory drilling, 7) identification of the producible resource and 8) development.

Each of these eight major areas includes a time function, associated costs, decision points, and success ratios (finding rates). The reference cost values and finding rates are assigned on the basis of industry estimates. However, these values and rates are variable and sensitivity analyses can be performed to evaluate their relative importance.

In the present submodel the discrete steps occur sequentially in time with some specified time overlap. Each one of the steps may contain several substeps which parallel each other in time.

All reservoir exploration costs are initially capitalized. As the sites are classified unfavorable through the success ratios, the costs which pertain to those sites are expensed. The remaining capitalized costs for the favorable site are recovered through a cost depletion account (analogous to straight line depreciation) throughout the producing life of the district heating system.

The reservoir development submodel simulates the field development of the proven geothermal reservoir identified by the exploration submodel. This submodel accumulates all costs associated with reservoir development; these costs include drilling, fluid transmission, and fluid disposal. The development submodel allows specifying the percentage of nonproducing (dry) wells, capacity of injection wells, geometry of the well field, and the fraction of excess producing wells. Input data are shown in Table 10.

TABLE 10. Input to Transmission and Disposal Submodels

Input Required for All Geothermal Plant Types[(a)]	Typical Value
Average well flow rate (lb_m/sec)	40
Well spacing (acres)	20
Wellhead fluid temperature (°F)	120
Well life (yr)	20
Fraction nonproducing wells	0.2
Fraction excess producing wells	0.2
Transmission maintenance factor	0.05
Disposal maintenance factor	0.05
Fraction of pipe that can be salvaged	0.10
Ratio of injection/production well flow rate	2
Distance from city to injection wells (m)	

(a) Also includes built-in data base for computing well layout design, pipe schedule, pipe cost, insulation cost, cost of valves, gauges, separators, flashers, electric motors, and booster pumps; also data base for computing nodal temperature drop, nodal pressure drop, and electrical power required by booster pumps.

Reservoir development costs include only those costs required to develop and provide the energy supply to the specified distribution system; if the reservoir could support several distribution systems, the costs of providing the energy supply to each would be treated separately.

DRILLING

Well drilling cost may be input directly or calculated. A submodel was developed for calculating drilling costs for geothermal wells as a function of the well depth, size of the well at the well bottom, the fraction of the well cased, and the hardness of the material being drilled. The component cost breakdown splits costs into tangible and intangible parts because tax regulations may treat these costs differently.

The GEOCITY program treats producing, nonproducing (dry), and injection wells differently. The tangible part of the producing wells is capitalized and expensed through a depreciation account. The intangible part may be either capitalized or expensed immediately. Nonproducing wells are expensed. All costs, both the tangible and intangible, for injection wells are capitalized; these costs are recovered through the depreciation account.

RESERVOIR OPERATION

The operation submodel simulates the operation of the required reservoir capacity throughout the life of the distribution system. It is composed of several annual costs, e.g., royalty payments, injection costs, taxes, overhead and management, and well maintenance. The operations submodel also includes operating costs for the transmission and disposal systems as well as replacement well drilling and redrilling costs. All of the operating costs are assumed to be constant each year throughout the life of the powerplant. As with reservoir development costs, operating costs refer only to a single distribution system. All annual operating costs are expensed except interim capital replacements. These are capitalized and recovered through the depreciation account. The capitalized part of replacement wells is treated analogously to interim capital replacements. The expensed part of replacement wells is treated as an operating expense.

FLUID TRANSMISSION AND DISPOSAL

The fluid transmission submodel simulates the conduction of the hot water from the well head to the distribution system. This submodel calculates the pipeline diameter, length, number of producing wells required, the well field layout, pumping requirements, and the costs of the transmission piping system, pumps, and associated equipment. It also calculates the fluid temperature, pressure, viscosity, density, and enthalpy on a node-by-node basis during transport from the wellhead to the city.

The disposal submodel is analogous to the transmission submodel and simulates the conduction of water effluent from the city to the injection well field. Disposal into a sewage system or river can also be simulated. It calculates the effluent pipeline diameter and length, number of injection wells, injection well field layout, and the costs of the disposal piping system and associated equipment.

The initial costs for the transmission and disposal systems are capitalized. Cost recovery is through the depreciation account using the sum-of-the-year's digit method.

CONCLUSIONS

GEOCITY has been developed to study the effects of different economic and technical parameters, assumptions, and uncertainties on the cost of providing district heat from a geothermal resource. GEOCITY can determine the economic incentives for research and development on geothermal resources, identify costs and assess incentives for a specific site, compare different heating system designs, and allows for uncertainties in resource conditions and technology. GEOCITY is another tool for assessing the value of geothermal energy.

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APPENDIX A

CAPITAL AND OPERATING COST MODELS FOR DISTRICT HEATING DISTRIBUTION SYSTEMS

APPENDIX A

CAPITAL AND OPERATING COST MODELS FOR DISTRICT HEATING DISTRIBUTION SYSTEMS

As pipes are sized for each segment of the distribution network, capital cost models are used to price the piping string and associated components. The capital cost models are primarily functions of pipe size and design options, although other parameters are used in many of the models. Other capital cost models and operating cost models are used for pumps, instrumentation, operating expenses, and taxes.

This appendix describes the cost models in three sections: capital cost models, operating cost models, and cost model equations. The first two sections describe the bases and assumptions used in the models. The third section lists the equations or cost tables used. Each cost model is associated with an account in which the costs are accumulated.

CAPITAL COST MODELS

Costs are calculated for the entire piping system up to the outer wall of housing units. The basic design is a two-pipe network (Figure A-1). A two-pipe network includes both a supply and a return pipe for each building. The cost models also apply to one-pipe networks which have only a supply pipe for each building.

The total piping bundle is called a conduit. The conduit consists of one or more pipes, which may be insulated, enclosed by the casing.

Depending upon the pipe option, insulation option, conduit option, and material option chosen, applicable component cost models are selected, and costs generated. Component costs are then added to give total piping system capital costs. Fittings and valves are costed at each pipe intersection.

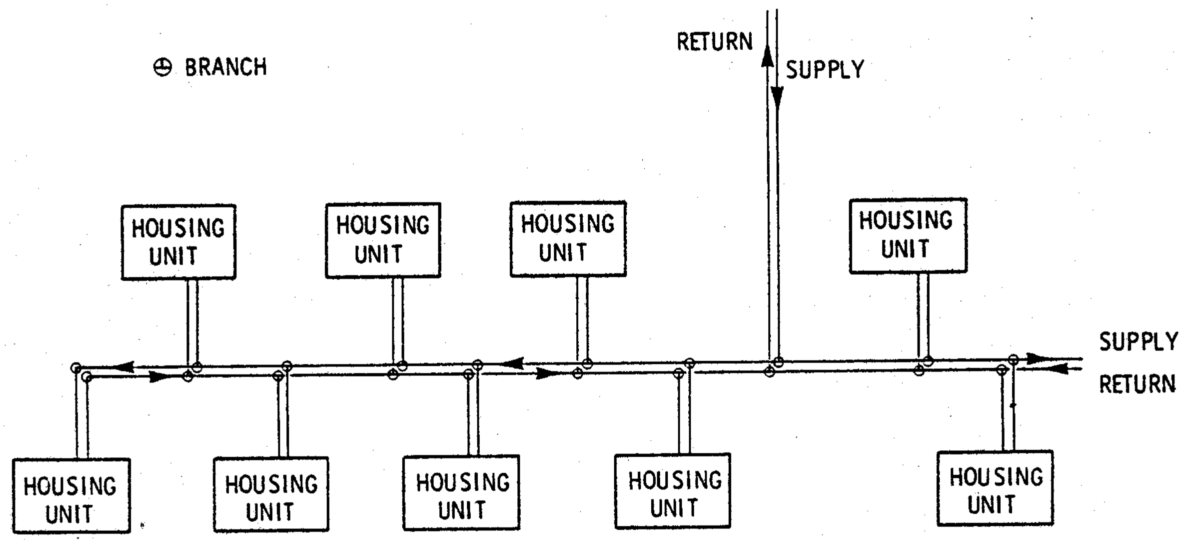

FIGURE A-1. District Heating System Two Pipe Network (shown without expansion loops)

Pipe

Optimal pipe diameter is selected for each segment of the piping network by minimizing the sum of the annualized capital cost of pipe, fittings, insulation, casing valves, pump capacity and the annual costs of heat loss and pumping. Head losses are based on correlations for aged pipe. The default valve assumes a pipe age of 10 years, but the value can be changed through the input data. Pipe may be either carbon steel, schedule 40, or fiberglass reinforced plastic (FRP) depending on the pipe material options.

The pipe account includes only the material cost for straight lengths of pipe.

Insulation

Optimal insulation thickness is that which produces minimum annual costs of insulation and casing and heat loss values. Either polyurethane foam or calcium silicate insulation can be specified. Insulation is assumed to be factory installed unless foam insulation and field erected concrete casing is specified. For that situation, it is assumed that the insulation is foamed in place.

The insulation account includes material and labor cost for insulating straight pipe lengths and pipe fittings.

Casing

The smallest standard casing size that will contain the pipe(s), insulation, and annular air space is selected for each segment of the piping network. Casing may be either felt and tar wrapped steel, polyvinyl chloride (PVC) or concrete. Concrete casing is assumed to be a field constructed rectangular box.

The casing account includes costs of material, labor for placing the pipe(s) in the casing, warehousing, transportation, field placement, and alignment of the casing sections.

Fittings

Two pipe fittings and one casing fitting, sized according to the pipe and casing, are accumulated at each pipe intersection. Two additional fittings are accumulated for each pipe into a building.

The fitting account includes both material cost for the fittings and labor for field connection of the pipes and casing sections.

Expansion Loops

One expansion loop is located in each 300 ft segment of the piping network. The size of the loop is calculated as a function of pipe diameter. Expansion loop cost is the sum of the pipe, fitting, insulation casing, trench and installation costs. Each of these component costs for the expansion loops are calculated separately as described previously and then summed.

The expansion loop account includes all labor and material costs associated with the expansion loop.

Trench

The trench model assumes slopes of 1/2 to 1 in, damp sandy loam. Sifted fill material is hauled to the site. The casing is laid on 2 to 4 in. of sifted fill and is covered to a depth of 4 in. with hand placed and tamped sifted fill material. The rest of the trench is then filled and packed by dozer. The top of the casing will be at the specified burial depth below the surface. A trenching difficulty factor may be specified through input to reflect unusual circumstances.

The trench account includes excavation, purchase and delivery of sifted fill, hand filling and tamping, and dozer filling and packing costs.

Valves

One valve, sized according to the larger pipe size, is located at each pipe intersection. Screwed valves are used when the nominal pipe size is less than 2.5 in. Larger sized valves are flanged. The valve is assumed to be a forged steel ball type.

The valve account includes valve, mating flange, bolt-up, handling, insulation, casing and field connection costs.

Meters

One meter is located at each building. Meters are sized according to the expected range of flowrates.

The meter account includes meter, connections, and installation labor costs.

Pumps

One pump and a standby pump are located in each district. The pump is sized to overcome the total head loss and pump the district fluid requirements. Pump motor size is determined from the hydraulic horsepower and the input pump and motor efficiency factors.

The pump account includes the main pump, standby pump, motors, vault, setting and installation, fittings, and labor costs.

