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RENOVATION OPPORTUNITIES FOR STEAM DISTRICT HEATING SYSTEMS: A DECISION PROCESS IN SAN FRANCISCO

A Project Report

Energy Task Force
of the
Urban Consortium for
Technology Initiatives

Conducted by the
Energy Group, Department of City Planning
San Francisco, California

PREFACE

The Urban Consortium for Technology Initiatives was formed to pursue technological solutions to pressing urban problems. The Urban Consortium conducts its work program under the guidance of Task Forces structured according to the functions and concerns of local governments. The Energy Task Force, with a membership of municipal managers and technical professionals from eighteen Consortium jurisdictions, has sponsored sixty-eight energy management and technology projects in 30 Consortium member cities and counties since 1978.

To develop in-house energy expertise, individual projects sponsored by the Task Force are managed and conducted by the staff of participating city and county governments. Projects with similar subjects are organized into "Units" of four to six projects each, with each Unit managed by a selected Task Force member. A description of the Units and Projects included in the Fourth Year (1982-1983) Energy Task Force Program follows:

UNIT -- MUNICIPAL FINANCIAL MECHANISMS

Designed to develop and apply innovative local financial management systems for municipal energy programs, projects focused on both capital and noncapital expenditures for energy management and the inclusion of these procedures into the normal budgeting practices of local governments. The Unit consisted of six projects:

- Cleveland, Ohio - "The Energy Savings Payback Fund (ESPF): A Municipally Financed Shared Savings Program"
- Dade County, Florida - "Energy Financing For Local Governments: Metropolitan Dade County's Energy Investment Fund"
- Houston, Texas - "Alternative Sources and Techniques for Financing Local Government Energy Conservation Projects"
- New Orleans, Louisiana - "An Innovative Financing and Incentive Package to Reduce Municipal Energy Consumption"
- Pittsburgh, Pennsylvania - "Improving Energy Management and Accountability in Municipal Operations: A Model Budget for Local Governments"
- Public Technology, Inc. - "Financing Energy Efficiency: Options and Decisions in Five Local Governments"

UNIT -- PUBLIC/PRIVATE COORDINATION

Designed to define effective strategies to increase private sector participation and financial investment for energy management and energy related business development in urban areas, projects focused on means to improve private/public collaboration in energy efficient land development, for industrial and business expansion and for participation with energy utilities. The Unit consisted of five projects:

- Detroit, Michigan - "Rehabilitation of Older Housing to Superinsulated Standards: Energy and Air Quality Impacts"
- Indianapolis, Indiana - "Financial Options for the Construction of Fluidized Bed Combustion Systems"
- Kansas City, Missouri - "Development of an Energy Park in Kansas City: Issues and Implementation Options"

- Memphis, Tennessee - "Memphis Area Rideshare On-Line Information System"

- Washington, DC - "Service and Conservation Alternatives to Increased Electricity Generation"

UNIT -- **INNOVATIVE ENERGY TECHNOLOGIES**

Designed to develop and apply new energy technologies not previously proven for use in local governments, projects covered a variety of topics ranging from the use of municipal wastes as alternate energy resources to innovative applications of telecommunications technology for energy management. The Unit consisted of five projects:

- Baltimore, Maryland - "A Hydrate Process for Dewatering Sewage Sludge: Feasibility and Energy Resource Potential"

- Columbus, Ohio - "Planning for Telecommunications in a Local Government: Issues, Strategies and Energy Management Aspects"

- Denver, Colorado - "Alternative Uses for Digester Methane Gas: An Analysis of Technical and Economic Feasibility"

- Phoenix, Arizona - "Energy Conservation through Computerized Automation of a Wastewater Treatment Plant"

- San Antonio, Texas - "Landfill Gas Recovery: A Methodology for Site Planning"

UNIT -- **INTEGRATED ENERGY SYSTEMS**

Designed to identify procedures to resolve difficulties inherent in the implemention of integrated energy systems, projects addressed initial feasibility studies, technology assessments and analyses of institutional or financial barriers. The Unit consisted of four projects:

- Chicago, Illinois - "An Initial Assessment of District Heating and Cooling: A General Methodology Applied in Chicago"

- Hennepin County, Minnesota - "Multi-jurisdictional Planning for District Heating: A Concept Plan for Bloomington and Hennepin County, Minnesota"

- New York, New York - "Financial Planning for District Heating: The Brooklyn Navy Yard Project"

- San Francisco, California - "Renovation Opportunities for a Steam District Heating System: A Decision Process in San Francisco"

Reports from each of these projects are specifically designed to aid the transfer of proven experience to other local governments. Readers interested in obtaining any of these reports or further information about the Energy Task Force and the Urban Consortium should contact:

Energy Program
Public Technology, Inc.
1301 Pennsylvania Avenue, NW
Washington, DC 20004

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INTRODUCTION

PROBLEM STATEMENT

District heating systems are thermal-energy systems which produce heat in the form of steam or hot water, and convey it from one or more central generating stations to service the energy needs of commercial, residential, institutional and industrial users. Steam-based district heating was introduced in the United States in 1877 at Lockport, New York, and spread to many other cities during the next forty years. While several systems are still in operation, most face an unhealthy financial prognosis because of several factors. They characteristically suffer from aged, deteriorated components; expensive fuel sources compared with competitive means of providing heat; leaky, hard-to-access distribution systems; imprecise metering techniques; the need to maintain capacity which is under-utilized for a large portion of the year; and low owner interest in maintaining and improving the system.

