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A case study to identify and evaluate the pricing policy for geothermal energy in the San Bernardino Municipal Geothermal District heating system

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A CASE STUDY TO IDENTIFY AND EVALUATE THE PRICING POLICY FOR GEOTHERMAL ENERGY IN THE SAN BERNARDINO MUNICIPAL GEOTHERMAL DISTRICT HEATING SYSTEM

A Project
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Faculty of
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San Bernardino

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ABSTRACT

Energy diversification is a direct result of the recent energy crisis. Many communities in the United States have changed their current utilization of natural gas to geothermal energy. Geothermal Energy is the earth's internal heat. Through several forms of geologic processes, this heat can be used in the form of steam or hot water. Geothermal hot water is currently being used in San Bernardino California. The San Bernardino Municipal Water Department uses this heat in the form of district heating. Several buildings and process use the heat in lieu of natural gas heating. The savings that these facilities are experiencing range from 15 percent to 50 percent in energy billings. These savings are based on the San Bernardino Geothermal Pricing Policy.

There have been no attempts to use policy analysis to evaluate the pricing policies now used in the Nation's geothermal heating districts. Through the use of policy analysis, this project identifies and analyzes the development of San Bernardino's current geothermal pricing policy, describes the current pricing policy, evaluates its strengths and weaknesses, and proposes a new policy based on the findings.

The San Bernardino Geothermal Pricing Policy was found to have many strengths and few weaknesses. The strengths were directly attributed to its flexibility in giving preferential treatment to customers who use the geothermal energy more efficiently. The weaknesses were a result of the policy not allowing the Board of Water Commissioners the authority to reevaluate the geothermal price more often than once a year.

Policy analysis was used to develop a set of criteria that would measure the effectiveness of several different variations of the San Bernardino Geothermal Pricing Policy. The financial impact of each alternative policy was estimated by the San Bernardino Municipal Water Staff who operate the Geothermal District Heating System. The criteria scores were then graphed against the financial impact on a scatter diagram. This allowed the selection of a more preferred policy that could be used in the San Bernardino Geothermal Heating District and similar geothermal heating districts.

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INTRODUCTION

Geothermal Energy

In response to the energy crisis, the United States has attempted to diversify its energy sources. Energy diversification has led to the utilization of non-conventional energy sources. Examples of this diversification include: synthetic fuels, wind driven generators and natural geothermal energy. Perhaps the most misunderstood energy source of all is that of geothermal energy. The term geothermal is derived from the Greek words geo meaning "earth" and thermal meaning "heat." As this definition indicates, geothermal means heat from the earth.

Geothermal energy is the earth's internal heat. It is known that the temperature within the earth increases with increasing depth. Molten rock at temperatures between 1300 and 2200 ^{o}F is thought to exist 60 miles beneath the earth's surface. Through several forms of geological processes such as fractures and natural heat convection, this heat resource, in the form of hot water or steam, can be found near or at the surface of the earth. There are several of these geothermal resources located in the United States. According to the U.S. Geological Survey, "approximately 60 percent of the known and proven geothermal resources in the United States are in California."[1]

The consumption of geothermal energy is currently carried out by two processes. These processes are known as indirect and direct consumption. Indirect consumption of geothermal energy involves the conversion of the natural geothermal heat into electricity through the use of a generator or other mechanical devices. The process of direct consumption (otherwise known as district heating) involves the moving of geothermal energy from its source in the form of steam or hot water through pipelines to another location where the heat and/or fluid is then consumed directly. District heating systems produce heat centrally, then distribute it to individual buildings through a system of insulated pipelines. Sources of heat for district heating can come from fossil fuels, waste heat from power plants, solar energy and geothermal energy.

The largest direct-use geothermal district heating system in the United States is in San Bernardino, California. It is managed by the City of San Bernardino Municipal Water Department. This system utilizes two geothermal hot water wells which pump approximately two million gallons of hot water each day to private and public buildings. The heat and water used by each

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[1]Gregory A. Daneke and George K. Lagassa, _Energy Policy and Public Administration_ (Lexington, MA.: Lexington Books, 1980), 112.

building are metered and billed by the water utility. Therefore, instead of paying a natural gas bill, the building owner pays a geothermal bill. The complicated key to making the San Bernardino Geothermal District Heating System (SBGDHS) a success does not lie solely with the engineering of the system but also with the setting of the retail price of the geothermal resource. The technical difficulties of exploiting natural geothermal energy have been addressed in the existing operational geothermal heating districts. Conversely, the financial problems of the direct use geothermal industry are difficult to solve.

Many of the municipal geothermal systems, including San Bernardino, are not "operating in the black." There are several reasons for this phenomenon. Many of the reasons are institutional in nature. One of the major institutional problems appears to be the pricing policy used to set the optimum retail price for the geothermal resource. According to one observer, "The relative success of many geothermal projects directly correspond to the marketing efforts of the heating district's management."[1] The price of the resource directly affects the marketing efforts of the district heating staff.

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[1]Mr. Joeseph Stejskal, interview by author, March 1989, San Bernardino California.

Therefore, the pricing of the geothermal resource plays an important role in the success of the geothermal heating district.

Pricing Of Geothermal Energy As A Public Policy Issue

Municipal geothermal utilities are currently being financed and/or promoted by the California Energy Commission (CEC), the Department of Energy, the Washington State Energy Office, the Oregon Department of Energy and the New Mexico Physical Science Laboratory. With the financial contributions of these governmental offices, there is a growing need to analyze the issues that impact the pricing of geothermal energy in public geothermal district heating systems. There have been attempts to document the current pricing trends of geothermal energy in the western states. However, there have been no significant attempts to identify the pricing policy that adequately identifies the optimum retail price of directly consumed geothermal energy. Since there are no systematic guidelines to assist the developers of municipal geothermal district heating systems, the wheel of pricing the retail energy must be recreated each time, with the risk of over or under pricing its real value. The pricing of retail geothermal energy can be an expensive and time consuming effort. With the current expansion of geothermal district heating in the coastal states there is a need for a policy to price retail geothermal energy.

Project Objectives

This research project will identify and analyze the development of San Bernardino's current pricing policy, describe the current pricing policy, evaluate its strengths and weaknesses and, if necessary, propose a new pricing policy. Other municipal geothermal district heating system pricing policies will be compared and evaluated with the pricing policy that is currently being applied in the San Bernardino Municipal Geothermal District Heating System (SBMGDHS). The other geothermal pricing policies will serve as alternatives to San Bernardino's pricing policy in the final analysis and policy development sections of this research project.

Policy Analysis

To achieve these objectives, this research project will utilize policy analysis methods to determine an optimum pricing policy for direct use geothermal energy sold by the San Bernardino Water Department and similar public geothermal district heating systems. Policy analysis attempts "to bring modern science and technology to bear on society's problems, policy analysis searches for feasible courses of action, generating information and marshaling evidence of the benefits and other consequences that would follow their adoption and implementation, in order to help the policy-maker choose the most advantageous action."[1] Policy analysis can aid in the discovery and selection of better objectives and alternatives leading to the solution of a problem. "In principle, policy analysis can help in any area where decisions are to be made or policy determined."[2] Policy analysis is the utilization of insight and judgement and includes the examination of a policy by breaking it down into parts (i.e. suboptimization) and the designing and analysis of new alternative policies.

Policy analysis generally follows five steps. The first step in policy analysis is to determine the goals or objectives that are desired. The goals of this research project are to evaluate the San Bernardino Geothermal Pricing Policy and to develop a better proto-type pricing policy. The second step would be the development of alternative policies. For example, an alternative would be some variation of the current geothermal pricing policy used in San Bernardino. The third step in policy analysis is the development or identification of a model in which the alternatives can be evaluated. For illustration, the model in this research project will be the San Bernardino Geothermal District Heating System. The fourth step in

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[1]Edward S.Quade, Analysis for Public Decisions, 2nd ed. (New York: North Holland, 1984), 5.

[2]Ibid., 14.

policy analysis is the estimation of the impacts of each alternative if implemented. The impacts could be either financial, social or both. The final step in policy analysis is the selection of the best alternative based on some sort of criterion or criteria that would order the impacts from least preferred to most preferred. The criteria can be developed using the information from the evaluation of the strengths and weaknesses of the current policy.

Policy analysis is a powerful tool that can be applied to resolve several types of social and political issues. However, policy analysis is not a perfected discipline. Policy analysis can be incorrectly applied to justify a decision that has already been made. Public policies are also difficult to evaluate. The problems they address are usually "wicked" in nature. The problems have no definite answer or solution. The best answer cannot be judged to be true or false but good or bad. "There may be neither an immediate nor even an ultimate test of a solution-the set of potential solutions may seem endless; every problem is essentially unique and is a symptom of another problem."[1]

Policy analysis will never be a "... purely rational,

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[1]Ibid., 9.

coldly objective, scientific aid to decision-making that will neatly lay bare the solution to every problem to which it is applied."[1] Many public decisions must rely on intuition and sound judgement. However, policy analysis can assist the decision maker in making the final decision of not changing anything or selecting an alternative course of action.

Policy Analysis Methods

This research project includes an analysis of the San Bernardino geothermal district heating system pricing policy. The analysis will involve the identification of several alternative geothermal pricing policies. Using policy analysis, the alternatives will then be analyzed to determine their possible positive and negative impacts if implemented in San Bernardino. The positive and negative impacts of each possible pricing policy will be evaluated using a specific set of criteria. The policy that best meets the selection criteria will be recommended for adoption in San Bernardino.

Standard text, documents, articles, interviews and surveys were used to gather the necessary information to complete the project objectives. The types of text used to complete this research project were oriented towards the subjects of public policy analysis, basic research

[1]Ibid., 11.

methods and general/technical geothermal engineering. The documentation reviewed included: professional geothermal literature, feasibility studies of various public geothermal district heating systems and various pricing strategies of many public geothermal district heating systems. Several personal and telephone interviews were conducted with the operators and managers of the San Bernardino Municipal Water Department, the Boise Geothermal Heating District, the Klamath Falls Geothermal Heating District and the Susanville Geothermal Heating District. Data on geothermal pricing policies were also obtained from the Oregon Institute of Technology/Geo-Heat Center, the California Energy Commission and the Oregon Department of Energy.

Limitations and Constraints

This policy analysis of pricing geothermal energy is limited to public geothermal district heating systems. The San Bernardino Municipal District Heating System is the model used in the analysis. Specific criteria are, therefore, developed around the San Bernardino Municipal Geothermal District Heating System.

PRICING GEOTHERMAL ENERGY IN SAN BERNARDINO

History of Geothermal Energy In San Bernardino

The residents of San Bernardino have known the existence of a geothermal resource within the city limits for over a hundred years.[1] With the San Andreas fault on the north side and the Loma Linda and San Jacinto faults on the south side, the City of San Bernardino is located over a very large geothermal resource. The faults allow vast amounts of ground water to be heated through natural convection, friction and pressure between the continental plates.

The residents of San Bernardino have been enjoying this geothermal resource for at least one hundred years. What is now the Inland Center Mall, used to be the Urbita Hot Springs, a place where residents could enjoy relaxing in geothermal water. Still existing are the steam caves located under the old hotel at, what is now, Campus Crusade for Christ. "The steam caves have been enjoyed by thousands of people for over 50 years."[2]

Geothermal energy has not always been used just for pleasure. Geothermal energy has significant industrial

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[1]Mr. Harold Willis, interview by author, March 1989, San Bernardino, California.