Metering and Control

This account covers the cost of instrumentation, additional flow controllers, and sensors required to operate the distribution system. The metering and control account covers capital and installation costs, and is calculated to one percent of the piping system capital cost.

Building and Land Use

This account covers the expense of purchase or lease of land and the construction or modification of a building to house the system's instrumentation and control equipment. The costs are calculated to one percent of the piping system capital cost.

Building Retrofit

The user can specify retrofit costs for buildings in each district type in order to study total costs of district heating in old built-up areas. The user specifies the retrofit cost per building in input data. The retrofit account will consist of retrofit costs for all of the buildings in the distribution system.

Storage

Water can be stored in vertical tanks at the terminus of the transmission line. The tanks are assumed to be vertical painted and insulated steel tanks.

The storage account includes material cost, field erection, handling and setting, piping, concrete, instrumentation, insulation, painting, and indirect costs.

Heat Pump

Several possible configurations using heat pumps and a water circulation system are possible (see discussion in section on "Special Options and Capabilities"). Due to the wide range in heat pump capital costs and rapidly evolving technology, a capital cost model for heat pumps is not used. The user should input the heat pump capital cost including installation, instrumentation, and indirect costs.

Heat Exchanger

If the heat exchanger option is specified, a tube and shell heat exchanger is designed to satisfy the input requirements and is located at the geothermal reservoir, even though the costs appear in the distribution system account.

The heat exchanger account includes material, installation, and indirect costs.

Engineering and Administration

This account is 12% of the piping system total cost to cover the engineering and administration costs of building the distribution system.

OPERATING COST MODELS

The operating cost accounts consist of annual expenses and taxes. Meter reader and operating costs are related to the number of meters connected in the system. Maintenance cost is proportional to the capital investment and is based on estimates from water distribution systems. The pump operating, heat pump, supplemental heat, and heat exchanger costs are derived from models which are controlled by the system design. The other accounts (interest, taxes, capital replacement and insurance) are percentages of capital investment or portions of annual revenue. The percentages are specified through input data (see discussion in the section on "Capital and Operating Costs").

Operating

This account includes the personnel cost for operating the distribution system and administrative functions. The charges to this account depend on the number of meters connected to the system.

Maintenance

The maintenance account includes routine repair and maintenance of the distribution system. The charges depend on the pump size, the number of buildings connected, and the flow to each building.

Pump Operation

This account includes charges for the annual pumping costs, calculated from the input values for the cost of electricity, and pump and motor efficiencies.

Meter Readers

This account includes wages, benefits, and overhead for meter readers with an assumed productivity of 50 meters/day.

Heat Pump Operation

This account includes the electrical cost of operating the heat pump or heat pumps if they are used. The cost depends on the climatic data, the input values for the coefficient of performance and the cost of electricity.

Supplemental Heat

The difference in heat demand at design temperature and the minimum temperature is met by purchasing heat and elevating the temperature of the circulating water. The charges to this account depend on the climatic data, the design temperature, and input value for the cost of supplemental heat.

Heat Exchanger

The annual operating cost of the heat exchanger is assumed to be 2% of the total capital cost of the heat exchanger.

Other Operating Cost Accounts

The following accounts are calculated as percentages of other accounts. The percentages are specified in the input data.

- Interim Capital Replacement - percent of total system capital cost
- Bond Interest - percent rate, charges assume compound interest on unpaid portion of debt and are calculated for each year
- Gross Revenue Tax - percent of annual revenue
- State Income Tax - percentage of taxable income (revenue less operating expenses including capital costs, energy costs, operating costs, interim capital replacement, property tax and insurance, interest and depreciation)
- Federal Income Tax - percentage of taxable income less state income tax
- Property Tax and Insurance - percentage of distribution system capital cost

COST MODEL EQUATIONS

Capital cost models are summarized in Table A-1, and operating cost models are summarized in Table A-2. The cost models use the equational form:

$$\text{Cost} = a + b(x)^{(s)(t)}$$

Equation coefficients reflect fixed costs (a), variable costs (b), and scale size (s) and (t). Costs are in July 1976 dollars. Where cost equations are not appropriate, cost tables (Tables A-3 through A-6) are used. Cost data was gathered from three sources: industry vendors, mechanical contractors, and architect-engineers.

TABLE A-1. District Heating System Capital Cost Coefficients (July 1976 Dollars) (NOTE: All measurements are in meter units) [Cost = $a + b(x)^{st}$]

Account No.	Component	Unit	a	b	x	s	t
1.0	Pipe						
	Carbon Steel Pipe	Meter	0	368.71	P	1.27	1
	FRP Pipe (Fiberglass reinforced plastic)	Meter	0	2.89	2.72 (=e)	11.62	P
2.0	Insulation						
	Calcium Silicate	Meter	0	3.12	2.72 (=e)	4.25	P
						+22.33	R
	Fiberglass	Meter	-1.30	51.90	P		
				+221.77	R		
	Rigid Polyurethane (See Note 1)	Meter	0	1	2.72 (=e)	3.56	
						+4.83	P
						+1.00	ln(R)
	Foam-in-Place Polyurethane	Meter	0	141.00	$(Q)(P)+(Q)(R)(2)-(Y)(P)^2(0.79)$		
	Fitting Insulation	Each	0	0.91	F		
	Valve Insulation						
	- Nom. pipe size ≤ 0.0635	Each	0	0.61	F		
	- Nom. pipe size < 0.0635	Each	0	9	F		

NOTE: (1) If nominal pipe diameter = 0.0254 meters and pipe material = carbon steel - Add $3.50/meter to pipe cost.
If nominal pipe diameter = 0.0381 meters and pipe material = carbon steel - Add $1.70/meter to pipe cost.

F = Insulated Cost/Meter P = Pipe Diameter Q = Outside Diameter of Pipe & Insulation R = Insulation Thickness

Y = Number of Pipes in Conduit

TABLE A-1. (contd)

Account No.	Component	Unit	a	b	x	s	t
3.0	Casing						
	Steel (One Pipe Conduit)	Meter	0	40.54	2.72 (=e)	2.06	U
						-0.07	V
	Steel (Two Pipe Conduit)	Meter	0	38.99	2.72 (=e)	2.16	U
						-0.06	V
	PVC (See Note 1)	Meter	0	5.54	2.72 (=e)	5.09	N
	Concrete Box	Meter	18.87	49.73	Q		
				+142.27	P		
				+264.54	R		
	Placement Labor	Meter	0	111	N		
4.0	Fittings						
	Steel Pipe Fitting	Each			See Table A-3		
	FRP Pipe Fitting	Each	0	5.47	2.72 (=e)	14.30	P
	Fitting Steel Casing	Each			See Table A-4		
	Fitting PVC Casing	Each			See Table A-5		
	Valve Casing						
	- Nom. pipe size ≤ 0.0635 meters	Each	0	0.61	H		
	- Nom. pipe size > 0.0635 meters	Each	0	9	H		

Note 1) If U = 0.0254 meters and pipe is carbon steel then add $3.50/meter to pipe cost
If U = 0.0381 meters and pipe is carbon steel then add $1.70/meter to pipe cost

H = Casing Cost/Meter

N = Casing Diameter

U = Nominal Casing Size

V = Pipe Diameter

Q = Outside Diameter of Pipe and Insulation

[illegible]

TABLE A-1. (contd)

Account No.	Component	Unit	a	b	x	s	t
5.0	Expansion Loop						
	Expansion loop (See Note 2)	Each			(C)(D)		
					+(4)(E)		
					+(C)(F)		
					+(4)(G)		
					+(C)(H)		
					+(4)(J)		
					+(C)(K)		
6.0	Trenching Labor						
	Trenching						
	- Two conduit (Pipe opt. 4)	Meter	0.95	12.77	N	2.0	1
				+11.75	N		
	- Two conduit (Pipe opt. 5)	Meter	0.98	6.19	N	2.0	1
				+0.19	N		
				+2.38	P		
				-12.47	P	2.0	1
				+18.66	(N)(P)		
	- One conduit (Pipe otp. 1,2,3,6)	Meter	0.61	6.19	N	2.0	1
				+6.79	N		
	- Concrete box conduit	Meter	0.92	2.97	Q	2.0	1
				+3.98	Q		
				+0.27	R		

NOTE: (2) Expansion loop length = $(19.27)(\text{nom. pipe dia.})^{0.46} - (9)(\text{nom. pipe dia.})$

C = Expansion loop length D = Pipe cost/meter E = Pipe fitting cost F = Insulated Cost/Meter G = Insulation fitting cost
H = Casing Cost/Meter J = Casing fitting cost K = Trenching cost/meter N = Casing Diameter P = Pipe Diameter R = Insulation Thickness
Q = Outside Diameter of Pipe and Insulation

TABLE A-1. (contd)

Account No.	Component	Unit	a	b	x	s	t
7.0	Valves						
	Valve	Each			See Table A-4		
8.0	Meters						
	Water meter (1 per housing unit)	Each			See Table A-6		
9.0	Pumps						
	Basic Pump (2 per district)						
	- horsepower ≤ 26	Each	1269	80	M		
	- horsepower > 26	Each	4929	64	M		
	Accessor Pump (2 per district)	Each	0	81.53	2.72 (=e)	6.08	P
10.0	Metering and Control		0	.01	CT		
11.0	Building and Land Use		0	.01	CT		
12.0	Building Retrofit		0	Input	NB		
13.0	Storage			.35	GL	1.315	
14.0	Heat Pump	Input					
15.0	Heat Exchanger			93.3	HTA	.78	
16.0	Engineering and Administration		0	.12	CT		

M = Horsepower CT = Piping System Capital Cost GL = Storage Capacity in Gallons HTA = Heat Transfer Areas
NB = Number of Buildings Connected to the System P = Pipe Diameter

TABLE A-2. Operating Cost Models

$$[\text{Cost} = a + b(x)^{st}]$$

Account No.	Component	a	b	x	s	t
1	Operating	25,000	5	NB		
2	Maintenance	500	.1	CP		
			+.05	CM		
3	Pump Operation		6532	$\frac{HP*CKW*PF}{ETA}$		
4	Meter Readers	25,000	2.1	NB		
5	Heat Pump Operation		293	$\frac{AD*CKW}{COP}$		
6	Supplemental Heat		CSHEAT	SDD		
7	Heat Exchanger		.02	HEC		
8	Interim Capital Replacement		Input	CT		
9	Bond Interest		Input	UB		
10	Gross Revenue Tax		Input	REVENUE		
11	State Income Tax		Input	Revenue-items 1-9 above, and energy costs		
12	Federal Income Tax		Input	Revenue - items 1-11 above, and energy costs		
13	Property Tax and Insurance		Input	CT		

NB = Number of Connected Buildings
CP = Total Cost of Pumps
CM = Total Cost of Meters
HP = Total Hydraulic Horsepower

CKW = Cost of Electricity ($/KwH)
AD = Average Annual Heat Demand (MBTU/yr)
COP = Coefficient of Performance
CSHEAT = Cost of Supplemental Heat ($/MBTU)

SDD = Supplemental Heating Degree Days
HEC = Heat Exchanger Capital Cost
CT = Total Distribution System Capital Cost
UB = Amount of Unpaid Bonds

TABLE A-3. Valves and Carbon Steel Fitting

Nominal Pipe Diameter (meters)	Cost/Fitting ($)	Cost/Valve ($)
0.0254	3	58
0.0381	3	70
0.0508	3	85
0.0635	4	118
0.0762	5	274
0.1016	9	375
0.1524	24	528
0.2032	41	776
0.2540	84	1276
0.3048	109	1687
0.3556	162	2535
0.4064	227	3802
0.4572	322	5052
0.5080	433	6740
0.6096	638	9678

TABLE A-4. Steel Casing Fitting

Nominal Inside Casing Diameter (meters)	Cost/Fitting ($)
0.1614	145
0.2122	158
0.2662	189
0.3170	222
0.3488	238
0.3996	259
0.4504	295
0.5012	315
0.5489	340
0.5997	373
0.6505	406
0.6998	432
0.7506	436
0.8014	505
0.8522	550
0.9144	558

TABLE A-5. PVC Casing Fitting

Nominal Inside Casing Diameter (meters)	Cost/Fitting ($)
0.0762	27
0.1016	27
0.1143	35
0.1270	40
0.1524	40
0.1778	57
0.2032	76
0.2540	108
0.3048	143
0.3556	190
0.4064	247
0.4572	437
0.5080	591
0.6096	828

TABLE A-6. Meter

Minimum Flow (GPM)	Maximum Flow (GPM)	Cost/Meter ($)
0	7	164
7	30	229
30	50	333
50	100	628
100	160	941
160	360	3111
360	500	4766
500	1000	9639

Costs are factored to reflect lower unit costs for larger piping systems; such systems have reduced material unit costs because of quantity purchase discounts. Also the installation labor learning curve lowers unit labor costs for large systems. Costs are "factored" after they are generated from component cost models. Pipe, insulation, casing, expansion loop, and trenching labor costs are multiplied by FACTOR 1. Fitting, valve, and meter costs are multiplied by FACTOR 2. Table A-7 lists values for these factors.