Opportunities exist to markedly improve both the economic and energy efficiency of older steam systems operating in this country to the point where they could effectively compete with individual heating systems. Preventive maintenance and capital improvement programs can be initiated to retard component deterioration and bolster overall operating efficiency. Less expensive, lower quality energy sources such as municipal solid waste, coal or waste heat from an electric generating plant can be substituted for natural gas or oil. Conversion of the system from steam to hot water can reduce both heat losses and maintenance requirements. Abandoning uneconomic portions of the distribution network (by converting selected customers to alternate heat sources) can eliminate unnecessary distribution losses.

Time, effort and capital are necessary ingredients to a district heating renovation program. Of the three, financing is the key ingredient. Unfortunately, many present owners are often not willing to commit additional capital to older district heating systems, given the uncertainty that system renovation is a worthwhile investment. In addition, most system owners, whether they be local governments, private industry, or a utility, are not in a position to finance the necessary capital improvements on their own.

As such, local government officials must play a leadership role in determining whether revitalizing older district heating systems is both technically and economically justified. Local government leaders cannot, however, act alone. A joint effort on the part of utility and business leaders, members of the financial community, private investors, and federal, state and local officials is required to adequately address the issue.

PROJECT PURPOSE

District heating systems can, under the right conditions, provide urban areas with an economically competitive source of heat energy. This is because of the district heating system's ability to utilize inexpensive fuel sources, such as municipal solid waste and waste heat from electric generating stations, which are not available to individual buildings. Other benefits which can be derived from a district heating system include improved air quality, resulting from fewer emission sources to be controlled; increased flexibility in the event of fuel shortages, since a few central plants can adapt to a shortage more readily than a multitude of buildings; and improved generation efficiencies, since central plants undergo less cycling, and hence, operate more efficiently than do individual boilers. Moreover, district heating can enhance local economic development by creating construction jobs while reducing the outflow of dollars from the community to foreign energy suppliers.

This project was undertaken to develop a procedure by which local governments can examine old steam-based systems operating within their boundaries, and identify and evaluate renovation opportunities for improving system performance. The Energy Group, San Francisco Department of City Planning, developed such a procedure, and applied it to two district heating systems which have been operating in San Francisco since the early 1900's. This procedure encompasses six principal phases: general planning approach;

information acquisition; problem identification; solution identification; investment evaluation; and financial analysis. The testing of the procedure on the San Francisco systems has led to further refinements, and recommendations for use by other jurisdictions.

REPORT ORGANIZATION

Information in this report is arranged to provide a sequential review of the major steps that a city or county should undertake when evaluating the merits of renovating an older steam-based district heating system.

Chapter I provides a general overview of district heating systems, and discusses some of the major system components, requirements and advantages. The section focuses specifically on older steam based systems operating in U.S. cities, and includes a brief history of the development and evolution of these systems, as well as a discussion of some of their problems. A brief description is also provided of state and federal research directed at assisting cities to bring about improvements to these systems.

Chapter II outlines procedures for evaluating both the economic and energy efficiency merits of measures designed to renovate old steam-based district heating systems. This chapter presents a six-phased process for identifying, reviewing and evaluating options which could bridge the gap between the real potential for district heating as a preferred energy supply system for cities and the real problems of existing steam-based systems.

Chapter III describes the application of the procedure developed in Chapter II to two steam-based district heating systems in San Francisco. These systems provide "textbook" examples of district heating systems in need of major rehabilitation.

Chapter IV concludes with a discussion on lessons learned from the San Francisco case study. Procedures and research methods that were used throughout the project are evaluated for both their overall effectiveness and transferability to other counties. In addition, this chapter suggests methods for adapting San Francisco's project results to the needs of other counties.

Appendix A is a list of major reference materials used during this project. A technical supplement to the project report is available from the Energy Group, Department of City Planning. It contains a detailed technical review on existing district heating system operations in San Francisco. In addition, the appendix provides detailed economic analyses on options to improve present conditions.

Appendix B contains the results of an end user survey that was conducted in conjunction with this project. This survey provides valuable insight into the perceptions of respondents regarding various issues, that influence their choice of a building heating system.