[2]Mr. Gary Culbertson, interview by author, January 1989, San Bernardino, California.

uses as well. For example, in San Bernardino "the Baseline Laundry has been using geothermal energy for over forty years."[1] On a larger scale, the San Bernardino Municipal Water Department has been developing commercial geothermal energy since the late 1970's.

The SBMGDHS was first conceived in 1979. Under the direction of the Board of Water Commissioners (BOWC), the staff of the San Bernardino Municipal Water Department investigated the use of geothermal energy at the Waste Water Treatment Plant. The BOWC decided to construct a demonstration geothermal project using Department of Energy (DOE) funds to investigate the geothermal resource, and California Energy Commission (CEC) funds to construct the infrastructure required to use the geothermal resource. The infrastructure consisted of five geothermal monitoring wells; one "purchased" geothermal production well from the Meeks and Daley Water Company; and building retrofits for several offices at the Waste Water Treatment Plant, for the Waste Water Treatment Plant anaerobic digester, and for the Riverside/San Bernardino Blood Bank and the San Bernardino Animal Control Shelter. Figure 1 is a map showing the configuration of the geothermal demonstration project.

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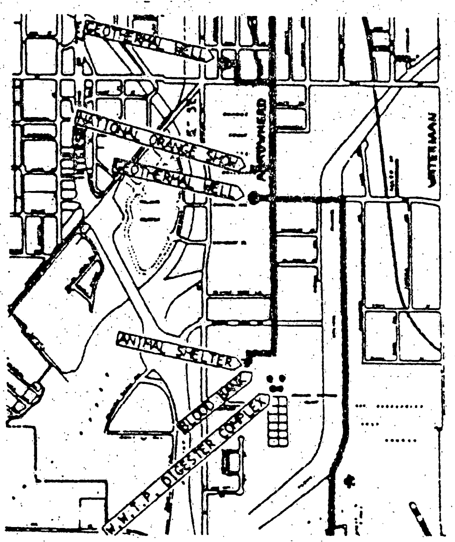
[1]Mr. Harold Willis, interview by author, March 1989, San Bernardino, California.

Figure 1

Map of the San Bernardino Waste Water
Geothermal Demonstration Project



Source: San Bernardino Municipal Water Department.

According to Mr. Harold Willis, Water Commissioner, the successful completion and operation of the Waste Water Geothermal Demonstration Project influenced the BOWC to pursue the development and construction of a larger geothermal district heating system.[1] The BOWC directed the staff to evaluate the potential success of a geothermal district heating system in San Bernardino, California. Several contractors familiar with direct use geothermal energy were retained to assist the SBMWD staff

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[1]Ibid.

in a feasibility study. The study commenced in May, 1981, and was completed in February, 1983. The study concluded that a geothermal project was "... economically feasible, and can be constructed and operated in a cost effective manner."[1]

Organization of the Geothermal Heating Utility

There are several ways in which a geothermal system can be managed and structured. The following are the ones proposed most frequently: The first structure could be a city acting through its public works department. For example the City of Boise, Idaho operates its Geothermal District Heating System through the City's Public Works Department. The City Engineer is the systems manager.

The second structure could be a community energy authority. California law permits a town to indirectly create a legally distinct subsidiary district known as a Community Energy Authority (CEA). Under 1984 state legislation, counties and cities may establish CEA's to plan, coordinate, construct and/or operate energy projects for the purposes of encouraging conservation and

[1]California Energy Commission, Feasibility of Geothermal Direct Use Application in San Bernardino, California, Final Report (Sacramento, CA.: Office of Small Power Producers, 1983), i.

efficiency, and minimizing energy price increases."[1]

The third structure could be a municipal utility district (MUD). As an alternative to supplying geothermal energy through a city department or indirectly through a CEA subsidiary district, a city could join with a water district to form a municipal utility district. Similar to a CEA an MUD would be a distinct legal entity of a community. However, unlike the CEA, the MUD would be governed by a board of directors who represent the city and the water district.[2]

The fourth could be a heating district working under the authority of another public utility such as water. It was the Board of Water Commissioners who saw the potential advantages of developing a geothermal heating district working under the Municipal Water Department. The reason for using the Water Department as the parent organization was that the Water Department had the resources to develop a heating district. The Department also had an immediate current application for the Heating District. The waste water treatment plant offered the Water Department a large geothermal consumer, for example the anaerobic digesters. Further expansion of the heating district had advantages

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[1]California Energy Commission, Mammoth Lakes Geoheating Report (Sacramento, CA.: Office of Small Power Producers, 1989), 27.

[2]Ibid., 28.

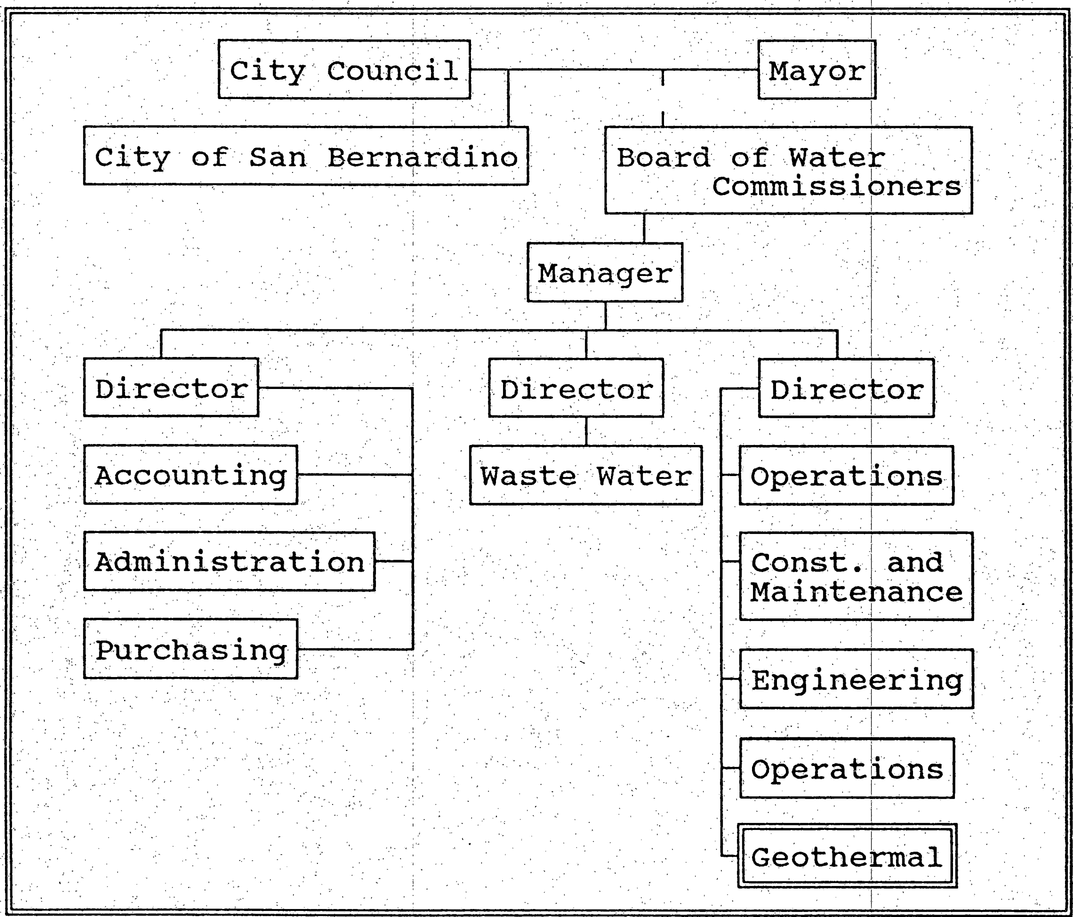
that were essentially twofold. The first advantage was the expansion the Water Department could experience. The second advantage, and most likely the most important, was that another utility could be developed that would effectively serve the citizens of San Bernardino. The citizens could lower there utility bills and keep the revenues within the City of San Bernardino.

The San Bernardino Geothermal District Heating System is owned and operated by the San Bernardino Municipal Water Department. A clear description of the Water Department Management structure is required to understand the development of the pricing policy of geothermal energy in the San Bernardino. The San Bernardino City Charter gives the City the authority to control the distribution of water and heat. The Water Department in San Bernardino is guided by a five member Board of Water Commissioners who are appointed by the Mayor. The City Council can remove a Water Commissioner with a 4/5 vote. Other than this relationship, the San Bernardino Municipal Water Department has no other management ties to the City of San Bernardino. The Water Department is a semi-autonomous agency of the City.

The BOWC is also responsible for the San Bernardino Waste Water Treatment Plant, Water and Geothermal facilities. The management of SBMWD is headed by a manager and three directors. These four persons serve at the will and pleasure of the BOWC. The directors, who answer to the manager, are responsible for three basic divisions within SBMWD which are: the waste water treatment plant, finance and administration, and engineering/construction and maintenance. The Director of engineering/construction and maintenance is responsible for the SBMGDHS. Figure 2 illustrates the management breakdown as discussed above.

Figure 2

Water Department Relationships Within the City of San Bernardino



Pricing Public Goods and Services

Prices in the public sector serve a different purpose than prices in the private sector. Prices in the private sector serve to exclude those not willing to pay for the service and maximize profits of suppliers within the market place. This may be somewhat true in the public sector. However, in the public sector prices also serve to manipulate demand in accordance with the public criteria. In the San Bernardino Geothermal District Heating System Model the prices could serve to allow as many people as possible access to cheap energy, stimulate geothermal growth, minimize cost to public sector facilities, preserve the environment, and enforce the efficient use of energy. Conversely, the price of the geothermal resource could be designed to be customer specific. The price could be high enough to only allow the most efficient customers to connect to the geothermal system.

However, for the project to be a success the price of the geothermal energy must be low in comparison to the alternative forms of energy. According to the Center for Renewable Resources, the cost of the district heating resource must be low enough to subsidize the conversion cost of the district customers.[1] This is based on the

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[1]Center for Renewable Resources, Renewable Energy In Cities (New York: Van Nostrand Reinhold Company Inc., 1984), 216.

marginal economics of customer conversion to district heating.

The price of the resource must also reflect the elasticity of its demand. For example, during 1979 the price of gas went up 100 percent. According to the National Petroleum Institute the consumption fell only 1 percent.[1] The demand in very inelastic. Space heating is also very inelastic. People will pay high prices to have space heating. However, in the San Bernardino Geothermal Heating District, each of the district heating customers have the ability to switch back and forth form natural gas to geothermal energy. Hence, geothermal energy and natural gas are substitutes for each other. Therefore, geothermal energy is very elastic; if the price of geothermal energy goes up relative to natural gas, people will switch to natural gas. Conversely, if the price of natural gas goes up relative to geothermal energy, people will switch to geothermal energy.

Development of the Pricing Policy

The San Bernardino pricing policy was based on the original feasibility study, Feasibility of Geothermal Direct Use Applications In San Bernardino, California. During the feasibility stage of the project the SBMWD staff decided that the price of the geothermal energy

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1Maurice Levi, Economics Deciphered, A Layman's Guide (New York: Basic Books Inc., 1981), 189-190.

should be significantly lower than the price of natural gas. The reason was that the SBMWD staff faced a classic problem of a seller attempting to introduce a new product line which appeared promising, but which required the buyer to make substantive changes and incur up-front costs in order to accept and use the product. Hence, a significantly lower price in energy would justify the customer's up front costs for the conversion of the facility's mechanical system to accept geothermal energy.