TABLE A-7. Cost Factors

Housing Units in District	> 800	FACTOR 2 = 0.6
Housing Units in District	> 600 and < 800	FACTOR 2 = 0.75
Housing Units in District	> 400 and < 600	FACTOR 2 = 0.85
Housing Units in District	> 200 and < 400	FACTOR 2 = 0.95
Housing Units in District	< 200	FACTOR 2 = 1.00
Length of Same Diameter Pipe in District	> 4000 m	FACTOR 1 = 0.85
Length of Same Diameter Pipe in District	> 2500 m and < 4000 m	FACTOR 1 = 0.90
Length of Same Diameter Pipe in District	> 1000 m and < 2500 m	FACTOR 1 = 0.95
Length of Same Diameter Pipe in District	< 1000 m	FACTOR 1 = 1.00

APPENDIX B

DESCRIPTION OF PREDEFINED RESIDENTIAL DISTRICT TYPES FOR OPTIONAL USE IN THE GEOCITY MODEL

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DESCRIPTION OF PREDEFINED RESIDENTIAL DISTRICT TYPES FOR OPTIONAL USE IN THE GEOCITY MODEL

Many residential areas in the United States can be described by one of five residential district types defined in the GEOCITY model data base. These district types are:

- Suburban
- High density single family
- Garden apartments
- Townhouses
- Highrise apartments

The district type parameters of peak heat demand, hot water demand, density, reject temperature and diversity factor have been calculated for each of these district types. The user may use these district types as defined or may modify one or more parameters as required.

Peak heat demand was calculated by designing typical residential units for each district type and calculating the heat loss according to ASHRAE procedures assuming -5°F outside temperature, 67°F inside temperature and a 15 mph wind. Floor plans, dimensions and construction parameters for each of these district types are summarized in Figures B-1 through B-5. Hot water demand is based on the number of residents in a typical building and ASHRAE design recommendations. Density data is an average of the values recommended in various planning books and zoning guides. The district type parameters used by GEOCOST are also summarized in Tables B-1 through B-5.

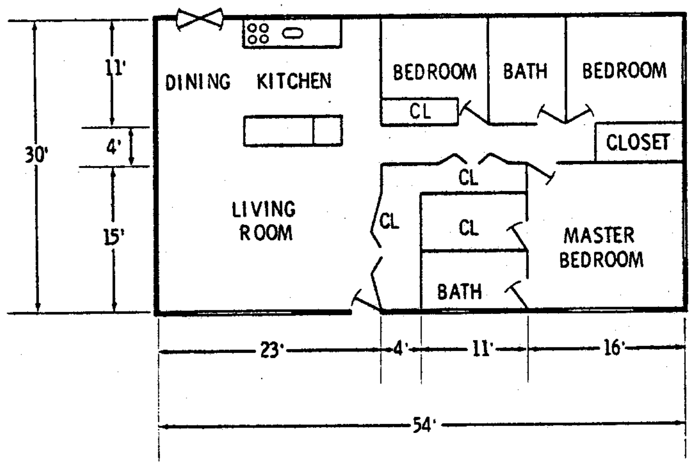

FIGURE B-1. Plan of Suburban Residential House 125 x 30 ft. Attached garage not shown.

TABLE B-1. Design Basis for Suburban Residential House 125 x 30 ft

SUBURBAN RESIDENTIAL	
NUMBER OF STORIES - 1	
DIMENSIONS	
FLOOR ft^2	1620
EXTERIOR WALL AREA ft^2	918 (NET OF GLASS)
GARAGE WALL AREA ft^2	240
WINDOW GLASS ft^2	186
DOOR AREA ft^2	21
CEILING ft^2	1620
STORY HEIGHT ft^2	8
CONSTRUCTION PARAMETERS	
FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING.
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS
DISTRICT TYPE PARAMETERS	
PEAK HEAT DEMAND	53,000 BTU/hr
HOT WATER DEMAND	60 gallons/day
DENSITY	2560 HOUSES/SQ. MILES
REJECT TEMPERATURE	100 °F
DIVERSITY FACTOR	0.7

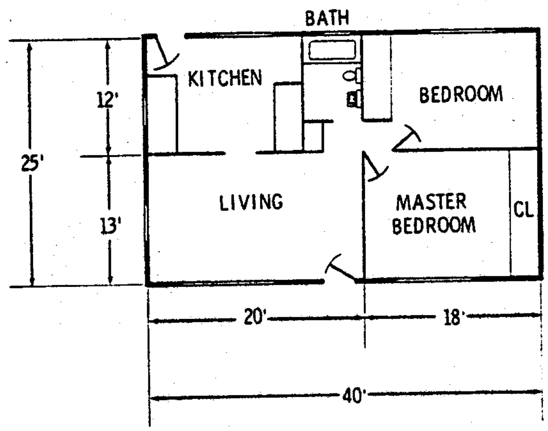

FIGURE B-2. Plan for High Density Single Family Home

TABLE B-2. Design Basis for High Density Single Family Home

HIGH DENSITY	
NUMBER OF STORIES 1	
DIMENSIONS	
FLOOR ft^2	1000
EXTERIOR WALLS ft^2	865
WINDOW ft^2	133
DOOR ft^2	42
CEILING ft^2	1000
STORY HEIGHT ft	8
CONSTRUCTION PARAMETERS	
FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS
DISTRICT TYPE PARAMETERS	
PEAK HEAT DEMAND	34,000 BTU/hr
HOT WATER DEMAND	55 gallons/day
DENSITY	4,480 HOUSES/SQ. MILE
REJECT TEMPERATURE	100°F
DIVERSITY FACTOR	0.7

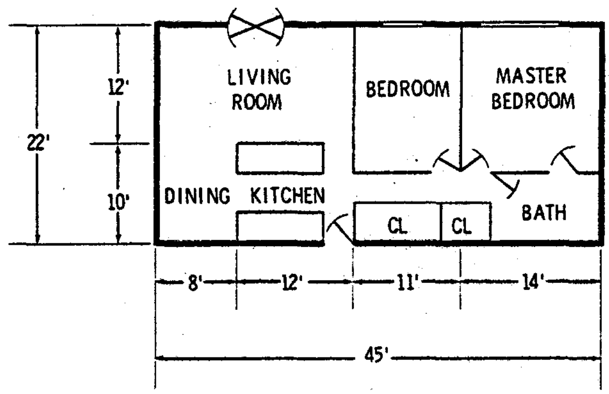

FIGURE B-3. Plan for Garden Apartment Unit

TABLE B-3. Design Basis for Garden Apartment Unit

GARDEN APARTMENT	
NUMBER OF STORIES - EACH APARTMENT IS ONE STORY AND IS CONTAINED IN A 2 STORY BUILDING	
DIMENSIONS	
FLOOR ft^2	990
EXTERIOR WALLS ft^2	617
WINDOWS ft^2	82
DOOR ft^2	21
CEILING	1/2 (990) FOR HEAT LOSS
STORY HEIGHT ft	8
CONSTRUCTION PARAMETERS	
FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS
DISTRICT TYPE PARAMETERS	
PEAK HEAT DEMAND	1.38 MBTU/hr
HOT WATER DEMAND	3030 gallons/day
DENSITY	293 BUILDINGS/SQ. MILE
REJECT TEMPERATURE	100 °F
DIVERSITY FACTOR	0.7

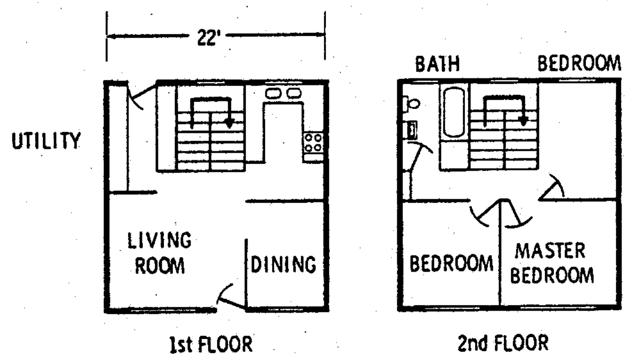

FIGURE B-4. Plan for Townhouse Unit

TABLE B-4. Design Basis for Townhouse Unit

ROW HOUSE	
NUMBER OF STORIES - 2	
DIMENSIONS	
FLOOR ft^2	506 (1st STORY)
FLOOR ft^2	506 (2nd STORY)
EXTERIOR WALL ft^2	582
WINDOW ft^2	124
DOOR ft^2	21
CEILING ft^2	506
STORY HEIGHT ft	8
CONSTRUCTION PARAMETERS	
FLOOR	MAPLE FINISH FLOORING ON YELLOW PINE SUBFLOORING
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS
DISTRICT TYPE PARAMETERS	
PEAK HEAT DEMAND	0.9 MBTU/hr
HOT WATER DEMAND	1515 gallons/day
DENSITY	373 BUILDINGS / SQ. MILE
REJECT TEMPERATURE	100 °F
DIVERSITY FACTOR	0.7

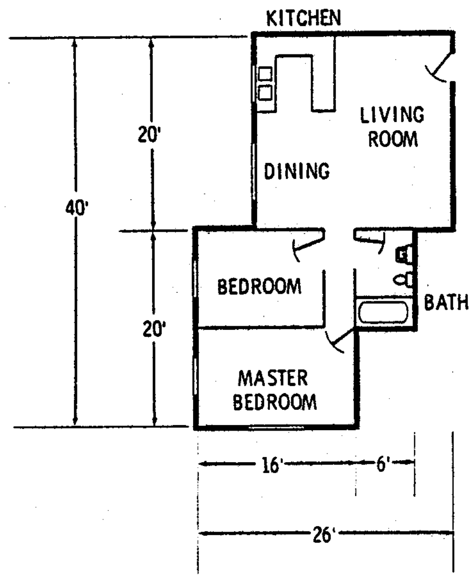

FIGURE B-5. Plan for High Rise Apartment Unit Eight Apartments per Floor

TABLE B-5. Design Basis for High Rise Apartment Unit

HIGH RISE APARTMENT	
NUMBER OF STORIES -	EACH APARTMENT IS ONE STORY AND IS CONTAINED IN A 9 STORY BUILDING.
DIMENSIONS	
FLOOR ft^2	780
EXTERIOR WALL ft^2	370
WINDOWS ft^2	78
DOOR ft^2	21
ROOF ft^2	1/9 (780) FOR HEAT LOSS
STORY HEIGHT ft	8
CONSTRUCTION PARAMETERS	
EXTERIOR WALLS	BRICK VENEER, BUILDING PAPER, WOOD SHEATHING, STUDDING, METAL LATH, 2 in. INSULATION
CEILING	METAL LATH AND PLASTER, 6 in. INSULATION
WINDOWS	DOUBLE-HUNG WOOD WINDOWS
DISTRICT TYPE PARAMETERS	
PEAK HEAT DEMAND	1.73 MBTU/hr
HOT WATER DEMAND	5400 gallons/day
DENSITY	385 BUILDINGS/SQ. MILES
REJECT TEMPERATURE	100°F
DIVERSITY FACTOR	0.7

APPENDIX C

EXAMPLE PRINTOUT FROM GEOCITY

APPENDIX C

EXAMPLE PRINTOUT FROM GEOCITY

An example summary printout from the GEOCITY code for a city consisting of six districts with a two-pipe distribution system is shown in the following pages. More detailed output of the fluid transmission system is available at the user's option. Detailed printout for only one of the six districts is included.