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AN OVERVIEW OF DISTRICT HEATING TECHNOLOGY

CHAPTER I: AN OVERVIEW OF DISTRICT HEATING TECHNOLOGY

TECHNOLOGY REVIEW

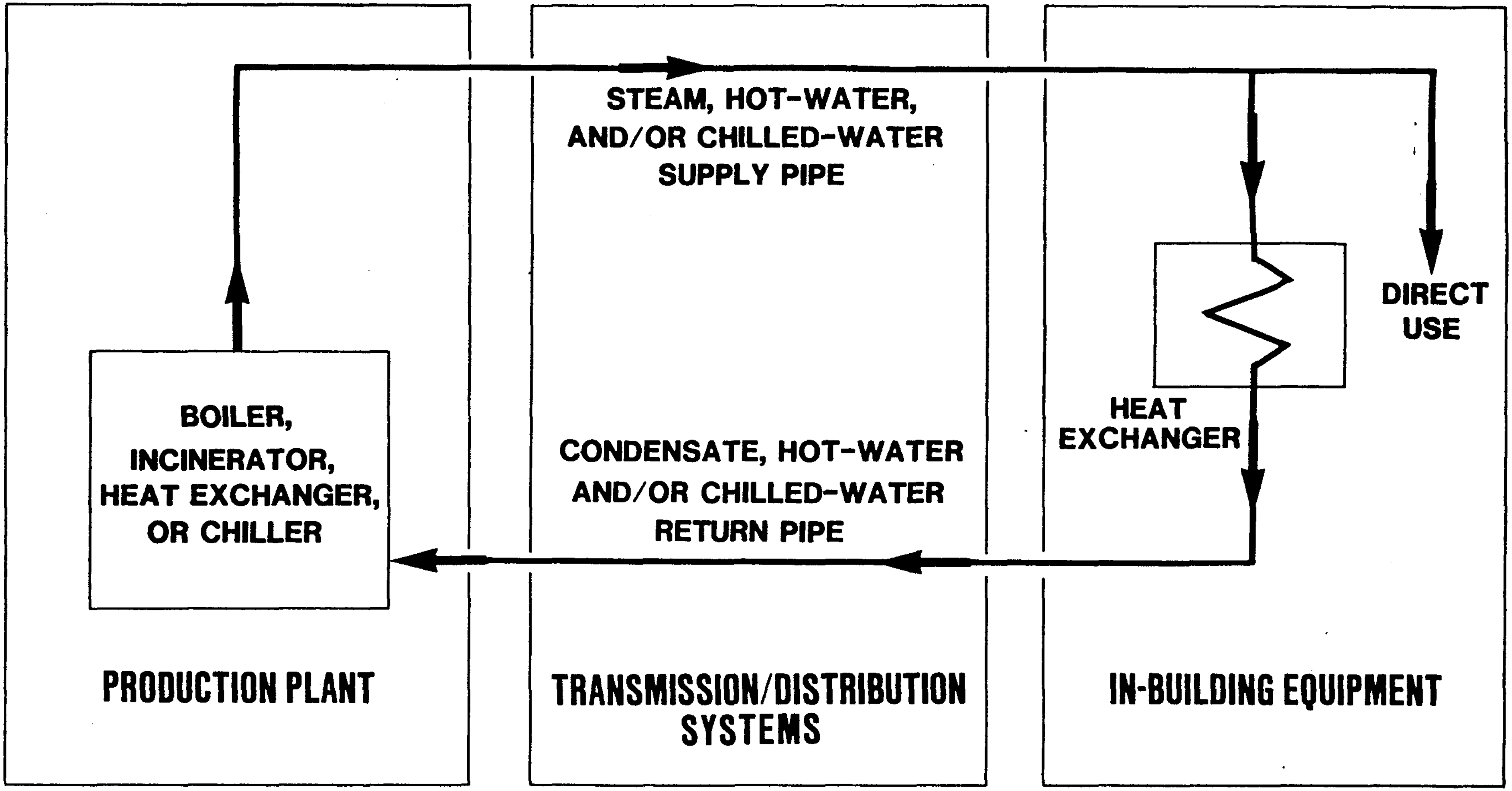
District heating systems are thermal-energy systems which produce heat in the form of steam or hot water, and convey it from one or more central production stations to service the energy needs of commercial, residential, institutional and industrial users. District heating systems range in size from small institutional systems which generally serve only a single user (e.g. a college campus), to large, city-wide networks.

There are three primary components of a district heating system: a central plant, a distribution network, and end-users. Figure 1 presents a schematic of a typical district heating system. The central plant converts primary energy fuels into usable forms of heat. A variety of fuels may be used for district heating systems. These include oil, natural gas, coal, municipal solid waste, waste heat from an electric generating plant, solar energy and geothermal energy. Typically, the lower grade fuels such as municipal solid waste and waste heat provide a district heating system with a competitive edge against individual boilers.

A generating unit, such as a heat-only boiler, converts the fuel to steam or hot water for distribution to end users. In a combined heat and power plant, or cogeneration unit, electricity is produced in addition to heat. The electricity can be used either on-site or fed into the utility grid. Cogeneration increases the total useful energy output of a district heating system.

Transmission pipelines deliver the thermal energy from the generating plant to the distribution loop. These pipes are either contained in pipe tunnels (culverts), or are direct-buried. The steam or hot water is conveyed through a distribution loop to building service connections, and is delivered by the

Figure 1



TYPICAL DISTRICT HEATING SYSTEM

service connection to the building mechanical system. It is then distributed for use in space heating, water heating, absorption chilling and/or industrial processing. In some instances the water or steam in each of these loops is separated by means of heat exchangers. In a hot water system, the cooled water is returned to the power station for re-use. In a steam system, the spent steam (condensate) is either returned to the power station or discharged into the storm sewer system.