It was also assumed that a prospective geothermal customer would require a long term contract that would hold the geothermal cost at a minimum. According to the SBMWD staff, "In this case, acceptance will come from two factors: lower cost energy and believable long-term price constraints."[1] To make long term price constraints plausible the feasibility study stated that "Cheaper energy can be made factual by supply contracts between the City and users which tie geothermal energy price to some fraction of natural gas prices."[2] Since cheaper energy was thought to be the key to a successful project, the initial geothermal services agreement between SBMWD and

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[1] California Energy Commission, Feasibility of Geothermal Direct Use Application in San Bernardino, California. Final Report (Sacramento, CA: Office of Small Power Producers, 1983), 5.7.

[2] Ibid.

its users arbitrarily set the price of geothermal energy at 75 percent of the cost of natural gas for ten years.

The feasibility study also addressed the market place. A determination was made on whether there were enough potential geothermal customers to justify the construction and operational costs of a municipal geothermal district heating system. A survey was conducted to ascertain if potential users could have cost-effective use of the geothermal resource. With geothermal energy arbitrarily priced at 75 percent of natural gas, the market survey assessed the economic feasibility of several individual user retrofit expenditures. Based on a conceptual system design, the data obtained in the survey made if possible to evaluate SBMWD's ability to repay a construction and development loan.

It is interesting to note that no actual contact was made with the potential customers other than a site visit to inspect the mechanical systems prior to the project construction. The potential customers of the geothermal heating system were not asked if they would consider geothermal energy based on the price setting at 75 percent of natural gas. It was thought that the investment tax credits (10 percent regular credit and 15 percent special geothermal credit) would persuade potential customers to utilize geothermal energy. Therefore, it was assumed that the price would be attractive enough to attract the potential customers without prior verification.

Upon the development of a conceptual design of the geothermal system, the cost to construct the system was estimated to be $2.75 million. The major component costs in the conceptual geothermal system were installed pipeline costs, well field costs, well pump costs, city connection costs and instrumentation costs. Operational cost considerations included: inflation in the price of natural gas and electricity, labor costs, management costs, interest rates and maintenance costs.

A computer simulation was developed to assess the effectiveness of the pricing policy's ability to meet both the user savings requirements and SBMWD's revenue requirements. The economic analysis began by estimating the costs of the project construction. These costs were estimated twice using discounted and un-discounted figures. The discounted figures reflected the loss in revenue since the money would most likely be invested with a bank in some form of an interest bearing account. The operational costs were estimated at 1.5 percent of the installed cost and inflated each year at 1.5 percent. Management costs were estimated to be 1.0 percent of the installed costs and inflated 1.5 percent each year. Electricity costs were inflated 5 percent each year. The entire financial analysis was computed twice using two different interest rates, 7.5 percent and 11.5 percent.

The reason for using two interest rates was to assure that the feasibility study would compensate for time if project approval took longer than expected. Appendix A is the actual financial spread sheet analysis taken from Feasibility of Geothermal Direct Use Application In San Bernardino, California. Final Report 1983.

Description of the Pricing Policy

According to Rule and Regulation No. 1, paragraph two, of the San Bernardino Geothermal Rules and Regulations, the pricing policy responsibility is under the control of the BOWC. This in turn gives the BOWC ultimate control of the SBMGDHS. The rule states, "All rules and regulations herein set forth are subject at all times to change or abolition by action of the Board of Water Commissioners as the respective and controlling authority of the City."[1]

The following is taken from the Rules and Regulations of the San Bernardino Municipal Water Department For Geothermal Service, Rule and Regulation No. 18 titled Geothermal Rates.[2]

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[1]San Bernardino, CA., Rules and Regulations of the San Bernardino Municipal Water Department for Geothermal Service. (1982), Rule No. 1.

[2]Ibid., Rule No. 18.

GEOTHERMAL RATES

RULE AND REGULATION NO. 18

The following rate shall be charged for all geothermal service for domestic, commercial, or industrial use within the City of San Bernardino, or for any other purpose for which no other rate is specified.

This rate shall be established at a price per usable therm set at 75 percent (75%) of the price of natural gas on November 1983, for the period through December 31, 1984. This geothermal rate is $0.54 per usable therm.

Thereafter, in accordance with the provisions of the applicable San Bernardino City Ordinance, the rate per usable therm will be established each year by the San Bernardino Board of Water Commissioners at a price effective on the first day of January of each year, commencing 1985, which will not exceed 75 percent (75%) of the natural gas as of that date.

Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application which uses totally the temperature difference between normal groundwater temperature (64 ^{o}F) and the geothermal temperature at the service connection point.

It was decided that the SBGDHS would use BTU meters and not just flow meters to provide billing data. The reason for this decision was three fold. First, when metering the exact amount of energy consumed by a facility there is little room for disagreement about the amount of energy that was used by the customer. Second, "... a BTU meter serves as a an excellent marketing device."[1] A BTU

[1]Mr. Bernard Kersey, interview by author, April 1989, San Bernardino, California.

meter allows the water department to show its customers just how inefficient their boilers really are. Through the use of a BTU meter the customer's energy bill will only reflect the amount of energy that was actually used by the facility. Hence, a BTU meter makes geothermal energy 100 percent efficient. This could equate to a 30 percent savings in the customers energy billing. Third, the second paragraph of the Rule and Regulation No. 18 states that the geothermal "... rate shall be established at a price per usable therm;" the only way to accurately measure the usable therms is with a BTU meter.[1] Appendix B contains an analysis showing two examples of a geothermal billing which illustrates the requirement of a BTU meter for metering usable therms.

The third paragraph in Rule and Regulation No. 18 allows the BOWC to change the price of geothermal energy with some guidelines and limitations. The rule states that "... the rate per usable therm will be established each year by the San Bernardino Board of Water Commissioners at a price effective on the first day of January of each year, commencing 1985, which will not exceed 75 percent (75%) of the natural gas as of that

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[1]San Bernardino, CA., <u>Rules and Regulations of the San Bernardino Municipal Water Department for Geothermal Service.</u> (1982), Rule No. 18.

date."[1] It is interesting to note that the price of the geothermal energy was not set at 75 percent of the price of natural gas but was set not to exceed 75 percent of the price on the first day of January of each year. Hence, if the price of natural gas increases prior to January 1st of any year the Board of Water Commissioners (BOWC) has the ability to raise its geothermal rate accordingly. If the natural gas rates drop after January 1st the BOWC do not have to lower the rate until the following January 1st of the following year.

The final paragraph of Rule and Regulation No. 18 allows for preferential treatment to curtain customers that use the geothermal fluid more efficiently. However, the law does not provide specific requirements for the preferential treatment.

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[1] Ibid.

EVALUATION OF THE SAN BERNARDINO PRICING POLICY

Strengths and Weaknesses of the San Bernardino Pricing Policy

This section defines and examines the strengths and weaknesses of the San Bernardino Pricing Policy. Each impact of the strengths and weaknesses of the San Bernardino policy is analyzed separately. This analysis serves as the foundation for development of a specific set of criteria that can be used to evaluate the San Bernardino Pricing Policy as well as other pricing policy alternatives if implemented in the San Bernardino Geothermal District Heating System.

Strengths of the San Bernardino Geothermal Pricing Policy

BTU meters can serve as an efficient marketing tool. "In measuring the heat to be sold, system efficiencies are generally considered in the price."[1] For example, the gas company uses only one meter that measures the amount of energy entering the building. The facility is still charged for the amount of energy lost through the flume pipe of the boiler. Conversely, a BTU meter monitors the amount of energy entering the facility and it subtracts the amount of energy exiting the facility. Hence, the facility is only being charged for the amount of energy

[1] Alex Sifford, Geothermal Direct Use Pricing Survey (Davis, CA.: Geothermal Resource Council Transactions, 1985), 150.

consumed, which in turn makes the facilities mechanical system nearly 100 percent efficient. Since most boilers are, at best, 75 percent efficient, the use of a BTU meter could save a potential geothermal customer 30 percent in billing charges alone.

Setting the rate at 75 percent of the price of natural gas gives the SBMWD great flexibility in its pricing policy. The vagueness of this rule makes it flexible. The gas company has flat, declining block and inclining block natural gas rates. A flat rate would be a rate for natural gas set at one price independent upon the amount of natural gas consumed. A declining block rate is dependent upon the amount of natural gas used. For example, a customer using natural gas has an assigned "base line" use of 5000 therms. The price of the natural gas could be set at $0.54/therm below a consumption of 5000 therms and any consumption over the life line will be charged at a rate of $0.37/therm. The price of the natural gas drops for any energy used above the base line. This type of rate policy encourages the use of natural gas. Conversely, an inclining block rate discourages the extensive use of the natural gas. For illustration, a customer has an assigned "base line" of 5000 therms. The price of the natural gas is $0.54/therm below 5000 therms of consumption. If the customer uses over 5000 therms the price of the therms used in excess of 5000 is now raised to $0.94/therm.

The geothermal utility can choose to take advantage of the block structures when convenient. For example, the utility can use the vagueness of the pricing rule as a marketing tool. Prospective geothermal customers with a marginal retrofit payback can be offered a declining block geothermal rate set at 75 percent the price per usable therm of natural gas. However, if the geothermal utility has the opinion that the prospective geothermal customer will have a relatively inexpensive retrofit and have a high return on his investment, an inclining block rate or flat rate policy can be used.

Since the SBGDHS does not charge tax on its commodity, the vagueness of Rule and Regulation No. 18 also allows the geothermal utility to decide whether to include the 8 percent tax assessed against the gas utility. The same holds true for the standby fees assessed by the gas company. These items give the SBGDHS great flexibility in setting the rate. Rule and Regulation no. 18 allows for this specialized treatment of preferential customers in the last paragraph of the rule: "Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water."[1]

Inflation and future costs play a extensive role in the development of a pricing policy. A pricing policy must be developed in such a manner that inflation will be addressed to cover operational costs and still keep the geothermal energy priced competitively. Hence, a yearly correction in the price of the geothermal energy is allowed via the third paragraph in Rule and Regulation No. 18, "... the rate per usable therm will be established each year by the San Bernardino Board of Water Commissioners at a price effective on the first day of January of each year, commencing 1985, which will not exceed 75 percent (75%) of the natural gas as of that date."[2] Therefore, if the price of natural gas increases prior to January 1st of any year the BOWC has the ability to raise its geothermal rate accordingly. If the natural gas rates drop after January 1st the BOWC do not have to lower the rate until the following January 1st of the following year.

In doing this the BOWC has the ability to keep the rates as high as possible for a longer period of time. For example, if the BOWC were using a flat geothermal rate

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[1]San Bernardino, CA., Rules and Regulations of the San Bernardino Municipal Water Department For Geothermal Service. (1982), Rule No. 18.

[2]Ibid.

that continuously floated with the price of the natural gas, the BOWC could not hold the price of the geothermal energy up until the following January 1st, the price would be corrected upon the deflation of the natural gas price. In writing the Rule and Regulation No. 18 in this fashion the revenues of the geothermal system can be raised by only lower their geothermal rate the following January.