The first page lists the characteristics of the districts comprising the city. All values are input or derived directly from the input data. The detailed description of the piping network including pipe size, flow rate, and fluid conditions is shown on page C-4. The detailed material requirement and capital costs for the distribution system of this district is on page C-5. The detailed printouts for districts 2 through 6 are not included, since they have format as for district 1. A description of the system's mains connecting the districts to the transmission line is shown on page C-6. On page C-7 the material requirement and capital and operating costs for all of the districts are summarized. Description of the climate, summary of heat demands, fluid demands, and capital costs are shown on page C-8.

Output from the reservoir model begins on page C-9 which summarizes the input characteristics of the reservoir and wells. The direct expenses associated with reservoir exploration, reservoir development, and reservoir operation are shown on page C-10. Other significant input economic factors for the reservoir and case identification information are listed on page C-11. Annual cash flow data for the major reservoir expenses are shown on page C12. Summary accounts of deductible expenses are contained on page C-13. A simplified income statement is shown on page C-14 and the net cash flow and investment position is shown on page C-15. Page C-16 contains a summary of the costs of energy for the reservoir. In the right-hand column labeled distribution of energy costs, the taxes, royalty payments, and bond interest have been reallocated to the direct cost components for the reservoir. The rate of return on investment is included in the distributed energy cost for each component. The deductible nature of bond interest causes this expense to be partially included in the rate of return (the part which is included in the present worth factor) and the remainder to be accounted for separately. This completes the reservoir model.

Costs associated with the distribution system begin on page C-17 with the capital costs and summary of the economic input data. Pages C-18 to C-21, contain the same economic and accounting information for the distribution system as pages C-12 to C-15 for the reservoir. A summary of the total costs for the distribution system are shown on page C-22. All costs from the reservoir are included in the energy supply cost item. The energy supply costs are derived from the energy cost account shown on page C-18. This energy cost account is identical to the total power sales from the reservoir. As for the reservoir cost distribution, the taxes and bond interest have been reallocated to the primary cost components in the righthand columns of the cost distribution.

SAMPLE OUTPUT FROM GEOCITY

DEFINITION OF DISTRICTS

DIST NO	DIST TYPE	DIS TO DISTRB (MI)	DENSITY (UN/SMI)	AREA (SMI)	LENGTH (MI)	WIDTH (MI)	DIVERS FACTOR	PEAK HEAT DEMAND/UN (MBTU/HR)	HOT WATER DEMAND (GAL./DAY)	HOUSE SPACING (MI)	STREET SPACING (MI)	GROWTH FACTOR (%)	REJECT TEMP (DEG F)	PEOPLE PER UNIT
01	01	1.000	2560.00	.469	.469	1.000	.72	.053000	60.6	.0198	.040	0	100.0	3.2
02	01	0.000	2560.00	.273	.523	.523	.72	.053000	60.6	.0198	.040	0	100.0	3.2
03	02	0.000	4480.00	.513	.477	1.076	.72	.039000	55.0	.0149	.030	0	100.0	4.0
04	03	0.000	293.00	.142	.377	.377	.72	1.380000	3030.0	.0584	.117	0	100.0	162.0
05	04	0.000	373.00	.089	.171	.523	.72	.900000	1515.0	.0518	.104	0	100.0	81.0
06	05	0.000	385.00	.019	.113	.171	.72	1.728000	5400.0	.0510	.102	0	100.0	324.0

METRIC EQUIVALENTS

DIST NO	DIST TYPE	DIS TO DISTRB (KM)	DENSITY (UN/SKM)	AREA (SKM)	LENGTH (KM)	WIDTH (KM)	DIVERS	PEAK HEAT DEMAND/UN (MCAL/HR)	HOT WATER DEMAND (LITERS/DAY)	HOUSE SPACING (KM)	STREET SPACING (KM)	GROWTH FACTOR (%)	REJECT TEMP (DEG C)	PEOPLE PER UNIT
01	01	1.609	988.42	1.21	.75	1.61	.72	13.36	229.4	.0318	.0636	0	37.8	3.2
02	01	0.000	988.42	.71	.84	.84	.72	13.36	229.4	.0318	.0636	0	37.8	3.2
03	02	0.000	1729.73	1.33	.77	1.73	.72	9.83	208.2	.0240	.0481	0	37.8	4.0
04	03	0.000	113.13	.37	.61	.61	.72	347.75	11468.6	.0940	.1880	0	37.8	162.0
05	04	0.000	144.02	.23	.28	.84	.72	226.79	5734.3	.0833	.1666	0	37.8	81.0
06	05	0.000	148.65	.05	.18	.28	.72	435.44	20439.0	.0820	.1640	0	37.8	324.0

SAMPLE OUTPUT FROM GEOCITY

DISTRIBUTION SYSTEM OF DISTRICT 1 TWO PIPE SYSTEM

		FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F) SUPPLY	RETURN	HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)
HOUSE DESCRIPTION								
HOUSE		.2	-.2	208.	100.	3.84	1.00	1.5
STREET DESCRIPTION								
STREET	HOUSE							
1	1	.3	-3.4	208.	99.	.62	1.00	1.5
	2	.6	-3.4	208.	98.	2.22	1.00	1.5
	3	.9	-3.4	208.	98.	4.68	1.00	1.5
	4	1.3	-3.4	209.	97.	7.94	1.00	1.5
	5	1.6	-3.4	209.	97.	11.97	1.00	1.5
	6	1.9	-3.4	209.	97.	16.75	1.00	1.5
	7	2.2	-3.4	209.	97.	22.24	1.00	1.5
	8	2.5	-4.0	209.	97.	3.68	1.50	2.0
	9	2.8	-4.0	209.	97.	4.57	1.50	2.0
	10	3.1	-4.0	209.	97.	5.55	1.50	2.0
	11	3.5	-4.0	209.	97.	6.62	1.50	2.0
	12	3.6	0.0	209.	96.	0.00	1.50	0.0
LATERAL DESCRIPTION								
LATERAL	STREET							
1	1	.2	-7.4	209.	96.	.08	1.50	3.0
	2	5.4	-8.4	210.	94.	8.73	2.00	3.0
	3	10.7	-8.7	210.	94.	12.85	2.50	3.0
	4	15.9	-9.8	210.	94.	6.79	3.00	3.0
	5	21.1	-9.8	210.	94.	11.45	3.00	3.0
	6	26.3	-12.0	210.	94.	4.80	4.00	3.0
	7	31.5	-12.0	210.	94.	6.69	4.00	3.0
	8	36.7	-12.0	210.	94.	8.87	4.00	3.0
	9	42.0	-12.0	210.	94.	11.32	4.00	3.0
	10	47.2	-12.0	210.	94.	14.05	4.00	3.0
	11	52.4	-16.1	210.	93.	2.43	6.00	3.0
	12	57.6	-16.1	210.	93.	2.89	6.00	3.0
	13	62.8	-16.1	210.	93.	3.39	6.00	3.0
	14	68.0	-8.6	210.	93.	2.22	6.00	2.0
MAIN DESCRIPTION								
MAIN		136.1	-492.6	210.	93.	81.69	8.00	3.5

SAMPLE OUTPUT FROM GEOCITY

DISTRICT 1 CAPITAL COSTS AND MATERIAL REQUIREMENTS

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST $X1000	NUMBER OF FTNGS	FTNGS COST $X1000	NUMBER OF VALVES	VALVE COST $X1000	INSUL COST $X1000	CASING COST $X1000	NUMBER OF EXP LOOPS	EXP LOOP COST $X1000	TRENCH COST $X1000	LIN.FT. COST ($/FT)
1.0	232385	206.8	6252	2.1	3126.	3.6	162.7	1299.1	774	74.8	141.3	8.14
1.5	44248	66.0	1048	.1	524.	.2	23.7	302.0	147	58.9	33.1	10.94
2.0	834	2.1	8	.1	4.	.2	.4	9.0	2	1.7	1.0	17.54
2.5	834	2.8	8	.1	4.	.3	.5	9.0	2	1.9	1.0	18.73
3.0	1669	7.1	16	.2	8.	1.1	1.0	22.0	5	5.2	2.2	23.20
4.0	4174	24.3	40	.2	20.	1.5	2.7	63.1	13	17.1	6.0	27.52
6.0	2922	29.9	32	.4	16.	2.0	2.4	65.6	9	22.4	5.5	43.91
8.0	10560	140.5	4	.6	2.	2.4	13.7	394.2	35	158.6	24.7	69.56
TOTALS	297630	479.5		3.8		11.3	207.2	2164.0		340.7	214.8	11.50

COST OF 1199. METERS OF FLOW RATING 11. GPM IS $ 453. (THOUSANDS)
COST OF PUMPS WITH 311. HORSEPOWER CAPACITY IS $ 25. (THOUSANDS)

PIPING SYSTEM($X1000.)	
PIPE	479.51
INSULATION	207.22
CASING	2164.05
FITTINGS	3.78
EXPANSION LOOP	340.69
TRENCH	214.83
VALVES	11.31
METERS	453.22
HEAT PUMP	0.00
PUMP	25.09

TOTAL SYSTEM CAPITAL COST 3899.70

SAMPLE OUTPUT FROM GEOCITY

DESCRIPTION OF MAINS SERVING THE DISTRICTS

MAIN NUMBER	DISTRICT NUMBER	FLOWRATE (LB/SEC)	HEAT LOSS (BTU/SEC)	TEMPERATURE (F) SUPPLY	RETURN	HEAD LOSS FEET	NOMINAL DIAM(IN)	INSUL (IN)	CUMULATIVE FLOWRATE (LB/SEC)
1	1	136.1	-492.6	210.	93.	81.69	8.00	3.5	136.1
2	2	79.4	0.0	210.	96.	0.00	4.00	3.5	79.4
3	3	196.7	0.0	210.	94.	0.00	6.00	3.5	196.7
4	4	136.3	0.0	210.	99.	0.00	4.00	3.5	136.3
5	5	68.8	0.0	210.	99.	0.00	4.00	3.5	68.8
6	6	35.1	0.0	210.	100.	0.00	3.00	3.5	35.1