NATURE OF OLD STEAM DISTRICT HEATING SYSTEMS

Most of the large urban centers in the U.S., particularly in the northeast and midwest, have steam district heating systems which have been serving the downtown areas since the late 1800's. These systems quite often started out as relatively small, independent systems serving isolated sections of the city; they were later agglomerated into a large, single system.

These older steam systems usually used the exhaust steam from small steam-electric power plants, which were located close to the centers of demand. However, the advancement of electric generating technology and the presence of economies of scale provided financial incentives for the construction of larger electric generating facilities; the development of long-distance transmission capabilities allowed for the siting of these larger power plants at a distance from the urban centers. As new, distant generating facilities came on-line, older in-city facilities were abandoned, reducing the availability of inexpensive exhaust heat for the district heating systems. These systems had to rely upon more costly steam-only boiler plants, resulting in higher steam production costs and steam rates.

The success of a district heating system is predicated upon the generation of revenues sufficient to cover the cost of the system infrastructure (piping, generating plant, etc.). The changing economics of district heating convinced many customers to convert to alternate energy systems, e.g. on-site boilers. Customer conversions accelerated during the 1930's and 1940's, further reducing both system sales and revenues. This led to a number of system abandonments through the end of World war II. Since then, the number of systems has remained relatively constant, even though customer conversions have continued to decline. Selected information on some of the larger systems is presented in Table 1.

The majority of the steam-based district heating systems that have remained in operation are earning less-than-allowed, or even negative returns on their rate base, while customers are spending as-much-as or more than they would for competitive forms of heat. The Electric Power Research Institute (EPRI) conducted a survey of fifty of the larger utility and municipally-owned systems in 1979 (the study excluded systems serving military bases, university campuses, and industrial parks). The results of the survey indicated that almost two-thirds of these systems have experienced a decline in both customers and sales over the past several years, while steam price increases have outpaced price increases for competitive forms of heat (EPRI 1980, p. 8-3). For example, the owner of the largest steam system in the U.S. -- Consolidated Edison in New York City -- lost 12 percent of its customers and 17 percent of its peak sales volume between 1970 and 1978. During this same period, the steam price increased at a rate twice that of home heating oil (OTA 1982, p.167).

Based upon financial information which was available from the Federal Energy Regulatory Commission (FERC), 16 of 31 of the systems surveyed by EPRI showed a net financial loss in 1978; the remaining 15 systems had a positive but less-than-allowed rate of return on fixed assets (EPRI 1980, p. 3-13). Table 2 summarizes this information.

One of the principal reasons given for the poor financial showings is the age and inefficiency of the steam generating plants, since these facilities contain equipment which was installed over 50 years ago. Another reason cited is the large amount of steam which is produced but not delivered to the end-users. This stems from a number of factors, including component deterioration within the distribution system; absence of a condensate return to the power plant; and reliance upon old meters which may inaccurately record the amount of steam sold. A third explanation stems from the need to install and maintain heat generating units to meet a peak demand which only occurs

Table 1

Summary of Larger District Heating Systems Operating in the U.S.

City (Owner)	Steam Sold in 1982 (mmlb)	Peak Steam Sendout in 1982 (mlb/hr)	Losses in Distribution System (%)	Percent of Steam Produced by Cogeneration	Fuels Used, Percent: Coal	Fuels Used, Percent: Residual Oil	Fuels Used, Percent: Natural Gas	Average Price of Steam in 1982 ($/mlb)	Number of Customers in 1982
New York (Consolidated Edison)	27,347	11,900 actual (13,201) maximum possible	16	80	0	84	16	NA	2,084
Philadelphia (Philadelphia Electric)	5,086	2,218 (3,857)	17	80	0	100	0	14.43	573
Detroit (Detroit Edison)	4,569	1,735 (2,500)	22	0	19	1	80	9.96	713
Boston (Boston Edison)	3,453	1,634 (1,790)	20	0	0	16	84	13.95	128
Baltimore (Baltimore Gas and Electric)	1,857	760 (1,060)	11	0	0	10	90	11.00	612
Indianapolis (Indianapolis Power and Light)	4,498	1,334 (1,802)	10	NA	NA	NA	NA	5.03	561

Source: International District Heating Association "Industry Statistics for 1982" IDHA, Washington, D.C. 1983

Table 2

Financial Status of Selected U.S. District Heating Systems

	Return (Loss) on Steam Fixed Assets (%)	Percent of Total Utility Gross Revenue From Steam Sales	Ratio of Net Steam Income (Loss) to Gross Revenue
Mean for 15 Systems With Net Steam Income	6.6	2.0	6.7
Mean for 16 Systems With Net Steam Losses	(9.9)	1.8	(7.4)

Source: EPRI 1980, pp. 8-2, 8-3

for a relatively few number of hours per year; for the remainder of the year, a large portion of this capacity is under-utilized. Finally, many system owners claim that existing regulations prevent them from charging steam rates sufficient to justify investing additional capital to improve system operations.