Mr. Gene Culver of the Oregon Institute of Technology, Geothermal Heat Center, stated that "... customers should receive some price breaks for more efficient utilization of the resource", (i.e. take more heat from the fluid).[1] The district heating system must pay for the pumping cost of the water to each facility. If the facility is very efficient in extracting the BTU from the water then the district heating system does not have to pump as much fluid to that building. Hence, the district saves in pumping costs. Mr. Culver is stating that these savings should be passed on to the more efficient customers. The current pricing policy does allow for preferential treatment for those customers who use the geothermal more efficiently. The fourth paragraph of Rule and Regulation No. 18 allows for lower price breaks for the more efficient customers. "Procedures are

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[1]Mr. Gene Culver, interview by author, February 1989, Klamath Falls, Oregon, telephone.

established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application which uses totally the temperature difference between normal groundwater temperature (64 ^{o}F) and the geothermal temperature at the service connection point."[1]

It would seem that the entity best suited to effectively and efficiently operate a municipal geothermal system in the public sector would be a Water District. There are several reasons for making this statement. First, a water district is very familiar with the technical side of the geothermal district heating system. Many water districts install their own piping systems. Therefore, the district heating distribution system installation and maintenance would be considered business as usual. Geothermal wells are also very similar to cold water wells. Again, with a few exceptions, the water district's expertise and experience in water well construction and operation would prove to be invaluable. Many existing geothermal district heating systems meter the energy consumed by each user in the same way water district meter the water consumed by their users.

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[1]San Bernardino, CA., Rules and Regulations of the San Bernardino Municipal Water Department For Geothermal Service. (1982), Rule No. 18.

Water district's also operate waste water treatment plants. The significance of operating a water treatment plant is that the Water District staff is familiar with surface discharge permitting regulations. This expertise assists the District in "cutting the environmental red tape" of obtaining a discharge permit for the used geothermal fluid. The fluid handling experience and available construction staff employed by water districts makes them a good candidate for becoming effective and efficient district heating operators.

The Rules and Regulations of the San Bernardino Geothermal District Heating System place control of the Heating District in the hands of a water authority. Therefore, there is an added advantage in the pricing structure. Since a water district is very familiar with the technology involved with geothermal energy, the district would is also very familiar with the costs involved in the day to day operations and maintenance of a district heating system. Therefore, the district would be very familiar with the revenues and pricing requirements necessary to keep the heating district operating and expanding.

<u>Weaknesses of the San Bernardino Geothermal Pricing Policy</u>

Rule and Regulation No. 18 can work against the BOWC. For example, if the price of natural gas is raised after

January 1st, the price of the geothermal energy cannot be raised until the following January 1st. Hence, the Gas Utility can be very competitive and profitable by raising their natural gas rates on January 2nd and lowering them on January 1st. For example, the BOWC examines the natural gas rates in effect on January 1st, and finds that an increase in geothermal energy is not warranted. The Gas Company, via the Public Utilities Commission, is then allowed to set new higher rates on January 2nd. Therefore, the SBGDHS loses revenue by not setting its geothermal rates at 75 percent of the price of natural gas.

The required use of BTU meters can also deter the growth of the Geothermal District Heating System. BTU meters are required to be utilized in the measuring of "usable therms." Even though the BTU meter serves as an effective marketing tool, they are an expensive item and may be cost prohibitive. Therefore, customers who do not warrant the expense of a BTU meter may not be able to take advantage of the geothermal utility. Hence, there are no guidelines for smaller customers to take advantage of the geothermal energy without an expensive BTU meter.

Problems with the San Bernardino Pricing Policy Development

Figure 3 depicts the assumed growth in energy prices for seven consecutive years that were used in the San Bernardino Feasibility Study. It is interesting to note just how far off the future estimates were. For example, in the year 1989 the feasibility study estimated the price of natural gas to be $12.94 a million BTU when in actuality it is $7.81 per million BTU.[1] This equates to an error of 40 percent. Another problem with the development of the pricing policy was that the staff investigating the feasibility of cost effective retrofit failed to question the potential geothermal customers if they would be interested in investing in a geothermal retrofit. The authors of the feasibility study assumed that the tax incentives, the 25 percent price reduction, and the boiler efficiency correction would be enough to sway the customer into taking advantage of the geothermal district heating system. As a result, the staff writing the feasibility study failed to evaluate what the energy market would bear.

Impacts of the Problems

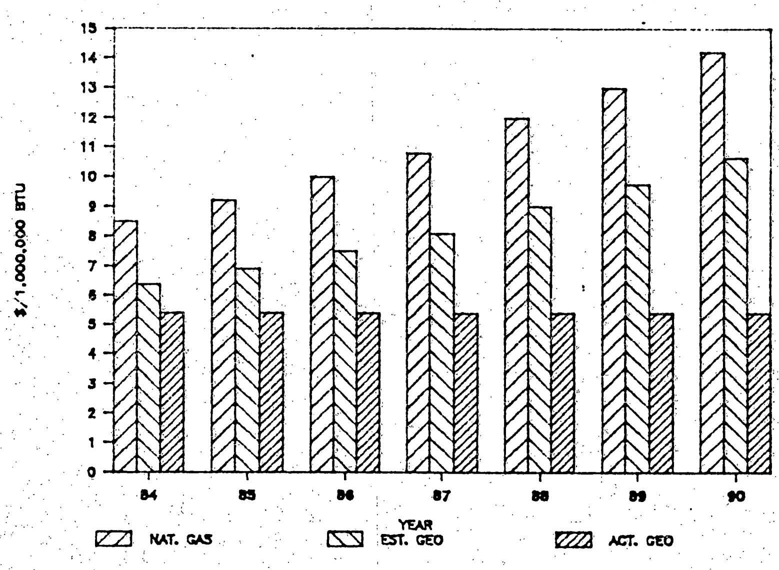
As noted earlier, no actual contact was made by SBMWD with the potential customers other than a site visit to inspect the mechanical systems prior to the project construction. The impact of this mistake was serious. The feasibility study attempted to predict a rate of geothermal expansion far beyond the actual growth now being experienced. The study predicted that geothermal

[1]Southern California Gas Company, Revised Rate Sheet #19086-G (Redlands, CA.: Southern California Gas Company, 1989), 1-2.

revenues would be $527,000 by the end of three full years of operation with 45 customers on line. Actual 1989 figures show $125,000 in revenues with 21 customers on line. During the first three years of operations the one limiting factor was that the construction of the Geothermal District Heating System's infrastructure was slow in getting under way. However, with this in mind, "the addition of new customers has been much slower than the study predicted."[1]

Figure 3

Assumed Natural Gas Costs and Geothermal Costs Vs. Actual Geothermal Costs



[1]Mr. Joe Stejskal, interview by author, March 1989, San Bernardino, California.

The projected price of natural gas was also in error. The projected price of natural gas was 40 percent higher than the actual price. In effect, the projected price of geothermal energy was in error by 40 percent. Even though operational cost estimates were accurate, the financial analysis in the feasibility study is no longer valid. With the projected number of users and the continuation of low cost natural gas, the Geothermal District Heating System now operates in a deficit. A break even year is now currently projected for 1991.

DEVELOPMENT OF A PROTO-TYPE PRICING POLICY

In this section, the criteria and alternatives are developed and discussed in detail. The criteria will then be used to evaluate each of the geothermal pricing alternatives.

Defining the Model

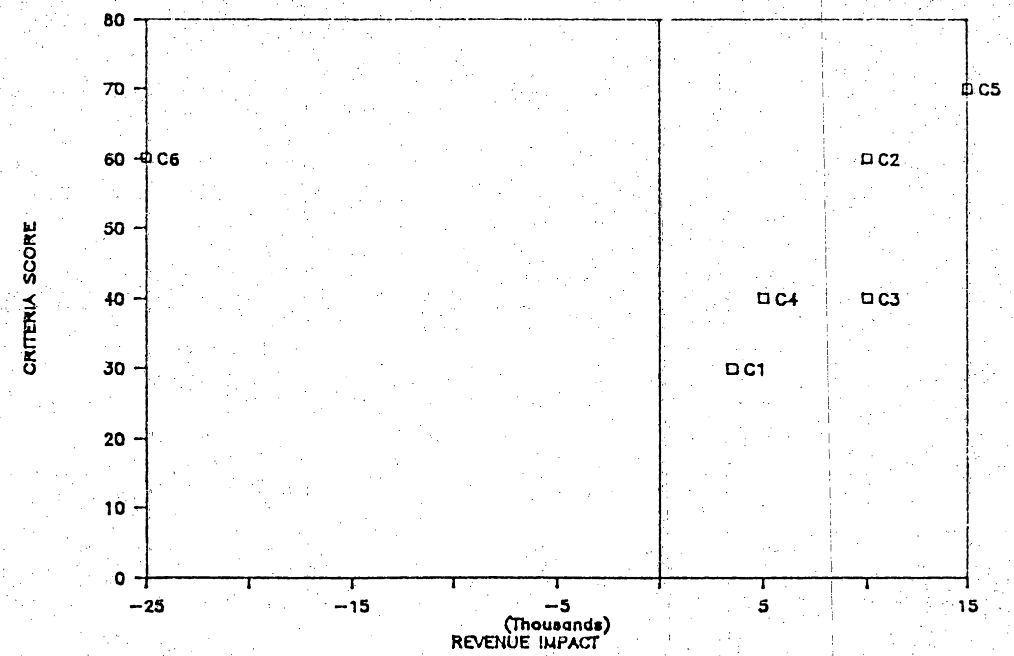
The model in which each all of the alternatives are to be evaluated is the San Bernardino Municipal Geothermal District Heating System. Each criterion was developed from the analysis of the impacts of the strengths and weaknesses of the geothermal pricing policy used in San Bernardino. The criteria will be used to address the strengths and weaknesses of alternative policies if they were to be implemented in San Bernardino.

Methodology

The methodology for the final acceptance of an alternative will involve the weighting of the total score of the criterion against the alternative's impact on the SBMWD geothermal revenue stream. The effectiveness of the pricing policy alternatives will be measured using the previous described criteria. The revenue impacts will be developed using the San Bernardino Municipal Geothermal Heating District as a model, and SBMWD staff to estimate the geothermal revenue stream impact of each alternative. The data obtained will be interpreted by graphing the costs against effectiveness. Figure 4 is a hypothetical depiction of how the data will be treated.

Figure 4

Hypothetical Criteria Totals Vs. Hypothetical Revenue Impacts



For example, C6 has a negative impact on the SBMWD revenue geothermal revenue stream and should not be selected as the most optimum choice. C5 has a positive impact on the revenue stream and rate the highest in the criterion analysis. Theoretically, C5 will have the best future impact of all the alternatives and should therefore be selected as the most optimum choice. A similar graph will be used in this analysis.

Defining the Criteria

Several of the strengths and weaknesses of the San Bernardino geothermal pricing policy have been identified. However, to assist in the selection of an optimum pricing policy, the following criteria have been developed to weigh the relative effectiveness of the alternative pricing policies. The criterion scores and the projected financial impacts shall be used to select the optimum pricing policy. The relative scoring weights of each criterion were set with a maximum score of 10 points and a minimum score of 0 points each.

The reason for setting the scores equal is that the relative importance of each criterion is the same. Although difficult to quantify, each criteria plays a role in measuring the future success that the policy will bring to the San Bernardino Geothermal District Heating System. An argument can be made that setting the points of each alternative equal may alter the true outcome of the final selection. However, the criteria also relate to the relative financial impact that the each policy will have, if implemented. For example, the first criterion states that if the policy allows the use of BTU meters then the score is 10 points; if not, the score is 0 points. The future of the Heating district is enhanced through the use of BTU meters; also, through the use of BTU meters the Heating District may add new customers, and therefore, increasing the District's revenues.

Recall that the financial impact of each policy is being graphed against the total criteria score on a scatter diagram and that the final selection will be the alternative that is found in the farthest NE point on the graph. Hence, the scoring of the criteria only raises the alternative in the north or positive Y direction, and a positive financial impact moves the alternative only in the east or positive X direction. Hence, any movement in the Y direction is partially attributed to the policy's relative impact to the financial impact to the revenue stream, (i.e. the criteria is partially measuring the same thing that is be measured on the x axis). Therefore, any error in criteria weighting is partially absorbed by the x axis score of estimated financial impacts.[1] Neither the criteria scores or the financial impact scores single handedly select the best alternative. If the selected alternative has a perfect criteria score and the best financial impact then the error cannot impact the accuracy of the final selection.