SAMPLE OUTPUT FROM GEOCITY

TOTAL CAPITAL COSTS AND MATERIAL REQUIREMENTS

PIPE SIZE (IN)	PIPE (LIN.FT)	PIPE COST $X1000	NUMBER OF FTNGS	FTNGS COST $X1000	NUMBER OF VALVES	VALVE COST $X1000	INSUL COST $X1000	CASING COST $X1000	NUMBER OF EXP LOOPS	EXP LOOP COST $X1000	TRENCH COST $X1000	LIN.FT. COST ($/FT)
1.0	711197	633.0	22072	6.5	11036.	11.4	503.7	3975.8	2370	233.1	432.5	8.15
1.5	154633	232.2	3268	11.0	1634.	18.3	84.6	1080.9	515	165.7	118.3	11.06
2.0	22837	50.5	736	.5	368.	.9	8.7	189.4	76	38.3	20.5	13.52
2.5	8071	26.3	64	1.1	32.	2.9	4.4	84.7	26	18.1	9.0	18.17
3.0	19685	79.3	164	1.5	82.	9.7	11.5	252.0	65	59.3	25.2	22.27
4.0	13858	83.5	148	1.7	74.	10.0	10.4	232.6	46	63.2	21.7	30.53
6.0	8602	85.2	116	.8	58.	4.0	7.2	189.7	28	64.7	15.9	42.74
8.0	10560	140.5	4	.6	2.	2.4	13.7	394.2	35	158.6	24.7	69.57
TOTALS	949446	1330.6		23.8		59.6	644.2	6399.3		801.1	667.7	10.45

COST OF 4279. METERS IS $1722. (THOUSANDS)
COST OF PUMPS WITH 1267. HORSEPOWER CAPACITY IS $ 108. (THOUSANDS)

CAPITAL COST ACCOUNTS ($X1000.)

PIPING SYSTEM	
PIPE	1330.60
INSULATION	644.19
CASING	6399.29
FITTINGS	23.82
EXPANSION LOOP	801.12
TRENCH	667.68
VALVES	59.65
METERS	1722.47
PUMPS	108.38
TOTAL PIPING SYSTEM	11757.20
METERING CONTROL	117.57
BUILDING AND LAND USE	117.57
BUILDING RETROFIT	0.00
STORAGE	0.00
HEAT PUMP	0.00
HEAT EXCHANGER	0.00
ENGINEERING AND ADMINISTRATION	1410.86
TOTAL CAPITAL COSTS	13403.21

OPERATING EXPENSE ACCOUNTS ($X1000.)

OPERATING EXPENSES	46.40
MAINTENANCE	86.92
PUMP OPERATION	94.04
METER READERS	33.91
HEAT PUMP OPERATION	0.00
SUPPLEMENTAL HEAT	394.77
HEAT EXCHANGER OPERATION	0.00
TOTAL OPERATING EXPENSES	656.04

DISTRIBUTION SYSTEM DESCRIPTION

DIST NO	TOTAL PEAK HEAT DEMAND (MBTU/HR)	UNIT TEMP DROP (F)	UNIT FLOW RATE (LB/HR)	TOTAL PEAK FLUID DEMAND (KLB/HR)	ANNUAL HEAT DEMAND (TBTU)	DISTR SYSTEM COSTS ($M)
01	51,310	104.4	567.	490.	.16	3.900
02	29,930	104.4	567.	286.	.10	1.899
03	74,194	104.4	428.	708.	.24	4.787
04	50,916	104.4	16225.	491.	.17	.621
05	25,417	104.4	10117.	248.	.08	.433
06	12,229	104.4	21934.	126.	.04	.117
TOTALS	243,996	0.0	0.	2349.	.79	11.757

DISTANCE FROM SOURCE TO DISTR. CENTER (MI)	10.0
SOURCE FLUID TEMPERATURE (F)	212.0
RETURN FLUID TEMPERATURE (F)	96.2
DISTRIBUTION SYSTEM HEAT LOSS (MBTU/HR)	-1,458
SUPPLEMENTAL HEAT REQUIREMENTS	
DEGREE DAYS	500.
PERCENT OF TOTAL DESIGN DEMAND	8.3
PEAK SUPPLEMENTAL HEAT REQUIREMENTS (MBTU/HR)	22,351
TOTAL SUPPLEMENTAL HEAT REQUIREMENTS (MBTU/YR)	65794.4

LOAD FACTOR	.37
TOTAL DISTRICT AREA (SMI)	1.5
COLDEST DAY TEMPERATURE (F)	-5.0
DESIGN TEMPERATURE (F)	0.0
ANNUAL DEGREE DAYS	6500.
DEGREE DAYS AT DESIGN TEMPERATURE	6000.

METRIC EQUIVALENTS

DIST NO	TOTAL PEAK HEAT DEMAND (MCAL/HR)	UNIT TEMP DROP (C)	UNIT FLOW RATE (KG/HR)	TOTAL PEAK FLUID DEMAND (KG/HR*1000)	ANNUAL HEAT DEMAND (GCAL)	DISTR SYSTEM COSTS ($M)
01	12929.679	58.0	257.	222.	41.33	3.900
02	7542.083	58.0	257.	130.	24.11	1.899
03	18696.120	58.0	194.	321.	60.22	4.787
04	12830.237	58.0	7360.	223.	42.17	.621
05	6404.908	58.0	4589.	112.	20.78	.433
06	-3081.560	58.0	9950.	57.	10.33	.117
TOTALS	61484.587	0.0	0.	1065.	198.95	11.757

DISTANCE FROM SOURCE TO DISTR. CENTER (KM)	16.1
SOURCE FLUID TEMPERATURE (C)	100.0
RETURN FLUID TEMPERATURE (C)	35.7
DISTRIBUTION SYSTEM HEAT LOSS (MCAL/HR)	-367.303
SUPPLEMENTAL HEAT REQUIREMENTS	
DEGREE DAYS (C)	278.
PERCENT OF TOTAL DESIGN DEMAND	8.3
PEAK SUPPLEMENTAL HEAT REQUIREMENTS (GCAL/HR)	.006
TOTAL SUPPLEMENTAL HEAT REQUIREMENTS (GCAL/HR)	16.6

LOAD FACTOR	.37
TOTAL DISTRICT AREA (SKM)	3.9
COLDEST DAY TEMPERATURE (C)	-20.6
DESIGN TEMPERATURE (C)	-17.8
ANNUAL DEGREE DAYS (C)	3611.
DEGREE DAYS AT DESIGN TEMPERATURE	3333.

SAMPLE OUTPUT FROM GEOCITY

ECONOMIC ANALYSIS FOR GEOTHERMAL DISTRICT HEATING

RESERVOIR CHARACTERISTICS

AVERAGE DEPTH	2000.0	M
AVERAGE TEMPERATURE	100.0	C
PRODUCING CAPACITY	275.0	MW(E)

WELL DESIGN (AVERAGE)

DEPTH	2000.0	M
BOTTOM DIAMETER	22.225	CM
FRACTION CASED	1.00	

WELL PROPERTIES (AVERAGE)

MW(TH)/WELL	90.9	
MW(E) /WELL (GROSS)	85.4	
MW(E) /WELL (NET)	748498.5	
MAXIMUM FLOW RATE/WELL	500000.0	LB/HR
WELL LIFE	30.0	YEARS
PRODUCING WELLS ON LINE	5.0	
DRY WELLS	0.0	
INJECTION WELLS	0.0	
INPUT WELL SPACING	20.0	ACRES
ACTUAL FLOW RATE/WELL	469691.7	#/HR
TOTAL FLOW RATE	2348458.3	#/HR
WELL PRESSURE AT SATURATION	14.7	PSIA
FRACTION STEAM (WELLHEAD)	0.00	
STEAM SEPARATION (WELLHEAD)	1	
STEAM/FLASH MIX OPTION	0	
WATER OVERPRESSURIZATION	50.000	
ADJUSTED OVERPRESSURIZATION	50.000	
WATER PRESSURE(PLANT-FLASHING)	734.8	

STRATIGRAPHY

ROCK TYPE	DEPTH(M)
HARD	2000.0

FLUID COMPOSITION

CACO3	0.00	%	
NACL	.05	%	
SIO2	.01	%	70. PPM
OTHER	0.00	%	
TOTAL DISSOLVED SOLIDS	.06	%	

PH= 7.00

NONCONDENSIBLE GASES

H2S	.003	%	30. PPM
CO2	.005	%	
CH4	0.000	%	
OTHER	0.000	%	
TOTAL NONCONDENSIBLE GASES	.008	%	

RESERVOIR ECONOMIC DEVELOPMENT FACTORS

FAVORABLE TARGET FRACTION	.500
FAVORABLE SITE FRACTION	.500
FRACTION OF SITES TO EVALUATE	.667
FRACTION OF SITES TO DRILL	.750
FRACTION OF WELLS TO CASE	.250
FRACTION OF SITES TO DEVELOP	.250
PERCENT NONPRODUCING WELLS	0.0
INJECTION/PRODUCTION WELL FLOW RATE	1.000
FRACTION EXCESS PRODUCING WELLS	0.00