As the physical condition of most of these systems continues to erode, system owners must decide to either continue to operate at a loss, abandon or sell the system (if allowed to do so by State Utility Regulatory Agencies) or make a commitment to system rehabilitation. The trend seems to be in the direction of continued attrition. Only 14 percent of the system owners surveyed by EPRI planned system expansion, and only 18 percent reported that they were actively seeking new customers. Several system owners interviewed by EPRI expressed an interest in selling their systems or closing them down. Ohio Edison has sold its Akron system to the City of Akron, while Commonwealth Edison in Chicago disconnected its last 4 customers in July 1979.

Most of the older district heating systems are owned by utilities which supply electricity and natural gas in addition to steam; these other energy sources are often promoted by the utility in direct competition with steam, thus frustrating efforts at building the district heating customer base. Utilities are less likely to direct funds to district heating systems, since revenues are often miniscule in comparison with revenues from other utility operations. The FERC information on the 31 district heating systems discussed earlier indicate that the ratio of gross steam revenue to total utility gross revenue averaged 1.7 percent (EPRI 1980, p. 3-14).

FEDERAL AND STATE RESEARCH

Over the past few years the U.S. Departments of Energy (DOE) and Housing and Urban Development (HUD) have been actively promoting both the renovation of older district heating systems and the establishment of new systems in major urban centers. DOE's interest in promoting district heating is related to the energy efficiency and environmental quality improvements which could potentially be realized from using exhaust heat from electric generating stations. The promotion has come in the form of small grants for initial planning studies, as well as larger grants for more detailed feasibility studies and actual development.

In 1978, DOE provided funds to nine cities to investigate the merits of using existing electric generating stations located near downtown areas to supply either steam or hot water. The economic feasibility of the proposed retrofits varied, depending upon the age and condition of the existing power plant. A few cities have proceeded with more detailed study, and Piqua, Ohio has broken ground on the development of a hot water system using waste heat from a coal-based electric generating plant. Others have concluded that power plant retrofit is not cost effective, because of the scheduled retirement of in-town plants, or the remote location of the plants from growing population centers.

In 1981, HUD, in conjunction with DOE, provided funds to 28 cities to perform district heating feasibility studies in their respective communities. HUD's primary impetus for promoting district heating systems relates to the role these systems could play in catalyzing economic development. Successful district heating systems can provide an inexpensive supply of heat energy to the community, attracting private investment and stimulating employment within the system service area. Moreover, district heating systems are better equipped to utilize local fuel resources, such as municipal solid waste, than are on-site heating systems. According to estimates made by Argonne National Energy Laboratory, district heating systems can save approximately 1.4 million barrels of oil equivalent per year. HUD is preparing a second round of technical studies for 1984, emphasizing municipal solid waste and centralized cooling options. This second round will not be restricted to the original 28 cities.

Brookhaven, Argonne and Oak Ridge National Laboratories have performed several district heating studies, primarily in support of the DOE and HUD programs. Several computer-based models were developed which are useful to cities wishing to plan new systems; included are subprograms which indicate the economic feasibility of system development in specific areas. Several state agencies have sponsored investigations into the potential for district heating within specific areas. Included are the New York State Energy Research and Development Agency (NYSERDA) studies of cogeneration and hot water supply systems, and the Minnesota Energy Agency and Northern States Power (NSP) studies of hot water systems in several cities in Minnesota, including Minneapolis and St. Paul.

SUMMARY

District heating systems can, under the right conditions, provide cities with an inexpensive way of supplying heat to downtown areas, while conserving energy resources and improving air quality. Existing systems in the U.S. currently suffer from a range of financial problems, stemming from the age and efficiency of these systems, the large quantities of steam which is lost in generation and transmission, and the need to maintain excessive capacity which is utilized for only a small portion of the year. System owners are reluctant to spend additional capital on a system which does not provide an adequate investment return, while system customers are responding to high heat prices by converting to alternate heat sources, i.e. on-site boilers.

Recent Federal government attention, particularly within the Departments of Energy and Housing and Urban Development, has been directed toward using district heating as a vehicle for reducing energy consumption and encouraging urban economic development. Federal research indicates that there is significant potential for the rehabilitation of old steam systems, particularly in downtown areas experiencing renewed economic growth, and where there is a large cost differential between centrally supplied heat and heat produced on-site.

Local officials interested in examining options for rehabilitating either municipal or utility-owned systems need a procedural guide to aid them in their investigation. The following Chapter outlines procedures for gathering information on a system's operations, identifying problems relating to system operation, developing solutions to these problems, conducting an investment analysis of various options and, finally, selecting from several options the ones that are most appropriate.

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GENERAL METHODS AND TECHNIQUES

CHAPTER II: GENERAL METHODS AND TECHNIQUES

INTRODUCTION

The renewed interest in district heating has caught many local decision makers short on established research procedures. It is one thing to applaud government policies that promote district heating technology as a local energy supply option; it is quite another matter to determine the economic and technical merits of renovating an older steam district heating system. A decision-making guide is needed that will provide cities and counties with general methods and techniques for assessing these systems.

The procedure described in this report encompasses six major research phases: planning approach; information acquisition; problem identification; solution identification; investment evaluation and financial analysis. Each of these phases is discussed in a general policy context that can be further refined when applied to a particular system.