Previous discussion also stated that the use of BTU meters serves as an excellent marketing tool for the use

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[1]Mr. Stephen Weed, interview by author, June 1989, Riverside, California, telephone.

of geothermal energy. BTU meters allow the utility to take advantage of block rates and other creative pricing strategies. The criterion developed to address this issue is:

Criterion 1 (C1)
Does the pricing policy allow the use of a BTU meter?

Yes 10 points No 0 points

To remain competitive with natural gas there is a need to tie the price of the geothermal energy to the price of natural gas. This in turn will help the geothermal utility to also keep in step with inflation and remain competitive. The criterion developed to address this issue is:

Criterion 2 (C2)
Does the policy tie the price of the geothermal resource to the price of an alternative fuel?

Yes 10 points No 0 points

To stay competitive and "operating in the red" the price of the geothermal energy should be able to be reevaluated on a yearly basis. The criterion developed to address this issue is:

Criterion 3 (C3)
Can the price of the geothermal energy be changed in any given year?

Yes 10 points No 0 points

A policy that was flexible enough to allow the Heating District to give preferential treatment to curtain customers who made more effective and efficient use of the geothermal fluid would be more effective in ensuring the future existence of the Heating District than a policy that did not allow for customer preferential treatment. The criterion developed to address this issue is:

Criterion 4 (C4)
Is the policy flexible enough to allow for user preferential treatment?

In all cases	10 points
In about half of the cases	5 points
No flexibility	0 points

A policy would also be more effective if it allowed the Governing body to adjust the price of the geothermal energy any time of the year to remain more competitive with natural gas and to ensure that the geothermal revenue stream remains in tact. The criterion developed to address this issue is:

Criterion 5 (C5)
Is the date of the pricing re-evaluation steadfast or flexible?

Very flexible w/ no restrictions	10 points
Somewhat flexible w some restrictions	5 points
Steadfast (the evaluation date can not change)	0 points

Some potential geothermal customers do not warrant the cost of a BTU meter installation. A simple flow meter could be used to estimate the amount of energy consumed by the smaller customers. Therefore, a policy that allowed the use of both BTU meters and flow meters would be better than a policy that limited the use of one or the other. The criterion developed to address this issue is:

Criterion 6 (C6)
Are BTU meters flat rates or flow meters mandatory? (i.e. one and not the other)

Both can be used 10 points
BTU meter, Flow meter or flat rate only 0 points

There is a need for a criterion that would evaluate the alternative pricing policies on the merits of who would have ultimate control of the heating district's pricing structure. Pricing policies that place the evaluation of the geothermal resource price in the hands of a group equivalent to the San Bernardino Board of Water Commissioners would rate higher than an alternative that placed the pricing of the geothermal resource in the hands of a common council of community action group. The criterion developed to address this issue is:

Criterion 7 (C7)
Is the geothermal pricing policy left at the discretion of a water board or public works department with knowledge of the water industry?

Yes 10 points No 0 points

Defining The Alternatives

It is, at best, difficult to develop geothermal pricing policy alternatives. To assist in the development of the different pricing policies, it was necessary to survey the existing municipal geothermal heating districts to analyze existing geothermal pricing policies and, if possible, develop and analyze variations of each.

However, it is doubtful that the other district heating systems have an optimum pricing policy. According to Mr. Gene Culver of the Oregon Institute of Technology, Geo-Heat Center "There are few systems to use as guidelines, and the existing ones, for the most part, probably are not good examples to follow, and the operators are not experienced in developing strategies (pricing policies) as say natural gas or electric power utilities are. Also, geothermal systems are mostly unregulated so they haven't had to develop the structures that regulated utilities have."[1] Hence, it is likely that the optimum policy alternative will be a variation of the existing pricing policies that are now in effect.

The San Bernardino Geothermal Pricing Policy will be the first alternative to be analyzed. There are also several other pricing policy alternatives that can be developed based on some variation of the San Bernardino Geothermal Pricing Policy. Each of these variations can get quite complicated. Hence, the analysis process must be broken down into parts. Therefore, suboptimization is utilized.

In the public sector, "... it is inevitable that decision-making be divided, some decisions being made by

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[1]Mr. Gene Culver, interview by author, March 1989, Klamath Falls, Oregon, telephone.

high-level officials or groups, and some being delegated to lower levels."[1] All decisions cannot be made simultaneously by one official or group. In the public sector authority is divided and any given decision is likely to involve many different participants at various stages.

Many public problems are difficult to understand due to their complexity. Public problems are very dynamic in nature and very difficult to understand and analyze. For these reasons, "the process of analysis must be broken into parts; alternatives at all levels cannot be analyzed simultaneously."[2] The analyst is forced to shelve certain aspects of the problem while analyzing other aspects. This process of analysis is known as suboptimization. Since the analysis does not analyze all of the options simultaneously, the alternative selected as most preferred may be less than optimum. Basic variations of the San Bernardino geothermal pricing policy can be developed by only changing certain items in the existing policy. With all things being equal (ceteris paribus) only the effects of the changes will be evaluated. Each alternative was

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[1]Edward S. Quade, Analysis for Public Decisions, 2nd ed., (New York: North Holland, 1982), 210.

[2]Ibid.

developed to address the issues brought out in the strengths and weaknesses section of this research project. Hence, the "issues" are being addressed individually, i.e., suboptimization. Perhaps a better description would be that each alternative is a building block for the next alternative.

The second geothermal pricing policy is a variation of the San Bernardino Geothermal Pricing Policy. However, this alternative will not require the sole use of BTU meters. This alternative will allow both BTU meters or simple low cost flow meters for billing purposes. The flow meters will only be able to <u>estimate</u> the level of <u>consumed usable therms.</u> The wording of the policy is as follows:

Alternative 2 (A2) GEOTHERMAL RATE

The following rate shall be charged for all geothermal service for domestic, commercial, or industrial use within the City of San Bernardino, or any other purpose for which no other rate is specified.

This rate shall be established at a price per usable therm set at 75 percent (75%) of the price of natural gas on November 1983, for the period through December 31, 1984. This geothermal rate is $0.54 per <u>estimated usable therm.</u>

Thereafter, in accordance with the provisions of the applicable San Bernardino City Ordinance, the rate per usable therm will be established each year by the San Bernardino Board of Water Commissioners at a price effective on the first day of January of each year, commencing 1985, which will not exceed 75 percent (75%) of the natural gas as of that date.

Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application which uses totally the temperature difference between normal groundwater temperature (64 ^{O}F) and the geothermal temperature at the service point.

Like A2, Alternative 3 is a variation of the San Bernardino Geothermal Pricing Policy. This alternative is identical to the second alternative which allows the use of BTU meters and Flow meters, with the exception of a mandatory price evaluation period. Unlike A1 and A2, the price evaluation of the geothermal resource shall be allowed as often as necessary at the discretion of the BOWC. The wording for alternative 3 is as follows:

Alternative 3 (A3) GEOTHERMAL RATE

The following rate shall be charged for all geothermal service for domestic, commercial, or industrial use within the City of San Bernardino, or any other purpose for which no other rate is specified.

This rate shall be established at a price per usable therm set at 75 percent (75%) of the price of natural gas on November 1983, for the period through December 31, 1984. This geothermal rate is $0.54 per <u>estimated usable therm.</u>

Thereafter, in accordance with the provisions of the applicable San Bernardino City Ordinance, <u>the rate per assumed usable therm</u> will be established <u>as necessary at the discretion of</u> the San Bernardino Board of Water Commissioners at a price which will not exceed 75 percent (75%) of the natural gas.

Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application which uses totally the temperature difference between normal groundwater temperature (64 ^{O}F) and the geothermal temperature at the service point.

Alternative 4 is identical to A3 with the exception of the 75 percent pricing schedule. In this alternative the BOWC sets the price of the geothermal resource independent of the price of any other utility. The wording of alternative 4 is as follows:

Alternative 4 (A4) GEOTHERMAL RATE

The following rate shall be charged for all geothermal service for domestic, commercial, or industrial use within the City of San Bernardino, or any other purpose for which no other rate is specified.

This rate shall be established at an equitable rate at the discretion of the Board of Water Commissioners. This geothermal rate is $0.54 per estimated usable therm.

Thereafter, in accordance with the provisions of the applicable San Bernardino City Ordinance, the rate per assumed usable therm will be established as necessary at the discretion of the San Bernardino Board of Water Commissioners.

Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application which uses totally the temperature difference between normal groundwater temperature (64 ^{o}F) and the geothermal temperature at the service point.

Alternative 5 is based on the Boise Geothermal Heating District. "The City of Boise discounts 30% below the prevailing price of natural gas. The assumptions are that geothermal is 100 percent efficient. The therm rate for geothermal is discounted 30 percent. Additionally, the City of Boise's pricing structure assumes that a geothermal customer will take 50 ^{o}F from the water delivered to the premises."[1] All things held equal, this alternative is identical to the San Bernardino Pricing Policy with the exception of measuring usable therms. The wording of the policy is as follows:

Alternative 5 (A5) GEOTHERMAL RATE

The following rate shall be charged for all geothermal service for domestic, commercial, or industrial use within the City of San Bernardino, or any other purpose for which no other rate is specified.

This rate shall be established at a price per usable therm set at 75 percent (75%) of the price of natural gas on November 1983, for the period through December 31, 1984. This geothermal rate is $0.54 per <u>assumed usable therm. It is assumes that the customer will strip a minimum of 50 °F from the geothermal fluid.</u>

Thereafter, in accordance with the provisions of the applicable San Bernardino City Ordinance, <u>the rate per assumed usable therm</u> will be established each year by the San Bernardino Board of Water Commissioners at a price effective on the first day of January of each year, commencing 1985, which will not exceed 75 percent (75%) of the natural gas as of that date.

Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application

which uses totally the temperature difference between normal groundwater temperature (64 °F) and the geothermal temperature at the service point.

Alternative 6 is identical to A5 with the exception of the once a year rule. In this alternative the BOWC can set the price of the geothermal energy as often as necessary. The wording for alternative 6 is as follows:

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[1]Mr. Chuck Mikelson, interview by author, March 1989, Boise, Idaho, written response.

Alternative 6 (A6) GEOTHERMAL RATE

The following rate shall be charged for all geothermal service for domestic, commercial, or industrial use within the City of San Bernardino, or any other purpose for which no other rate is specified.

This rate shall be established at a price per usable therm set at 75 percent (75%) of the price of natural gas on November 1983, for the period through December 31, 1984. This service for domestic, commercial, or industrial use within the City of San Bernardino, or any other purpose for which no other rate is specified.

This rate shall be established at a price per usable therm set at 75 percent (75%) of the price of natural gas on November 1983, for the period through December 31, 1984. This geothermal rate is $0.54 per <u>assumed usable therm. It is assumes that the customer will strip a minimum of 50 ^{o}F from the geothermal fluid.</u>

Thereafter, in accordance with the provisions of the applicable San Bernardino City Ordinance, <u>the rate per assumed usable therm</u> will be established <u>as necessary at the discretion of</u> the San Bernardino Board of Water Commissioners at a price which will not exceed 75 percent (75%) of the natural gas.

Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application which uses totally the temperature difference between normal groundwater temperature (64 ^{o}F) and the geothermal temperature at the service point.