SAMPLE OUTPUT FROM GEOCITY

RESERVOIR EXPLORATION COSTS

	TOTAL (DOLLARS)	CAPITALIZED (DOLLARS)	EXPENSED (DOLLARS)	FAVORABLE SITES	BEGINNING MONTH/YEAR	ENDING MONTH/YEAR
IDENTIFICATION OF TARGETS						
LITERATURE SEARCH	1248.	9.8	1238.3	128.	MAY/1970	OCT/1970
PRELIMINARY LAND CHECK	3120.	24.4	3095.7	128.	MAY/1970	OCT/1970
PRELIMINARY RECONNAISSANCE						
LITERATURE SEARCH	4368.	68.3	4299.9	64.	JUN/1970	DEC/1970
GEOLOGICAL RECONNAISSANCE	6240.	97.5	6142.7	64.	JUN/1970	DEC/1970
DETAILED LAND CHECK	7488.	117.0	7371.2	64.	JUN/1970	DEC/1970
DETAILED RECONNAISSANCE						
LEASE COST	187205.	5850.2	181355.3	32.	JUL/1970	MAY/1971
FIELD GEOLOGY	10238.	487.5	9750.3	21.	SEP/1970	JUN/1971
GEOCHEMICAL EXAMINATION	12285.	585.0	11700.3	21.	SEP/1970	JUN/1971
GEOPHYSICAL EXAMINATION	51189.	2437.6	48751.4	21.	SEP/1970	JUN/1971
IDENTIFICATION OF DRILLABLE SITES						
HEAT FLOW	18721.	1170.0	17550.5	16.	APR/1971	MAR/1973
TEMPERATURE GRADIENT	19501.	1218.8	18281.8	16.	APR/1971	MAR/1973
ELECTRICAL RESISTIVITY	5460.	341.3	5118.9	16.	APR/1971	MAR/1973
MICROSEISMIC	7800.	487.5	7312.7	16.	APR/1971	MAR/1973
DETAILED GEOCHEMISTRY	11700.	731.3	10969.1	16.	APR/1971	MAR/1973
EXPLORATION DRILLING						
COST OF DRILLING	136504.	11375.3	125128.7	4.	APR/1972	MAR/1974
WELL TESTING	3900.	975.0	2925.1	4.	APR/1974	APR/1974
TOTAL EXPLORATION COST *	486968.	25976.4	460991.8	1.00		
FIELD DEVELOPMENT						
PRODUCING WELLS	1000000.	333333.3	666666.7		APR/1974	SEP/1977
NONPRODUCING WELLS	0.	0.0	0.0		APR/1974	SEP/1977
INJECTION WELLS	0.	0.0	0.0		OCT/1977	DEC/1979
TRANSMISSION SYSTEM	7995010.	7995010.3	0.0		OCT/1977	DEC/1979
DISPOSAL SYSTEM	0.	0.0	0.0		OCT/1977	DEC/1979
TOTAL FIELD DEVELOPMENT COST	8995010.					
FIELD OPERATION						
REPLACEMENT WELL COST	33333.	11111.1	22222.2		JAN/1980	DEC/2008
NONPRODUCING WELL DRILLING COST	0.	0.0	0.0		JAN/1980	DEC/2008
ABANDONMENT	1667.	0.0	0.0		JAN/1980	DEC/2009
WELL MAINTENANCE	5000.	0.0	0.0		JAN/1980	DEC/2009
OVERHEAD AND MANAGEMENT	144769.	0.0	0.0		JAN/1980	DEC/2009
WELL REDRILLING COST	25000.	0.0	0.0		JAN/1980	DEC/2009
INJECTION COST	0.	0.0	0.0		JAN/1980	DEC/2009
PUMP OPERATIONAL COST	83435.	0.0	0.0		JAN/1980	DEC/2009
TRANSMISSION SYSTEM MTE.	399751.	0.0	0.0		JAN/1980	DEC/2009
DISPOSAL SYSTEM MTE.	0.	0.0	0.0		JAN/1980	DEC/2009
TOTAL FIELD OPERATION COST	692954.					

* TOTAL EXPLORATION COST ALLOCATED TO THIS 27. MWE DISTRICT HEATING SYSTEM IS .0975 OF TOTAL EXPLORATION COST FOR THIS

SAMPLE OUTPUT FROM GEOCITY

R E S E R V O I R   I N P U T   D A T A

BOND REPAYMENT PROPORTIONAL		
SUM OF YEARS DIGITS DEPRECIATION		
CAPITAL INVESTMENT, $M	8.3543	(INITIAL FINANCING)
PROJECT LIFE, YEARS	40.0000	
FRACTION OF INITIAL INVESTMENT IN BONDS	1.0000	(MUNICIPAL UTILITY FINANCING)
BOND INTEREST RATE	.0800	
EQUITY EARNING RATE (AFTER TAXES)	.1500	
FEDERAL INCOME TAX RATE	0.0000	
POWER PLANT SIZE (MWE)	26.8133	
DEPRECIABLE LIFE OF WELLS, YRS.	30.0000	
FIRST YEAR OF OPERATION	1980.	
STATE INCOME TAX RATE	0.0000	
STATE INCOME TAX RATE	0.0000	
STATE GROSS REVENUE TAX RATE	0.0000	
PROPERTY TAX RATE	0.0000	
DISPOSAL SYSTEM REPLACEMENT RATE	.0300	
TRANSMISSION SYSTEM REPLACEMENT RATE.	.0300	
PROPERTY INSURANCE RATE	.0012	
ROYALTY PAYMENT,%	10.00	
PLANT OPERATING LIFE	30.0000	
TRANSMISSION SYSTEM MTE. RATE	.0500	
DISPOSAL SYSTEM MTE. RATE	.0500	
EVALUES	.020000	.015000
GEOTHERMAL PLANT TYPE	5	
NUMBER OF FLASHING STAGES	0	
LOCATION OF FLASHERS	1	
STEAM SCRUBBER OPTION	0	
WELL REINJECTION OPTION	0	
DISTANCE(M) WELLS TO INJECTION FIELD	0.0000	
PLANT REINJECTION OPTION	0	
DISTANCE(M) PLANT TO INJECTION FIELD	0.0000	
CASE GENERATION OPTION	0	
REINJECTION PUMP OPTION	1	
DRILLING COST PER PRODUCING WELL($)	200000.	
DRILLING COST PER NONPRODUCING WELL($)	300000.	
DRILLING COST PER INJECTION WELL($)	350000.	
RESERVOIR TO DISTRIBUTION ORIGIN(MI)	10.0	

SAMPLE OUTPUT FROM GEOCITY

ANNUAL CASH FLOW DATA, EXPENSES IN $M/YR

	YEAR	LOAD FACTOR	FIELD IDENT.	FIELD EXPLOR.	FIELD DEVELOPMENT	RESERVOIR OPERATION	PROPERTY TAXES AND INSURANCE	INTERIM CAPITAL REPLACEMENT	TOTAL
1	1970	0.00000	.00437	.14969	0.00000	0.00000	.00001	0.00000	.15407
2	1971	0.00000	0.00000	.15301	0.00000	0.00000	.00001	0.00000	.15303
3	1972	0.00000	0.00000	.08278	0.00000	0.00000	.00002	0.00000	.08280
4	1973	0.00000	0.00000	.07615	0.00000	0.00000	.00003	0.00000	.07618
5	1974	0.00000	0.00000	.02096	.21429	0.00000	.00012	0.00000	.23537
6	1975	0.00000	0.00000	0.00000	.28571	0.00000	.00023	0.00000	.28595
7	1976	0.00000	0.00000	0.00000	.28571	0.00000	.00035	0.00000	.28606
8	1977	0.00000	0.00000	0.00000	1.10262	0.00000	.00150	0.00000	1.10412
9	1978	0.00000	0.00000	0.00000	3.55334	0.00000	.00576	0.00000	3.55910
10	1979	0.00000	0.00000	0.00000	3.55334	0.00000	.01003	0.00000	3.56336
11	1980	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
12	1981	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
13	1982	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
14	1983	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
15	1984	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
16	1985	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
17	1986	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
18	1987	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
19	1988	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
20	1989	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
21	1990	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
22	1991	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
23	1992	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
24	1993	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
25	1994	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
26	1995	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
27	1996	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
28	1997	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
29	1998	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
30	1999	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
31	2000	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
32	2001	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
33	2002	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
34	2003	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
35	2004	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
36	2005	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
37	2006	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
38	2007	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
39	2008	.36932	0.00000	0.00000	0.00000	.69295	.01003	.23985	.94283
40	2009	.36932	0.00000	0.00000	0.00000	.65962	.01003	0.00000	.66965

SAMPLE OUTPUT FROM GEOCITY

ANNUAL DEDUCTIBLE EXPENSES, $M

	YEAR	8,000 PCT PRESENT WORTH FACTOR	FIELD OPERATING EXPENSES	BOND INTEREST	WELL DEPRECIATION	RESERVOIR DEPLETION AND DEPRECIATION	TOTAL DEDUCTIBLE OPER. EXP.	STATE INCOME TAXES
1	1970	.96225	.00219	0.00000	0.00000	0.00000	.00219	0.00000
2	1971	.89097	.07799	.01233	0.00000	0.00000	.09032	0.00000
3	1972	.82497	.04694	.02555	0.00000	0.00000	.07250	0.00000
4	1973	.76387	.11098	.03422	0.00000	0.00000	.14520	0.00000
5	1974	.70728	.36593	.04305	0.00000	0.00000	.40898	0.00000
6	1975	.65489	.19071	.06533	0.00000	0.00000	.25603	0.00000
7	1976	.60638	.19082	.09343	0.00000	0.00000	.28425	0.00000
8	1977	.56146	.14435	.12379	0.00000	0.00000	.26814	0.00000
9	1978	.51987	.00576	.22202	0.00000	0.00000	.22778	0.00000
10	1979	.48136	.01003	.52451	0.00000	0.00000	.53454	0.00000
11	1980	.44571	.69187	.85154	.02151	.51667	2.08159	0.00000
12	1981	.41269	.69187	.84422	.03121	.72437	2.29106	0.00000
13	1982	.38212	.69187	.83631	.02984	.69325	2.25127	0.00000
14	1983	.35382	.69187	.82776	.02853	.66316	2.21132	0.00000
15	1984	.32761	.69187	.81854	.02726	.63411	2.17177	0.00000
16	1965	.30334	.69187	.80857	.02605	.60608	2.13257	0.00000
17	1986	.28087	.69187	.79781	.02487	.57909	2.09364	0.00000
18	1987	.26007	.69187	.78619	.02375	.55312	2.05493	0.00000
19	1988	.24080	.69187	.77364	.02268	.52819	2.01637	0.00000
20	1989	.22297	.69187	.76006	.02165	.50429	1.97789	0.00000
21	1990	.20645	.69187	.74544	.02067	.48143	1.93940	0.00000
22	1991	.19116	.69187	.72963	.01974	.45059	1.90082	0.00000
23	1992	.17700	.69187	.71255	.01885	.43879	1.86206	0.00000
24	1993	.16389	.69187	.69411	.01802	.41901	1.82301	0.00000
25	1994	.15175	.69187	.67419	.01723	.40027	1.78356	0.00000
26	1995	.14051	.69187	.65268	.01649	.38256	1.74360	0.00000
27	1996	.13010	.69187	.62945	.01579	.36589	1.70299	0.00000
28	1997	.12046	.69187	.60435	.01515	.35024	1.66161	0.00000
29	1998	.11154	.69187	.57726	.01455	.33562	1.61930	0.00000
30	1999	.10328	.69187	.54799	.01400	.32204	1.57590	0.00000
31	2000	.09563	.69187	.51638	.01350	.30949	1.53124	0.00000
32	2001	.08854	.69187	.48224	.01305	.29797	1.48513	0.00000
33	2002	.08198	.69187	.44538	.01264	.28748	1.43737	0.00000
34	2003	.07591	.69187	.40556	.01228	.27803	1.38773	0.00000
35	2004	.07029	.69187	.36256	.01197	.26960	1.33600	0.00000
36	2005	.06508	.69187	.31611	.01171	.26221	1.28190	0.00000
37	2006	.06026	.69187	.26595	.01149	.25585	1.22516	0.00000
38	2007	.05580	.69187	.21178	.01133	.25052	1.16549	0.00000
39	2008	.05166	.69187	.15328	.01121	.24622	1.10257	0.00000
40	2009	.04784	.66965	.09009	.11854	2.56150	3.43979	0.00000
TOTALS=					.65556	14.97665		