PLANNING APPROACH

A city or county must first decide on how to explore the issues involved in renovating an older steam district heating system. Basically, two options are available: conducting the research in-house, or contracting with a consultant. The Urban Consortium Energy Task Force advises that in-house staff be used whenever possible. This will contribute to local capacity building and foster the development of permanent in-house staff expertise. In addition, it will ease transferability of experience to other jurisdictions facing similar issues.

Whichever method is chosen, it is crucial that a community consensus be established early in the research process. Local government officials, the system owner (if different from the local government), system users, technical experts, building owners and managers and the local utility all have an interest in matters affecting present and future system operations.

One frequently relied-upon mechanism is the citizens committee. Such a committee draws on local community expertise to advise staff on specific issues relating to system assessment. Included are technical engineering analysis, investment and financial counseling, customer perceptions and general policy questions. The citizens committee provides a forum for discussing and resolving various issues that arise during the course of research. The knowledge brought together through this structure will greatly increase staff technical capabilities, thus reducing the time period for assessing the system.

It is important that the citizens committee be appointed by either the mayor of city manager. This will provide sufficient interest to the general public to warrant press coverage. Press coverage, in turn, will provide additional prestige to the committee's work program. This factor will have a subtle, but positive influence on how the committee views its role as guardian of the public interest.

The committee should, from the outset, be given specific directions as to the overall project goal and objectives, their role and responsibilities as advisory counsel, and general conclusions that should emerge from the research. This will help to ensure that the committee's time and effort is well spent. Furthermore, it will strengthen the trust placed in the committee by those local decision-makers who must ultimately respond to the committee recommendations.

The relationship of the citizens committee to the system owner is an important consideration at this juncture. The committee's effectiveness in establishing a policy direction with respect to an older steam district heating system is contingent upon the influence it has with the system owner. For example, a city or county may have only limited success in effecting changes to a utility owned system, despite recommendations made by the citizens committee, if that utility has little regard for the committee's work. From this standpoint, it is important that the system owner be represented on the citizens committee, so that the owner's viewpoints are aired and incorporated into the committee's findings and recommendations.

ACQUISITION AND ORGANIZATION OF INFORMATION

Once a planning process has been established, it is necessary to acquire and organize information on current system operations. The general purpose is to document whether or not the system, as presently operated, provides low cost energy to end users and operates in an efficient and economic manner. Information gathered will provide the basis for focusing on problem areas that affect current system operations. As such, this is a crucial phase of research.

Table 3 outlines major aspects of the system for which information must be obtained. This information is categorized according to the generation, distribution, and end-use portions of the system, as well as overall system economics. Sufficient information should be acquired to outline a historic trend which has occurred over the past ten to twenty years. This enables those reviewing system operations to adjust information fluctuations that occur in any one year because of unforeseen factors, e.g. unseasonly cold weather, the departure of a major sales customer, system shut down because of extensive steam leakage etc.

The system owner will be the key source of information in most cases. However, it is likely that not all of the information sought will be readily obtainable. Some of the information may not be maintained, and information which is maintained may not be in a ready-to-assimilate form, or may be proprietary to the system owner and not available to the advisory committee. If any of this information is not available, best estimates will have to be made, based upon industry statistics (such as the International District Heating Association's Report of Industry Statistics) applied to local conditions.

Generation Information. The generation system converts the fuel source to heat, and transfers heat to water to produce hot water or steam. The

Table 3

Information Required for System Evaluation

Generating System

- Amount and Type of Fuel Consumed
- Capacity, Age and Condition of Generators
- Boiler Efficiency
- Annual Steam Production
- Steam Production Pressure
- Auxiliary Loads
- Capacity Factor
- Maintenance Requirements

Distribution System

- Age and Condition
- Efficiency of Distribution
- Average Delivery Pressure
- Length and Diameter
- Heat Losses by Section of System
- Maintenance Requirements

End-Users

- Number and Class of Customers
- Historical Sales and Customer Trends
- Uses of Steam
- Load Factor
- Percentage of Customers Accounting for Major System Sales

Economics

- System Rate Base
- Annual Costs for Fuel, O&M, etc.
- Annual Revenues
- Return on Rate Base
- Historical Trend of Steam Rates

information relating to the generation system includes specific physical qualities of the generating units (e.g. the types of units, capacity, age and condition) as well as operating characteristics (e.g. annual steam production, production pressure, capacity factor, efficiency, quantity of fuel consumed, etc.). This information is an essential first ingredient in establishing a system profile, since the generating system is often responsible for the greatest amount of energy losses.

The amount of fuel consumed should be on record, based upon meter readings (if natural gas) or purchase receipts (if coal); however, this information may be in an aggregated form, which is not as useful as on a per-hour basis. If the heat produced is a by-product of an electric generating plant (i.e. cogeneration), there may be some ambiguity involved in apportioning the fuel consumption to these different products. The amount of steam produced may be measured by steam flow meters at the back-end of the turbine or boilers, but is most often determined by feedwater meters. This latter method relies on the assumption that all of the water provided to the boiler is converted to steam, and may lead to inaccuracies in certain cases.

Boiler efficiency can be defined as being either steady-state or annual average. Steady state efficiency, which is an indicator of the boiler's instantaneous efficiency in converting fuel to heat, can be measured by using special equipment. Annual average efficiency, which takes daily and seasonal cycling into account and is much more relevant to a boiler's long-term efficiency, requires that the annual steam production and annual fuel production figures be available (it is the ratio of these two quantities).