<u>Evaluation of the Alternatives</u>

This section of the paper is the evaluation of each alternative. The evaluation will analyze the criteria points and the financial impact of each alternative on the SBMWD revenue stream. A summary table detailing each of the criteria totals is at the end of each evaluation.

Evaluation of Alternative 1 (A1)

The first alternative is the existing San Bernardino Municipal Geothermal Heating District Pricing Policy.

The San Bernardino Pricing Policy uses BTU meters. The use of BTU meters enhances the District's marketing effort. Therefore the points for C1 is 10 points.

The San Bernardino Pricing Policy ties the price of the geothermal resource to the price of natural gas, which assures that the price of the geothermal resource will be in step with inflation and still be competitive. The score for C2 is 10 points.

The San Bernardino Pricing Policy does allow for the re-evaluation of the geothermal resource once a year. This assures that the Heating District can lower or raise its rates to remain competitive and still keep the rate high enough to absorb all operational costs. The score for C3 is 10 points.

The San Bernardino Pricing Policy does allow for preferential treatment of customers. SBMWD can use the vagueness of the 75 percent pricing rule. SBMWD can decide whether to use or not to use the inclining or declining block scales that the gas company would use. This pricing scheme could be used in all cases. Therefore, the score for C1 is 10 points.

The San Bernardino Pricing Policy specifies that the BOWC is only allowed to reevaluate and change the price of the geothermal energy only once a year on January 1st. Therefore, the gas utility could raise the price of natural gas after January 1st and lower it again prior to January 1st of the next year. This would in turn reduce to possible revenues of the Heating District. Since the re-evaluation date is steadfast the score for C5 is 0 points.

The San Bernardino Pricing Policy allows only the use of BTU meters. BTU meters are very expensive and some customers do not warrant this cost. Hence, the rule of requiring the utility to measure "usable therms" may be hampering the future growth of the utility. Since this alternative requires BTU meters, the score for C6 is 0 points.

The San Bernardino Geothermal Pricing Policy States that the BOWC is the guiding board of the Geothermal District Heating System. Hence, their experience in the water "moving" industry will benefit the utility in its pricing strategies. Therefore, the score for C7 is 10 points.

Costs of Implementing A1

Since the San Bernardino Municipal Geothermal Heating District is the model in which the policy is to be used, the cost of implementation will be estimated as relative impacts to the Utility's revenues. For example, A1 is now being implemented in the San Bernardino Geothermal

District Heating System and the current revenue stream is $125,000/year.[1] Therefore the cost of implementation holds the revenue stream at $125,000/year. The following alternatives will either raise or lower the revenue stream based on each of their financial impacts to the Geothermal Revenue Stream.

Table 1

Alternative 1 (A1) Summary

Criteria		Points
C1	Does policy allow BTU meters?	10 pts
C2	Is geothermal price tied to natural gas?	10 pts
C3	Can geothermal price be changed in any given year?	10 pts
C4	Does flexible to all for user preferential treatment?	10 pts
C5	Is re-evaluation date flexible or steadfast?	0 pts
C6	Are BTU meters or Flow meters mandatory? (i.e. one and not the other.)	0 pts
C7	Is the pricing policy at the discretion of the BOWC?	10 pts
	Total	50 pts
	Adjusted Revenue Stream	$125,000

[1]Mr. Joeseph Stejskal, interview by author, March 1989, San Bernardino, California.

Evaluation of Alternative 2 (A2)

The second geothermal pricing policy is a variation of the San Bernardino Geothermal Pricing Policy. This alternative will not require BTU meters alone. This alternative will allow both BTU meters or simple low cost flow meters for billing purposes. The flow meters will only be able to estimate the level of consumed usable therms.

Like the San Bernardino Geothermal Pricing Policy this alternative pricing policy does use BTU meters. This is unchanged from A1. Therefore the points for C1 is 10 points.

For this criterion, A2 is unchanged from A1. The score for C2 is 10 points.

The second pricing alternative is unchanged from the first which does allow for the re-evaluation of the geothermal resource once a year. The score for C3 is 10 points.

The second pricing policy is unchanged from the San Bernardino Pricing Policy which allows for preferential treatment to customers. Therefore, the score for C4 is 10 points.

A2 is unchanged from the San Bernardino Pricing Policy which specifies that the BOWC are only allowed to reevaluate and change the price of the geothermal energy only once a year on January 1st. Since the re-evaluation date is still steadfast the score for C5 is 0 points.

The only difference between the A1 and A2 is that A1 allows only the use of BTU meters. A2 allows the use of BTU meters and Flow meters. A1 requires the utility to measure "usable therms" which may in turn be hampering the future growth of the utility. Since A2 allows the use of BTU meters or simple flow meters, the score for C6 is 10 points.

A2 is no different than A1, the San Bernardino Geothermal Pricing Policy, which states that the BOWC is the guiding board of the Geothermal District Heating System. Therefore, the score for C7 is 10 points.

<u>Costs Of Implementing A2</u>

According to the SBMWD staff, the are only a few customers that could take advantage of this type of a pricing alternative. The customers would be small restaurants and fast food establishments. The increase in cast flow to SBMWD would be in the range of $10,000 per year raising the cash flow from $125,000 per year to $135,000 per year.[1]

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[1]Ibid.

Table 2

Alternative 2 (A2) Summary

Criteria		Points
C1	Does policy allow BTU meters?	10 pts
C2	Is geothermal price tied to natural gas?	10 pts
C3	Can geothermal price be changed in any given year?	10 pts
C4	Does flexible to all for user preferential treatment?	10 pts
C5	Is re-evaluation date flexible or steadfast?	0 pts
C6	Are BTU meters or Flow meters mandatory? (i.e. one and not the other.)	10 pts
C7	Is the pricing policy at the discretion of the BOWC?	10 pts
	Total	60 pts
	Adjusted Revenue Stream	$135,000

Evaluation of Alternative 3 (A3)

Like A2, A3 is a variation of the San Bernardino Geothermal Pricing Policy. This alternative will be identical to A2, which allows the use of either BTU meters or simple flow meters, with the exception of a mandatory price re-evaluation period. Unlike A1 and A2, A3 allows for a re-evaluation of the price of the geothermal resource as often as necessary at the discretion of the BOWC.

Like A1 and A2, A3 does use BTU meters. This is unchanged from the first two alternatives. Therefore the points for C1 is 10 points.

This remains unchanged from the first two alternatives. The score for C2 is 10 points.

This remains unchanged from the first two pricing policies. The first three alternatives allow for the re-evaluation of the price of the geothermal resource once a year. The score for C3 is 10 points.

The third pricing policy is unchanged from the first two pricing policy alternatives. All three policies allow for preferential treatment to customers. Therefore, the score for C4 is 10 points.

Here is where A3 is different form A1 and A2, which specify that the BOWC are only allowed to reevaluate and change the price of the geothermal energy only once a year on January 1st. A3 allows for the re-evaluation of the geothermal pricing structure at any time during the year. Since the re-evaluation date is no longer steadfast the score for C5 is 10 points.

The only difference between A1 and A2 is that the San Bernardino Pricing Policy allows only the use of BTU meters. Like A2, A3 also allows the use of BTU meters and flow meters. The San Bernardino Pricing Policy requires the utility to measure "usable therms" which may in turn be hampering the future growth of the utility. Since A3 allows the use of BTU meters and simple flow meters, the score for C6 is 10 points.

A3 is no different than A1 and A2, which state that the BOWC is the guiding board of the Geothermal District Heating System. Therefore, the score for C7 is 10 points.

<u>Costs of Implementing A3</u>

Not only does A3 have the increased advantage of allowing BTU meters and simple flow meters as discussed for A2, but it has the added advantage of allowing the BOWC to re-evaluate the price of the geothermal resource at the BOWC discretion. This alternative prevents the natural gas authority from raising its utility costs just after the BOWC has re-evaluated the price of geothermal energy. For example, A1 and A2 only allow the BOWC to re-evaluate the price of the geothermal utility based on the January 1st natural gas costs. The gas utility could raise the price of natural gas 5 percent on January 2nd. In San Bernardino the price of the geothermal utility is currently set at 75 percent the price of natural gas. Therefore the SBMWD could lose 75 percent of the allowable 5 percent increase. In monetary terms, if this policy was implemented the revenue stream would be increased from

$135,000 per year to $140,000 per year.[1]

Table 3

Alternative 3 (A3) Summary

Criteria		Points
C1	Does policy allow BTU meters?	10 pts
C2	Is geothermal price tied to natural gas?	10 pts
C3	Can geothermal price be changed in any given year?	10 pts
C4	Does flexible to all for user preferential treatment?	10 pts
C5	Is re-evaluation date flexible or steadfast?	10 pts
C6	Are BTU meters or Flow meters mandatory? (i.e. one and not the other.)	10 pts
C7	Is the pricing policy at the discretion of the BOWC?	10 pts
	Total	70 pts
	Adjusted Revenue Stream	$140,000

<u>Evaluation of Alternative 4 (A4)</u>

A4 is identical to A3 with the exception of the 75 percent pricing schedule. In this alternative the BOWC sets the price of the geothermal utility independent of the price of any other utility. The BOWC would set the

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[1]Ibid.

price of the geothermal resource in accordance with natural gas but would not tie the price of the resource directly to the going rate for natural gas.

Like the first three alternatives A4 uses BTU meters. Therefore the points for C1 is 10 points.

A4 is identical to A3 with the exception of linking the rate of the geothermal resource to the price of natural gas. This alternative does not tie the price of the geothermal resource to natural gas. Therefore the score for C2 is 0 points.

This remains unchanged from the first three pricing policies. The first four alternatives allow for the re-evaluation of the price of the geothermal resource a minimum of once a year. The score for C3 is 10 points.

A4 is unchanged from the first three pricing policy alternatives. All four policies allow for preferential treatment to customers. Therefore, the score for C4 is 10 points.

Unlike the first two policies the A3 and A4 specify that the BOWC are allowed to reevaluate the geothermal pricing structure at any time during the year. Since the re-evaluation date is no longer steadfast the score for C5 is 10 points.

Like A2 and A3, A4 allows the use of BTU meters and flow meters. The San Bernardino Pricing Policy requires the utility to measure "usable therms" which may in turn be hampering the future growth of the utility. Since A4 allows the use of BTU meters and simple flow meters, the score for C6 is 10 points.

A4 is no different than A1, A2 or A3, which state that the BOWC is the guiding board of the Geothermal District Heating System. Therefore, the score for C7 is 10 points.

Costs of Implementing A4

A4 has the advantages of A1, A2 and A3. However, A4 no longer ties the geothermal revenues to the price of natural gas as do the first three alternatives. The criterion counts this as a disadvantage since some customers may be unwilling to switch to geothermal energy without some constraints that would keep the price of geothermal energy under the price of natural gas. According to the SBMWD staff this could has effected two customers in the system. The financial impact of these two customers would be $40,000 per year. The revenue stream would be reduced from $140,000 per year to $100,000 per year.[1]

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[1]Ibid.

Table 4

Alternative 4 (A4) Summary

Criteria		Points
C1	Does policy allow BTU meters?	10 pts
C2	Is geothermal price tied to natural gas?	0 pts
C3	Can geothermal price be changed in any given year?	10 pts
C4	Does flexible to all for user preferential treatment?	10 pts
C5	Is re-evaluation date flexible or steadfast?	10 pts
C6	Are BTU meters or Flow meters mandatory? (i.e. one and not the other.)	10 pts
C7	Is the pricing policy at the discretion of the BOWC?	10 pts
	Total	60 pts
	Adjusted Revenue Stream	$100,000

Evaluation of Alternative 5 (A5)

A5, based on the Boise Idaho Geothermal Pricing Policy, uses assumed geothermal energy consumption rates for each customer using a flow meter or orifice plate. This policy is similar to the San Bernardino Pricing Policy with the exception of measuring usable therms.