SAMPLE OUTPUT FROM GEOCITY

ANNUAL INCOME STATEMENT, $M

	YEAR	POWER UNITS (T BTU)	TOTAL POWER SALES	BY PRODUCT SALES	PERCENTAGE DEPLETION ALLOWANCE	ROYALTY PAYMENTS EXPENSES	TOTAL TAX DEDUCTIBLE EXPENSES	TAXABLE INCOME (FEDERAL)	FEDERAL INCOME TAX
1	1970	0.00000	0.00000	0.00000	0.00000	0.00000	.00219	-.00219	0.00000
2	1971	0.00000	0.00000	0.00000	0.00000	0.00000	.09032	-.09032	0.00000
3	1972	0.00000	0.00000	0.00000	0.00000	0.00000	.07250	-.07250	0.00000
4	1973	0.00000	0.00000	0.00000	0.00000	0.00000	.14520	-.14520	0.00000
5	1974	0.00000	0.00000	0.00000	0.00000	0.00000	.40898	-.40898	0.00000
6	1975	0.00000	0.00000	0.00000	0.00000	0.00000	.25603	-.25603	0.00000
7	1976	0.00000	0.00000	0.00000	0.00000	0.00000	.28425	-.28425	0.00000
8	1977	0.00000	0.00000	0.00000	0.00000	0.00000	.26814	-.26814	0.00000
9	1978	0.00000	0.00000	0.00000	0.00000	0.00000	.22778	-.22778	0.00000
10	1979	0.00000	0.00000	0.00000	0.00000	0.00000	.53454	-.53454	0.00000
11	1980	.80231	2.09547	0.00000	0.00000	.20955	2.08159	-.19567	0.00000
12	1981	.80231	2.09547	0.00000	0.00000	.20955	2.29166	-.40574	0.00000
13	1982	.80231	2.09547	0.00000	0.00000	.20955	2.25127	-.36535	0.00000
14	1983	.80231	2.09547	0.00000	0.00000	.20955	2.21132	-.32540	0.00000
15	1984	.80231	2.09547	0.00000	0.00000	.20955	2.17177	-.28586	0.00000
16	1985	.80231	2.09547	0.00000	0.00000	.20955	2.13257	-.24665	0.00000
17	1986	.80231	2.09547	0.00000	0.00000	.20955	2.09364	-.20772	0.00000
18	1987	.80231	2.09547	0.00000	0.00000	.20955	2.05493	-.16901	0.00000
19	1988	.80231	2.09547	0.00000	0.00000	.20955	2.01637	-.13045	0.00000
20	1989	.80231	2.09547	0.00000	0.00000	.20955	1.97789	-.09197	0.00000
21	1990	.80231	2.09547	0.00000	0.00000	.20955	1.93940	-.05348	0.00000
22	1991	.80231	2.09547	0.00000	0.00000	.20955	1.90082	-.01490	0.00000
23	1992	.80231	2.09547	0.00000	0.00000	.20955	1.86206	.02386	0.00000
24	1993	.80231	2.09547	0.00000	0.00000	.20955	1.82301	.06291	0.00000
25	1994	.80231	2.09547	0.00000	0.00000	.20955	1.78356	.10236	0.00000
26	1995	.80231	2.09547	0.00000	0.00000	.20955	1.74360	.14232	0.00000
27	1996	.80231	2.09547	0.00000	0.00000	.20955	1.70299	.18293	0.00000
28	1997	.80231	2.09547	0.00000	0.00000	.20955	1.66161	.22431	0.00000
29	1998	.80231	2.09547	0.00000	0.00000	.20955	1.61930	.26662	0.00000
30	1999	.80231	2.09547	0.00000	0.00000	.20955	1.57590	.31002	0.00000
31	2000	.80231	2.09547	0.00000	0.00000	.20955	1.53124	.35468	0.00000
32	2001	.80231	2.09547	0.00000	0.00000	.20955	1.48513	.40079	0.00000
33	2002	.80231	2.09547	0.00000	0.00000	.20955	1.43737	.44855	0.00000
34	2003	.80231	2.09547	0.00000	0.00000	.20955	1.38773	.49819	0.00000
35	2004	.80231	2.09547	0.00000	0.00000	.20955	1.33600	.54992	0.00000
36	2005	.80231	2.09547	0.00000	0.00000	.20955	1.28190	.60402	0.00000
37	2006	.80231	2.09547	0.00000	0.00000	.20955	1.22516	.66076	0.00000
38	2007	.80231	2.09547	0.00000	0.00000	.20955	1.16549	.72043	0.00000
39	2008	.80231	2.09547	0.00000	0.00000	.20955	1.10257	.78335	0.00000
40	2009	.80231	2.09547	0.00000	0.00000	.20955	3.43979	-1.55387	0.00000

SAMPLE OUTPUT FROM GENCITY

PAYOUT OF INVESTMENTS, $M

	YEAR	NET CASH FLOW	OUTSTANDING BONDS	EQUITY CAPITAL NOT RECOVERED	BOND INTEREST	EARNINGS ON UNRECOVERED EQUITY	BONDS REPAID	RECOVERY OF EQUITY
1	1970	-.15407	0.00000	0.00000	0.00000	0.00000	-.15407	0.00000
2	1971	-.16535	.15407	0.00000	.01233	0.00000	-.16535	0.00000
3	1972	-.10835	.31942	0.00000	.02555	0.00000	-.10835	0.00000
4	1973	-.11040	.42777	0.00000	.03422	0.00000	-.11040	0.00000
5	1974	-.27842	.53817	0.00000	.04305	0.00000	-.27842	0.00000
6	1975	-.35127	.81659	0.00000	.06533	0.00000	-.35127	0.00000
7	1976	-.37949	1.16787	0.00000	.09343	0.00000	-.37949	0.00000
8	1977	-1.22791	1.54736	0.00000	.12379	0.00000	-1.22791	0.00000
9	1978	-3.78112	2.77526	0.00000	.22202	0.00000	-3.78112	0.00000
10	1979	-4.08787	6.55638	0.00000	.52451	0.00000	-4.08787	0.00000
11	1980	.09155	10.64426	0.00000	.85154	0.00000	.09155	0.00000
12	1981	.09887	10.55271	0.00000	.84422	0.00000	.09887	0.00000
13	1982	.10678	10.45383	0.00000	.83631	0.00000	.10678	0.00000
14	1983	.11533	10.34705	0.00000	.82776	0.00000	.11533	0.00000
15	1984	.12455	10.23172	0.00000	.81854	0.00000	.12455	0.00000
16	1985	.13452	10.10717	0.00000	.80857	0.00000	.13452	0.00000
17	1986	.14528	9.97265	0.00000	.79781	0.00000	.14528	0.00000
18	1987	.15690	9.82737	0.00000	.78619	0.00000	.15690	0.00000
19	1988	.16945	9.67047	0.00000	.77364	0.00000	.16945	0.00000
20	1989	.18301	9.50102	0.00000	.76008	0.00000	.18301	0.00000
21	1990	.19765	9.31801	0.00000	.74544	0.00000	.19765	0.00000
22	1991	.21346	9.12036	0.00000	.72963	0.00000	.21346	0.00000
23	1992	.23054	8.90690	0.00000	.71255	0.00000	.23054	0.00000
24	1993	.24898	8.67636	0.00000	.69411	0.00000	.24898	0.00000
25	1994	.26890	8.42738	0.00000	.67419	0.00000	.26890	0.00000
26	1995	.29041	8.15848	0.00000	.65268	0.00000	.29041	0.00000
27	1996	.31364	7.86807	0.00000	.62945	0.00000	.31364	0.00000
28	1997	.33874	7.55402	0.00000	.60435	0.00000	.33874	0.00000
29	1998	.36584	7.21569	0.00000	.57726	0.00000	.36584	0.00000
30	1999	.39510	6.84985	0.00000	.54799	0.00000	.39510	0.00000
31	2000	.42671	6.45475	0.00000	.51638	0.00000	.42671	0.00000
32	2001	.46085	6.02804	0.00000	.48224	0.00000	.46085	0.00000
33	2002	.49772	5.56719	0.00000	.44538	0.00000	.49772	0.00000
34	2003	.53753	5.06948	0.00000	.40556	0.00000	.53753	0.00000
35	2004	.58053	4.53195	0.00000	.36256	0.00000	.58053	0.00000
36	2005	.62698	3.95141	0.00000	.31611	0.00000	.62698	0.00000
37	2006	.67714	3.32443	0.00000	.26595	0.00000	.67714	0.00000
38	2007	.73131	2.64730	0.00000	.21178	0.00000	.73131	0.00000
39	2008	.78981	1.91599	0.00000	.15328	0.00000	.78981	0.00000
40	2009	1.12618	1.12618	0.00000	.09009	0.00000	1.12618	0.00000

SAMPLE OUTPUT FROM GEOCITY

	DETAILED CASH FLOW		DISTRIBUTION OF ENERGY COSTS	
	CENTS PER MBTU	ANNUAL ($ MILLIONS)	CENTS PER MBTU	ANNUAL ($ MILLIONS)
COST OF ENERGY	261.17850	2.09547		
FIELD IDENTIFICATION AND EXPLORATION	9.79489	.07859	10.88322	.08732
FIELD DEVELOPMENT (TOTAL)	107.84155	.86523	119.82395	.96136
PRODUCING WELLS	14.54153	.11667	16.15725	.12963
TRANSMISSION SYSTEM	93.30003	.74856	103.66670	.83173
DISPOSAL SYSTEM	0.00000	0.00000	0.00000	0.00000
NONPRODUCING WELLS	0.00000	0.00000	0.00000	0.00000
FIELD OPERATING COSTS (TOTAL)	117.42421	.94211	130.47134	1.04679
DISPOSAL COSTS	0.00000	0.00000	0.00000	0.00000
PRODUCING WELLS	8.06491	.06471	8.96101	.07190
TRANSMISSION COSTS	89.85511	.72092	99.83901	.80102
OTHER OPERATING COSTS	19.50418	.15648	21.67131	.17387
REVENUE TAXES	0.00000	0.00000		
STATE INCOME TAXES	0.00000	0.00000		
ROYALTY PAYMENTS	26.11785	.20955		
FEDERAL INCOME TAXES	0.00000	0.00000		
BOND INTEREST	0.00000	0.00000		
BY PRODUCT REVENUE	0.00000	0.00000	0.00000	0.00000
TOTALS	261.17850	2.09547	261.17850	2.09547

SAMPLE OUTPUT FROM GEOCITY

DISTRICT HEATING DISTRIBUTION SYSTEM INPUT DATA

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BOND REPAYMENT PROPORTIONAL
SUM OF YEARS DIGITS DEPRECIATION
PLANT INVESTMENT, $M                       13.4032    (INITIAL FINANCING)
PROJECT LIFE, YEARS                        33.0000
FRACTION OF INITIAL INVESTMENT IN BONDS     1.0000    (MUNICIPAL UTILITY FINANCING)
BOND INTEREST RATE                           .0800
EQUITY EARNING RATE (AFTER TAXES)            .1200
FEDERAL INCOME TAX RATE                     0.0000
POWER PLANT SIZE (MWE)                     26.8133
DEPRECIABLE LIFE OF PLANT,YRS.             30.0000
PLANT CONSTRUCTION AND LICENSING, YRS.      3.0000
FIRST YEAR OF OPERATION                       1980
STATE INCOME TAX RATE                       0.0000
STATE GROSS REVENUE TAX RATE                 .0400
PROPERTY TAX RATE                           0.0000
INTERIM CAPITAL REPLACEMENTS, RATE/YR        .0035
PROPERTY INSURANCE RATE                      .0012
ROYALTY PAYMENT, %                          0.0000
PLANT OPERATING LIFE                       30.0000
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SAMPLE OUTPUT FROM GEOCITY