Distribution Information. The distribution system transmits the heat produced in the generating plant to the system users. Energy losses in the distribution system are often exceeded only by those in the generation system. These losses can be determined from information regarding the amount of heat produced by the generating plant and the amount of heat consumed by the end-users. Since both of these figures are subject to error, estimates of the quantity of heat lost in the distribution system ("unaccounted for losses") may be inaccurate.

Apportioning energy losses over the different sections of the system is difficult. Estimates regarding the amount of heat lost through a specific portion of main can be made based upon either the age and condition of specific sections of pipe, or by undertaking an infra-red scan of the pipeline. The scan should be able to pinpoint areas where excessive steam losses are occurring. However, there is no way of making an accurate determination without installing steam flow meters throughout the distribution system. This information, in conjunction with a maintenance history (if available), is required to set priorities for repairing and replacing mains, and keeping distribution heat losses to a minimum.

End-User Information. The end-use refers specifically to the use which is made of the steam. This is normally limited to space heating, water heating and possibly absorption chilling, but can also include process heat (e.g. for laundry presses or kitchen equipment), depending upon the customer base. The type of information required includes both demand-related information (such as the number and type of customers -- historic and current; their use of steam; individual and agggregate load profiles -- daily and seasonal) as well as customer perception of the system. Some of this information, such as customer and sales trends, may be available from the system owner. The remainder will probably have to be obtained through a customer survey, conducted either by the local government or the system owner. The purpose of this information is to sketch how the heat supplied by the system is being used, and what factors are likely to influence a building owner to become a customer of central heat.

Economic Information. This information directly reflects the success of the system in providing an inexpensive supply of heat to the end-users. Included are annual costs for fuel, operation, maintenance, and administration; steam rates; and revenues from steam sales. Also of interest is the system rate base (the undepreciated operating equipment) and the after-tax profit as a percentage of the rate base. This information should be available from either the system owner or the state public utilities commission, if the system is regulated.

PROBLEM IDENTIFICATION

Once a profile of the existing steam system is in place, the next task involves identifying major problem areas. Comparing the existing system with a "model" of a hypothetical, efficiently-operated district heating system can ease the task of problem identification. This model, based upon current district heating practices in Europe and the United States, will serve as a theoretical upper limit of what can be attained by renovating the older steam system. Some of the most common problems are illustrated in Figure 2.

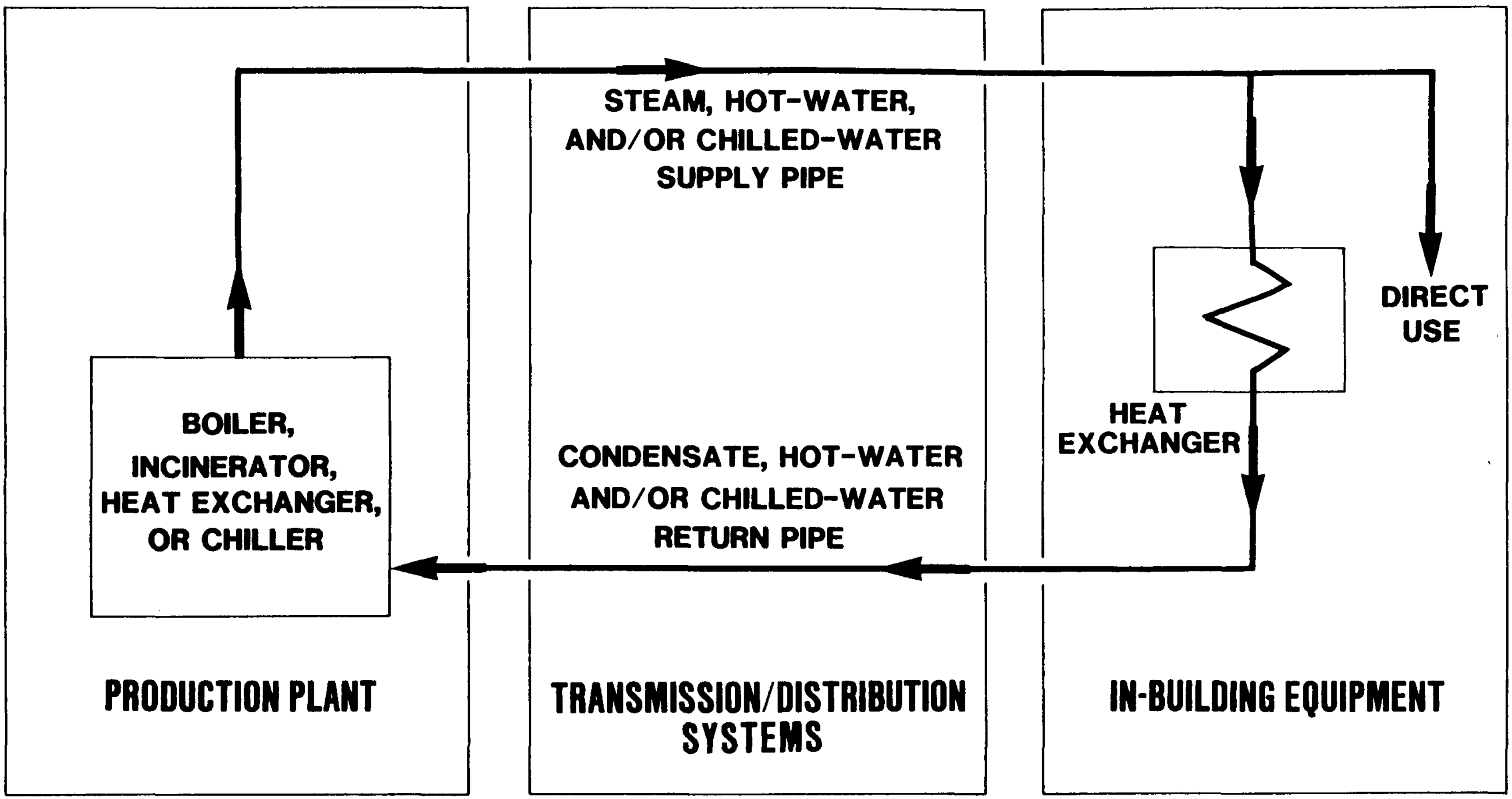
Generation Problems. New district heating systems characteristically trade-off higher initial capital costs for lower annual fuel costs. High investment costs, related principally to equipment purchase and installation, are usually offset by fuel savings made possible through the generation of heat from inexpensive, low quality fuels such as municipal solid waste. These fuels are either not available to on-site boilers or at efficiencies attainable by central systems.