Unlike the San Bernardino Pricing Policy, A1, A5 does not use BTU meters. Therefore the points for C1 is 0 points.

This policy does attempt to tie the price of the geothermal fluid to the price of natural gas. The score for C2 is 10 points.

A5 is similar to the San Bernardino Pricing Policy with respect to the re-evaluation of the price of the geothermal heat. A5 does allow for the re-evaluation of the geothermal resource once a year. The score for C3 is 10 points.

Like the San Bernardino Pricing Policy, A5 also allows for preferential treatment to customers. Therefore, the score for C4 is 10 points.

A5 specifies that the BOWC are only allowed to reevaluate and change the price of the geothermal energy only once a year on January 1st. Since the re-evaluation date is steadfast the score for C5 is 0 points.

A5 allows only the use of flow meters. Flow meters only estimate the energy intake of the facility. Since this alternative requires only flow meters or orifice plates, the score for C6 is 0 points.

A5 states that the BOWC is the guiding board of the Geothermal District Heating System. Hence, their experience in the water "moving" industry will benefit the utility in its pricing strategies. Therefore, the score for C7 is 10 points.

Costs of Implementing A5

The impact of the costs involved with the implementation of A5 are difficult to quantify. It can however be assumed that the financial impact would be positive. Similar to A2 this alternative would allow the smaller customers to take advantage of the geothermal resource. This would add some small restaurants and fast food establishments to he system. The increase in revenue is estimated to be about $10,000 per year. However, the marketing effort of the district may be impaired since there are is no BTU utilization. It has been stated that BTU meters are an excellent marketing device. If the staff maintained an aggressive marketing effort, it would be doubtful if any customers would be lost due to no BTU meter utilization. There the revised geothermal revenue stream would be $135,000 per year.[1]

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[1]Ibid.

Table 5

Alternative 5 (A5) Summary

Criteria		Points
C1	Does policy allow BTU meters?	0 pts
C2	Is geothermal price tied to natural gas?	10 pts
C3	Can geothermal price be changed in any given year?	10 pts
C4	Does flexible to all for user preferential treatment?	10 pts
C5	Is re-evaluation date flexible or steadfast?	0 pts
C6	Are BTU meters or Flow meters mandatory? (i.e. one and not the other.)	0 pts
C7	Is the pricing policy at the discretion of the BOWC?	10 pts
	Total	40 pts
	Adjusted Revenue Stream	$135,000

Evaluation of Alternative 6 (A6)

A6 is identical to the A5 with the exception of the once a year rule. In this alternative the BOWC can set the price of the geothermal energy as often as necessary.

Similar to A5, A6 does not use BTU meters. Therefore the points for C1 is 0 points.

Similar to A5, A6 also ties the price of the geothermal resource to the price of natural gas. The score C2 is 10 points.

Like A5, the re-evaluation of the geothermal price can be re-evaluated at by the BOWC. The score for C3 is 10 points.

Like the San Bernardino Pricing Policy, A5 and A6 are flexible enough to allow for preferential treatment to customers. Therefore, the score for C4 is 10 points.

Unlike the fifth alternative, the re-evaluation of the geothermal price can be re-evaluated at the discretion of the BOWC any time of the year when necessary. The score for C5 is 10 points.

A6 allows only the use of flow meters or orifice plates. Flow meters are not as an effective marketing tool as are BTU meters. Since this alternative requires only flow meters, the score for C6 0 points.

A6 states that the BOWC is the guiding board of the Geothermal District Heating System. Hence, their experience in the water "moving" industry will benefit the utility in its pricing strategies. Therefore, the score for C7 is 10 points.

<u>Costs of Implementing A6</u>

The impact of the costs involved with the implementation of A6 are difficult to quantify. It can however be assumed that the financial impact would be positive. Similar to A2 and A5, this alternative would allow the smaller customers to take advantage of the geothermal resource. This would add some small restaurants and fast food establishments to he system. The increase in revenue is estimated to be about $10,000 per year. However, the marketing effort of the district may be impaired since there are is no BTU utilization. It has been stated that BTU meters are an excellent marketing device. If the staff maintained an aggressive marketing effort, it would be doubtful that any customers would be lost due to no BTU meter utilization. Since the BOWC could also better track the price of natural gas the geothermal system would not be in the position to lose funds if the gas utility lowered its price after January 1st. However, this problem has not yet occurred in the San Bernardino Model so the financial impact is $0. However, by adding the smaller customers the revised revenue stream would be $135,000 per year.[1]

[1]Ibid.

Table 6

Alternative 6 (A6) Summary

Criteria		Points
C1	Does policy allow BTU meters?	0 pts
C2	Is geothermal price tied to natural gas?	10 pts
C3	Can geothermal price be changed in any given year?	10 pts
C4	Does flexible to all for user preferential treatment?	10 pts
C5	Is re-evaluation date flexible or steadfast?	10 pts
C6	Are BTU meters or Flow meters mandatory? (i.e. one and not the other.)	0 pts
C7	Is the pricing policy at the discretion of the BOWC?	10 pts
	Total	50 pts
	Adjusted Revenue Stream	$135,000

Selection of the Optimum Pricing Policy

The following Table 7 shows the results of the evaluations of each alternative.

Table 7

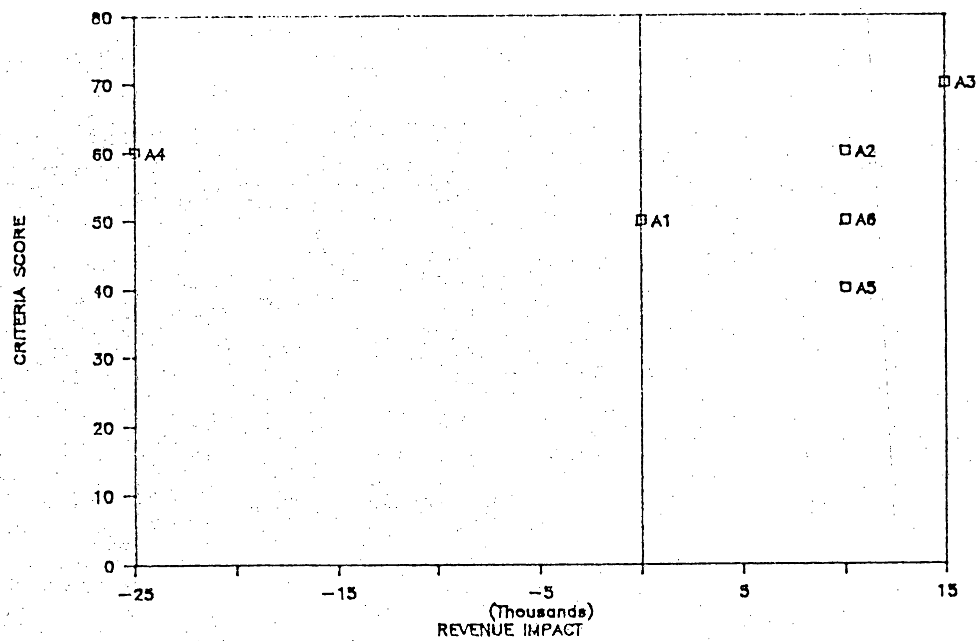
Results of the Criterion Evaluation and Financial Impacts to the Geothermal Revenue Stream

Criterion	Alternative Number					
	A1	A2	A3	A4	A5	A6
C1	10	10	10	10	0	0
C2	10	10	10	0	10	10
C3	10	10	10	10	10	10
C4	10	10	10	10	10	10
C5	0	0	10	10	0	10
C6	0	10	10	10	0	0
C7	10	10	10	10	10	10
Totals	50	60	70	60	40	50
Revised Revenue	125K	135K	140K	100K	135K	135K
Impact	0K	10K	15K	-25K	10K	10K

Note that A3 has the highest criterion rating and the most favorable impact on the San Bernardino Geothermal Revenue Stream. Figure 5 shows A3 at the farthest NE corner of the scatter diagram. This is a graphic representation which shows A3 as the most preferred. Like the second alternative, A3 is a variation of the San Bernardino Geothermal Pricing Policy. With the exception of a mandatory price re-evaluation period, this alternative is identical to the second alternative, which allows the use of either BTU meters or simple flow meters. However, unlike the A1 and A2, A3 allows, at the discretion of the BOWC, a re-evaluation of the price of the geothermal resource as often as necessary. A3 is selected as the optimum geothermal pricing policy for the San Bernardino Municipal Geothermal Heating District.

Figure 5

Scatter Diagram Results
of the Criteria Evaluation and
Financial Impact to the Geothermal Revenue Stream



CONCLUSION

Prior to this research project there were only a few attempts to document the current pricing trends of geothermal energy in the western states. However, there were no significant attempts to identify the pricing policies that would adequately identify or address the optimum retail price of directly consumed geothermal energy. This research project applied policy analysis to analyze the development of San Bernardino's current pricing policy, describe the current pricing policy, evaluate its advantages and disadvantages and propose a new proto-type pricing policy. Variations of the San Bernardino Geothermal Pricing Policy and other geothermal pricing policies served as alternatives to San Bernardino's pricing policy in the analysis and policy development sections of this research project.

The alternatives were developed from an in-depth analysis of the San Bernardino Pricing Policy. The analysis identified several strengths and weaknesses in the San Bernardino Policy. A set of criteria was developed that would address these strengths and weaknesses. The alternatives were then developed as variations of the San Bernardino Pricing Policy and weighted using the developed criteria. Each of the alternatives were also analyzed to estimate their financial impact on the existing San Bernardino Geothermal revenue stream, if implemented. With the criteria data and financial impact estimates complete, the most preferred pricing policy was selected.

The selection of a preferred policy was made by plotting the criteria totals of each alternative against each anticipated financial impact. Hence, the most preferred alternative would be the alternative found in the upper most right hand corner of the graph. This alternative would have the best financial impact on the revenue stream or the highest criterion score. In this case the best pricing policy, A3, had both the best financial impact and the highest criterion score. Having a perfect criteria score also left no concern for error in the placing of values for the individual criteria.

A3 is a variation of the San Bernardino Geothermal Pricing Policy. This alternative is identical to A2 which allowed the use of BTU meters and flow meters. However, unlike A1 and A2, A3 does not limit the number of times that the BOWC can reevaluate the price of the geothermal resource. A3 allows the reevaluation of the price as often as necessary at the discretion of the BOWC.

Alternative 3 GEOTHERMAL RATE

The following rate shall be charged for all geothermal service for domestic, commercial, or industrial use within the City of San Bernardino, or any other purpose for which no other rate is specified.

This rate shall be established at a price per usable therm set at 75 percent (75%) of the price of natural gas on November 1983, for the period through December 31, 1984. This geothermal rate is $0.54 per estimated usable therm.

Thereafter, in accordance with the provisions of the applicable San Bernardino City Ordinance, the rate per assumed usable therm will be established as necessary at the discretion of the San Bernardino Board of Water Commissioners at a price which will not exceed 75 percent (75%) of the natural gas.

Procedures are established to provide for preferential costs to those users who utilize and extract the largest amount of heat from the geothermal water. For purposes of clarification, the most efficient application is an application which uses totally the temperature difference between normal groundwater temperature (64 oF) and the geothermal temperature at the service point.