CASH FLOW TABLE POWER PLANT, $ MILLIONS

	YEAR	LOAD FACTOR	CAPITAL COSTS	ENERGY COSTS	PLANT OPERATING COSTS	INTERIM CAPITAL REPLACEMENT	PROPERTY TAXES INSURANCE	TOTAL COSTS
1	1977	0.00000	1.26800	0.00000	0.00000	0.00000	0.00000	1.26800
2	1978	0.00000	7.27697	0.00000	0.00000	0.00000	.00152	7.27849
3	1979	0.00000	4.85824	0.00000	0.00000	0.00000	.01025	4.86849
4	1980	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
5	1981	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
6	1982	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
7	1983	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
8	1984	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
9	1985	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
10	1986	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
11	1987	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
12	1988	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
13	1989	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
14	1990	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
15	1991	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
16	1992	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
17	1993	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
18	1994	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
19	1995	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
20	1996	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
21	1997	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
22	1998	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
23	1999	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
24	2000	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
25	2001	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
26	2002	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
27	2003	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
28	2004	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
29	2005	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
30	2006	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
31	2007	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
32	2008	.36932	0.00000	2.09547	.65604	.04691	.01608	2.81450
33	2009	.36932	0.00000	2.09547	.65604	0.00000	.01608	2.76759

SAMPLE OUTPUT FROM GEOCITY

ANNUAL TAX DEDUCTIBLE EXPENSES, $ MILLIONS

	YEAR	8.000 PCT PRESENT WORTH FACTOR	OPERATING EXPENSES	BOND INTEREST	DEPRECIATION	TOTAL DEDUCTIBLE OPERATING EXPENSES	STATE INCOME TAX
1	1977	.96225	0.00000	0.00000	0.00000	0.00000	0.00000
2	1978	.89097	.00152	.10144	0.00000	.10296	0.00000
3	1979	.82497	.01025	.69183	0.00000	.70209	0.00000
4	1980	.76387	2.76759	1.13666	.86472	4.76898	0.00000
5	1981	.70728	2.76759	1.12666	.87988	4.77414	0.00000
6	1982	.65489	2.76759	1.11586	.84834	4.73179	0.00000
7	1983	.60638	2.76759	1.10419	.81699	4.68878	0.00000
8	1984	.56146	2.76759	1.09160	.78585	4.64503	0.00000
9	1985	.51987	2.76759	1.07799	.75490	4.60049	0.00000
10	1986	.48136	2.76759	1.06330	.72416	4.55505	0.00000
11	1987	.44571	2.76759	1.04743	.69362	4.50864	0.00000
12	1988	.41269	2.76759	1.03029	.66329	4.46116	0.00000
13	1989	.38212	2.76759	1.01178	.63315	4.41252	0.00000
14	1990	.35382	2.76759	.99179	.60322	4.36259	0.00000
15	1991	.32761	2.76759	.97020	.57348	4.31127	0.00000
16	1992	.30334	2.76759	.94686	.54395	4.25842	0.00000
17	1993	.28087	2.76759	.92169	.51463	4.20391	0.00000
18	1994	.26007	2.76759	.89450	.48550	4.14759	0.00000
19	1995	.24080	2.76759	.86512	.45657	4.08929	0.00000
20	1996	.22297	2.76759	.83340	.42785	4.02884	0.00000
21	1997	.20645	2.76759	.79914	.39933	3.96606	0.00000
22	1998	.19116	2.76759	.76213	.37101	3.90073	0.00000
23	1999	.17700	2.76759	.72217	.34289	3.83265	0.00000
24	2000	.16389	2.76759	.67901	.31498	3.76158	0.00000
25	2001	.15175	2.76759	.63240	.28726	3.68725	0.00000
26	2002	.14051	2.76759	.58206	.25975	3.60940	0.00000
27	2003	.13010	2.76759	.52769	.23244	3.52772	0.00000
28	2004	.12046	2.76759	.46897	.20533	3.44189	0.00000
29	2005	.11154	2.76759	.40555	.17842	3.35156	0.00000
30	2006	.10328	2.76759	.33706	.15172	3.25637	0.00000
31	2007	.09563	2.76759	.26309	.12521	3.15590	0.00000
32	2008	.08854	2.76759	.18321	.09891	3.04971	0.00000
33	2009	.08198	2.76759	.09693	.52629	3.39081	0.00000

DEPRECIATION SUM = 14.7636

SAMPLE OUTPUT FROM GEOCITY

ANNUAL INCOME STATEMENT, $ MILLIONS

	YEAR	POWER UNITS (T BTU)	TOTAL POWER SALES	REVENUE TAXES	TOTAL TAX DEDUCTIBLE EXPENSES	TAXABLE INCOME (FEDERAL)	FEDERAL INCOME TAX
1	1977	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	1978	0.00000	0.00000	0.00000	.10296	-.10296	0.00000
3	1979	0.00000	0.00000	0.00000	.70209	-.70209	0.00000
4	1980	.78953	4.24601	.16984	4.76898	-.69280	0.00000
5	1981	.78953	4.24601	.16984	4.77414	-.69796	0.00000
6	1982	.78953	4.24601	.16984	4.73179	-.65562	0.00000
7	1983	.78953	4.24601	.16984	4.68878	-.61260	0.00000
8	1984	.78953	4.24601	.16984	4.64503	-.56886	0.00000
9	1985	.78953	4.24601	.16984	4.60049	-.52431	0.00000
10	1986	.78953	4.24601	.16984	4.55505	-.47888	0.00000
11	1987	.78953	4.24601	.16984	4.50864	-.43247	0.00000
12	1988	.78953	4.24601	.16984	4.46116	-.38499	0.00000
13	1989	.78953	4.24601	.16984	4.41252	-.33635	0.00000
14	1990	.78953	4.24601	.16984	4.36259	-.28642	0.00000
15	1991	.78953	4.24601	.16984	4.31127	-.23510	0.00000
16	1992	.78953	4.24601	.16984	4.25842	-.18225	0.00000
17	1993	.78953	4.24601	.16984	4.20391	-.12774	0.00000
18	1994	.78953	4.24601	.16984	4.14759	-.07141	0.00000
19	1995	.78953	4.24601	.16984	4.08929	-.01311	0.00000
20	1996	.78953	4.24601	.16984	4.02884	.04733	0.00000
21	1997	.78953	4.24601	.16984	3.96606	.11012	0.00000
22	1998	.78953	4.24601	.16984	3.90073	.17544	0.00000
23	1999	.78953	4.24601	.16984	3.83265	.24352	0.00000
24	2000	.78953	4.24601	.16984	3.76158	.31459	0.00000
25	2001	.78953	4.24601	.16984	3.68725	.38892	0.00000
26	2002	.78953	4.24601	.16984	3.60940	.46678	0.00000
27	2003	.78953	4.24601	.16984	3.52772	.54846	0.00000
28	2004	.78953	4.24601	.16984	3.44189	.63428	0.00000
29	2005	.78953	4.24601	.16984	3.35156	.72461	0.00000
30	2006	.78953	4.24601	.16984	3.25637	.81980	0.00000
31	2007	.78953	4.24601	.16984	3.15590	.92027	0.00000
32	2008	.78953	4.24601	.16984	3.04971	1.02646	0.00000
33	2009	.78953	4.24601	.16984	3.39081	.68536	0.00000

SAMPLE OUTPUT FROM GEOCITY

PAYOUT OF INVESTMENTS, $ MILLIONS

	YEAR	NET CASH FLOW	OUTSTANDING BONDS	EQUITY CAPITAL NOT RECOVERED	BOND INTEREST	EARNINGS ON UNRECOVERED EQUITY	BONDS REPAID	RECOVERY OF EQUITY
1	1977	-1,26800	0,00000	0,00000	0,00000	0,00000	-1,26800	0,00000
2	1978	-7,37993	1,26800	0,00000	,10144	0,00000	-7,37993	0,00000
3	1979	-5,56033	8,64793	0,00000	,69183	0,00000	-5,56033	0,00000
4	1980	,12501	14,20826	0,00000	1,13666	0,00000	,12501	0,00000
5	1981	,13501	14,08326	0,00000	1,12666	0,00000	,13501	0,00000
6	1982	,14581	13,94825	0,00000	1,11586	0,00000	,14581	0,00000
7	1983	,15747	13,80244	0,00000	1,10419	0,00000	,15747	0,00000
8	1984	,17007	13,64496	0,00000	1,09160	0,00000	,17007	0,00000
9	1985	,18368	13,47489	0,00000	1,07799	0,00000	,18368	0,00000
10	1986	,19837	13,29121	0,00000	1,06330	0,00000	,19837	0,00000
11	1987	,21424	13,09284	0,00000	1,04743	0,00000	,21424	0,00000
12	1988	,23138	12,87860	0,00000	1,03029	0,00000	,23138	0,00000
13	1989	,24989	12,64721	0,00000	1,01178	0,00000	,24989	0,00000
14	1990	,26988	12,39732	0,00000	,99179	0,00000	,26988	0,00000
15	1991	,29147	12,12744	0,00000	,97020	0,00000	,29147	0,00000
16	1992	,31479	11,83596	0,00000	,94688	0,00000	,31479	0,00000
17	1993	,33998	11,52117	0,00000	,92169	0,00000	,33998	0,00000
18	1994	,36717	11,18120	0,00000	,89450	0,00000	,36717	0,00000
19	1995	,39655	10,81402	0,00000	,86512	0,00000	,39655	0,00000
20	1996	,42827	10,41747	0,00000	,83340	0,00000	,42827	0,00000
21	1997	,46253	9,98920	0,00000	,79914	0,00000	,46253	0,00000
22	1998	,49954	9,52667	0,00000	,76213	0,00000	,49954	0,00000
23	1999	,53950	9,02713	0,00000	,72217	0,00000	,53950	0,00000
24	2000	,58266	8,48763	0,00000	,67901	0,00000	,58266	0,00000
25	2001	,62927	7,90498	0,00000	,63240	0,00000	,62927	0,00000
26	2002	,67961	7,27570	0,00000	,58206	0,00000	,67961	0,00000
27	2003	,73398	6,59609	0,00000	,52769	0,00000	,73398	0,00000
28	2004	,79270	5,86211	0,00000	,46897	0,00000	,79270	0,00000
29	2005	,85612	5,06941	0,00000	,40555	0,00000	,85612	0,00000
30	2006	,92461	4,21329	0,00000	,33706	0,00000	,92461	0,00000
31	2007	,99857	3,28868	0,00000	,26309	0,00000	,99857	0,00000
32	2008	1,07846	2,29011	0,00000	,18321	0,00000	1,07846	0,00000
33	2009	1,21165	1,21165	0,00000	,09693	0,00000	1,21165	0,00000

SAMPLE OUTPUT FROM GEOCITY

INSTALLED COST .00 $ PER KWE (GROSS)
.00 $ PER KWE (NET)

	DETAILED CASH FLOW CENTS PER MBTU	DETAILED CASH FLOW ANNUAL ($ MILLIONS)	EQUIVALENT CASH FLOW CENTS PER MBTU	EQUIVALENT CASH FLOW ANNUAL ($ MILLIONS)
COST OF HEAT	537,78790	4,24601	537,78790	4,24601
COST DISTRIBUTION				
INITIAL PLANT	159,71808	1,26103	166,37300	1,31357
INTERIM CAPITAL REPLACEMENTS	5,88920	,04650	6,13458	,04843
ENERGY SUPPLY	265,40586	2,09547	276,46444	2,18278
OPERATING EXPENSES	83,09226	,65604	86,55443	,68338
PROPERTY TAXES AND INSURANCE	2,17099	,01714	2,26145	,01785
STATE REVENUE TAX	21,51152	,16984		
STATE INCOME TAX	0,00000	0,00000		
FEDERAL INCOME TAX	0.00000	0.00000		
BOND INTEREST	0,00000	0,00000		
TOTAL	537,78790	4,24601	537,78790	4,24601

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