The steps leading to the implementation of this pricing policy would be relatively simple. Acceptance of A3 by the Board of Water Commissioners and the public, via a public hearing, would complete the process. This appears simple but may not be easy to accomplish. Public officials face a dilemma; they may fully understand the advantages of using an analytic approach to solving or addressing a policy issue, but at the same time the realities of politics must be faced. The adoption of A3 requires a public hearing. The public may not like the Water Department changing polices, even for the better, due to mistrust or some other issue. Even though the BOWC does not consist of elected officials, they answer to elected officials, the City Council. Hence, the decisions of the BOWC are under the scrutiny of the City Council. A public outcry could prevent the implementation of the alternative.

To avoid a controversy, it is necessary that the public hearing address the positive issues of the rate structure, such as the use of flow meter to allow smaller customers the use of geothermal energy and ensuring a sharper competitive edge towards the Gas company by allowing the BOWC the ability to reevaluate the pricing structure as often as the BOWC finds it necessary. The fact that the BOWC would have this new ability may have negative overtones. However, by reminding the public that the price of the utility can be only as high as 75 percent of the price of natural gas should circumvent any hostility. Alternative 3 is similar to the current policy that is now being used set the maximum price of the geothermal resource at 75 percent the price of natural gas. Therefore, in reality, there has been little change in the policy concerning the reevaluation of the maximum geothermal rate.

In conclusion, through the use of policy analysis, the San Bernardino Geothermal Pricing Policy was evaluated. This evaluation led to the development of a proto-type geothermal pricing policy, which, if implemented in the San Bernardino Municipal Geothermal District Heating System or similar system, would be effective in assuring system expansion and customer satisfaction.

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APPENDIX A (Feasibility Study Financial Analysis)

CATEGORY		PRESENT VALUE DISCOUNTED	INVESTMENT SUMMARY
MANAGEMENT	$	89,991	
RESEARCH		92,774	
DESIGN		89,991	
WELL FIELD		329,349	
TRANSMISSION		0	
DELIVERY :			
DISTRIBUTION		1,949,189	
HOOKUP		0	
RETROFIT		0	
HEAT EXCH		0	
TOTAL	$	2,551,294	

CATEGORY		PRESENT VALUE UNDISCOUNTED	INVESTMENT SUMMARY
MANAGEMENT	$	97,000	
RESEARCH		100,000	
DESIGN		97,000	
WELL FIELD		355,000	
TRANSMISSION		0	
DELIVERY :			
DISTRIBUTION		2,101,000	
HOOKUP		0	
RETROFIT		0	
HEAT EXCH		0	
TOTAL	$	2,750,000	

SHARP Investment Summary

SALES DEMAND
(MILLION BTU / YEAR)

YEAR	USER CONSUMPTION	CITY SALES POTENTIAL
1983	2,228,571,429	1,560,000,000
1984	75,330,000,006	52,731,000,004
1985	127,630,000,011	89,341,000,008
1986	127,630,000,011	89,341,000,008
1987	127,630,000,011	89,341,000,008
1988	127,630,000,011	89,341,000,008
1989	127,630,000,011	89,341,000,008
1990	127,630,000,011	89,341,000,008
1991	127,630,000,011	89,341,000,008
1992	127,630,000,011	89,341,000,008
1993	127,630,000,011	89,341,000,008
1994	127,630,000,011	89,341,000,008
1995	127,630,000,011	89,341,000,008
1996	127,630,000,011	89,341,000,008
1997	127,630,000,011	89,341,000,008

SHARP Total Demand Summary

YEAR	MANAGEMENT	+ OPERATIONS	+ ELECTRICITY	= TOTAL EXPENSES
1	0	5,404	29,942	35,346
2	24,983	5,485	45.053	75,521
3	25,358	38,522	57,532	121,412
4	25,738	39,100	60,409	125,247
5	26,124	39,687	63,430	129,241
6	26,516	40,282	66,601	133,399
7	26,914	40,886	69,931	137,731
8	27,318	41,499	73,428	142,245
9	27,727	42,122	77,099	146,948
10	28,143	42,754	80,954	151,851
11	28,565	43,395	85,002	156,962
12	28,994	44,046	89,252	162,292
13	29,429	44,707	93,715	167,850
14	29,870	45,377	98,400	173,648
15	30,318	46,058	103,320	179,696

YEAR	INCOME	- EXPENSES	- AMORTIZATION	= NET CASHFLOW
1	7,441	35,346	0	¯27,905
2	251,526	75,521	0	176.005
3	624,493	121,412	469,499	33.582
4	671,844	125,247	469,499	77.098
5	722,768	129,241	469,499	124.028
6	792,454	133,399	469,499	189.556
7	867,501	137,731	469,499	260.270
8	955,948	142,245	469,499	344,204
9	1,045,289	146,948	469,499	428,842
10	1,150,712	151,851	469,499	529.361
11	1,255,241	156,962	469,499	1,098.279
12	1,383,892	162,292	0	1,221.600
13	1,537,558	167,850	0	1,369.708
14	1,699,265	173,648	0	1,525.617
15	1,877,947	179,696	0	1,698.251

SHARP Operating Cost Summary (Low Case)

YEAR	MANAGEMENT	+ OPERATIONS	+ ELECTRICITY	= TOTAL EXPENSES
1	0	5,404	29,942	35,346
2	24,983	5,485	45,053	75,521
3	25,358	38,522	57,532	121,412
4	25,738	39,100	60,409	125,247
5	26,124	39,687	63,430	129,241
6	26,516	40,282	66,601	133,399
7	26,914	40,886	69,931	137,731
8	27,318	41,499	73,428	142,245
9	27,727	42,122	77,099	146,948
10	28,143	42,754	80,954	151,851
11	28,565	43,395	85,002	156,962
12	28,994	44,046	89,252	162,292
13	29,429	44,707	93,715	167,850
14	29,870	45,377	98,400	173,648
15	30,318	46,058	103,320	179,696

YEAR	INCOME	- EXPENSES	- AMORTIZATION	= NET CASHFLOW
1	7,441	35,346	0	-27,905
2	251,526	75,521	0	176,005
3	624,493	121,412	543,947	-40,866
4	671,844	125,247	543,947	2,650
5	722,768	129,241	543,947	49,580
6	792,454	133,399	543,947	115,108
7	867,501	137,731	543,947	185,822
8	955,948	142,245	543,947	269,756
9	1,045,289	146,948	543,947	354,394
10	1,150,712	151,851	543,947	454,913
11	1,255,241	156,962	0	1,098,279
12	1,383,892	162,292	0	1,221,600
13	1,537,558	167,850	0	1,369,708
14	1,699,265	173,648	0	1,525,617
15	1,877,947	179,696	0	1,698,251

SHARP Operating Cost Summary (High Case)

YEAR	PRINCIPLE	+ INTEREST	= TOTAL PMT
1	0	0	0
2	0	0	0
3	263,249	206,250	469,499
4	282,993	186,506	469,499
5	304,217	165,281	469,499
6	327,033	142,465	469,499
7	351,561	117,937	469,499
8	377,928	91,570	469,499
9	406,273	63,226	469,499
10	436,743	32,755	469,499
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0

UNDISCOUNTED

YEAR	NET ANNUAL CASHFLOW	CUMULATIVE CASHFLOW
1	¯27,905	¯27,905
2	176,005	148,100
3	33,582	181,682
4	77,098	258,780
5	124,028	382,808
6	189,556	572,364
7	260,270	832,634
8	344,204	1,176,838
9	428,842	1,605,680
10	529,361	2,135,041
11	1,098,279	3,233,320
12	1,221,600	4,454,920
13	1,369,708	5,824,628
14	1,525,617	7,350,245
15	1,698,251	9,048,496

UNDISCOUNTED

YEAR	NET ANNUAL CASHFLOW	CUMULATIVE CASHFLOW
1	¯25,889	¯25,889
2	151,489	125,600
3	26,816	152,416
4	57,116	209,532
5	85,243	294,775
6	120,866	415,641
7	153,964	569,605
8	188,903	758,508
9	218,348	976,856
10	250,052	1,226,908
11	481,304	1,708,213
12	496,665	2,204,878
13	516,643	2,721,521
14	533,871	3,255,392
15	551,341	3,806,734

DISCOUNTED

SHARP Cashflow Summary (Low Case)

YEAR	PRINCIPLE	+ INTEREST	= TOTAL PMT
1	0	0	0
2	0	0	0
3	227,697	316,250	543,947
4	253,882	290,064	543,947
5	283,078	260,868	543,947
6	315,633	228,314	543,947
7	351,930	192,016	543,947
8	392,402	151,544	543,947
9	437,529	106,418	543,947
10	487,845	56,102	543,947
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0

UNDISCOUNTED

YEAR	NET ANNUAL CASHFLOW	CUMULATIVE CASHFLOW
1	¯27,905	¯27,905
2	176,005	148,100
3	¯40,866	107,234
4	2,650	109,884
5	49,580	159,464
6	115,108	274,572
7	185,822	460,394
8	269,756	730,150
9	354,394	1,084,544
10	454,913	1,539,457
11	1,098,279	2,637,736
12	1,221,600	3,859,336
13	1,369,708	5,229,044
14	1,525,617	6,754,661
15	1,698,251	8,452,912

UNDISCOUNTED

YEAR	NET ANNUAL CASHFLOW	CUMULATIVE CASHFLOW
1	¯24,874	¯24,874
2	139,842	114,968
3	¯28,942	86,026
4	1,673	87,699
5	27,899	115,598
6	57,735	173,333
7	83,079	256,412
8	107,503	363,915
9	125,890	489,805
10	144,042	633,847
11	309,977	943,825
12	307,328	1,251,153
13	307,155	1,558,308
14	304,952	1,863,260
15	302,583	2,165,843

DISCOUNTED

[illegible]
SHARP Cashflow Summary (High Case)

APPENDIX B (Example Energy Calculations)

Example A

The geothermal fluid enters the building at 140 °F. The heating system in the building was designed to strip 40 °F out of the geothermal water, cooling the geothermal water to 100 °F. A flow meter attached to the building showed a gallon usage of 10,000 during the billing period. The weight of the geothermal water is 8.34 pounds per gallon. Based on the above data the energy used by the building would be:

$$BTU = (Temp_{in} - Temp_{out}) \text{ X } (gallons) \text{ X } (8.34 \text{ \#/gal})$$

or $$BTU = (140\ ^{o}F - 100\ ^{o}F) \text{ X } (10,000 \text{ gal}) \text{ X } (8.34 \text{ \#/gal})$$

$$BTU = 3.33 \text{ million BTU}$$

The total available energy per gallon of geothermal energy is therefore:

$$BTU/GAL = 3,330,000 \text{ BTU} / 10,000 \text{ Gal}$$

$$= 333 \text{ BTU/Gal}$$

The geothermal bill would be based on 10,000 gal @ an estimated 333 BTU/Gal.

Example B

The geothermal fluid enters the building at 140 °F. The heating system in the building was designed to strip 40 °F out of the geothermal water, cooling the geothermal water to 100 °F. A BTU meter attached to the building showed a thermal consumption of 3.33 million BTU. The BTU meter is designed to continuously monitor the geothermal fluid entering the facility and the temperature of the cooled geothermal fluid leaving the facility. The meter multiplies the total flow of the geothermal fluid times the temperature drop of the geothermal fluid and therefore computes the actual BTU consumed by the facility.

The main difference between examples A and B is that example A only estimates the energy consumed by a facility based on the actual flow rate of the fluid and the presumed temperature strip produced by the building mechanical system while example B shows how an energy meter or BTU meter can be used to accurately calculate the energy consumed by a facility using geothermal energy.