The primary shortcoming of old steam-based systems is that the cost of producing heat is not competitive with heat produced by on-site boilers. This is due to two reasons: (1) old steam systems characteristically use older, less efficient generation equipment; and (2) this equipment, usually heat-only boilers, is not always capable of utilizing the most inexpensive fuel sources available. Only four of thirty-five member systems of the International District Heating Association (IDHA) reported using waste heat from a cogeneration cycle as their principal source of heat, while one system used municipal solid waste and five used coal. The majority (over 70 percent) relied entirely upon expensive oil and natural gas fuels.

Distribution Problems. New district heating systems generally employ hot water to convey the heat from the generating plant to the end-users. The benefits of low-temperature hot water distribution, as compared with steam distribution, are numerous, including: lower line losses owing to lower temperatures, less corrosion and absence of losses because of traps; longer distances served; recycling of low-grade heat and water returned to the power station; better storage capabilities to possibly reduce peak requirements;

Figure 2

SYSTEM PROBLEMS



Aged generation equipment
+
Single purpose boilers
+
Premium fuels
=
High cost of heat; inefficient energy use

Deteriorated components
+
Leaky mains
+
Faulty steam traps
+
No condensate return
=
High heat losses

Reduced customer base
+
Skewed load profile
=
Inefficient use of installed capacity

greater flexibility of heat sources; reduced purchase and installation costs for the piping; and higher electricity production from a cogeneration plant.

Old steam systems typically contain distribution components, e.g. piping, insulation, and traps, which have undergone substantial deterioration, and are responsible for an extensive amount of heat loss. Specifically, steam escaping through corroded pipes is difficult to locate, allowing a significant amount of heat to be lost before the problem is discovered and pipes are repaired. In addition, the original insulation has often worn away, so that the prevention of heat loss to the surrounding environment is less than what is achievable with currently available insulating materials. Steam traps, which provide a means of expelling condensate from the steam lines, will fail to operate if not maintained on a regular basis. This results in the loss of a significant amount of steam.

It is fairly common for older steam systems to use high pressure steam, even though water and space heating requirements, which account for the vast proportion of end uses, could be met by low pressure steam. Using high pressure steam in a deteriorated distribution system only adds to the amount of steam lost through conduction and leaks.

Steam also goes unaccounted for in buildings, since some of the spent steam (condensate) is not returned to the meters, and not all of the condensate meters accurately measure what is returned. Moreover, return of the condensate to the power station is not a common feature among most old steam systems; hence, low-grade heat, in addition to water and chemicals, is wasted.

Thirty-one of thirty-five IDHA member systems reported that less than one half of the system send-out was returned. The amount of heat lost through the distribution system in old steam-based district heating systems averages 15 to 20 percent, based upon information provided by the IDHA.

End-User Problems. Developers of new district heating systems generally strive to serve a load which is well balanced, i.e. one which is fairly constant on a daily and seasonal basis. This can be achieved by connecting customers in dense areas that have varied heating schedules. This practice allows for the installation of generation and distribution equipment optimally sized to satisfy the thermal demand.

Old steam-based systems, on the other hand, generally have excess generating capacity. This excess capacity can be attributed to two major factors. Most systems have experienced an overall decline in steam sales, as customers have either left the system or reduced their steam requirements by enacting energy management programs. In addition, these systems generally serve a customer base exhibiting a fairly similar heat demand schedule, with peaks occurring during a relative few number of hours per year. This results in the need to maintain generating capacity which is underutilized during much of the year.

TECHNICAL RENOVATION OPPORTUNITIES

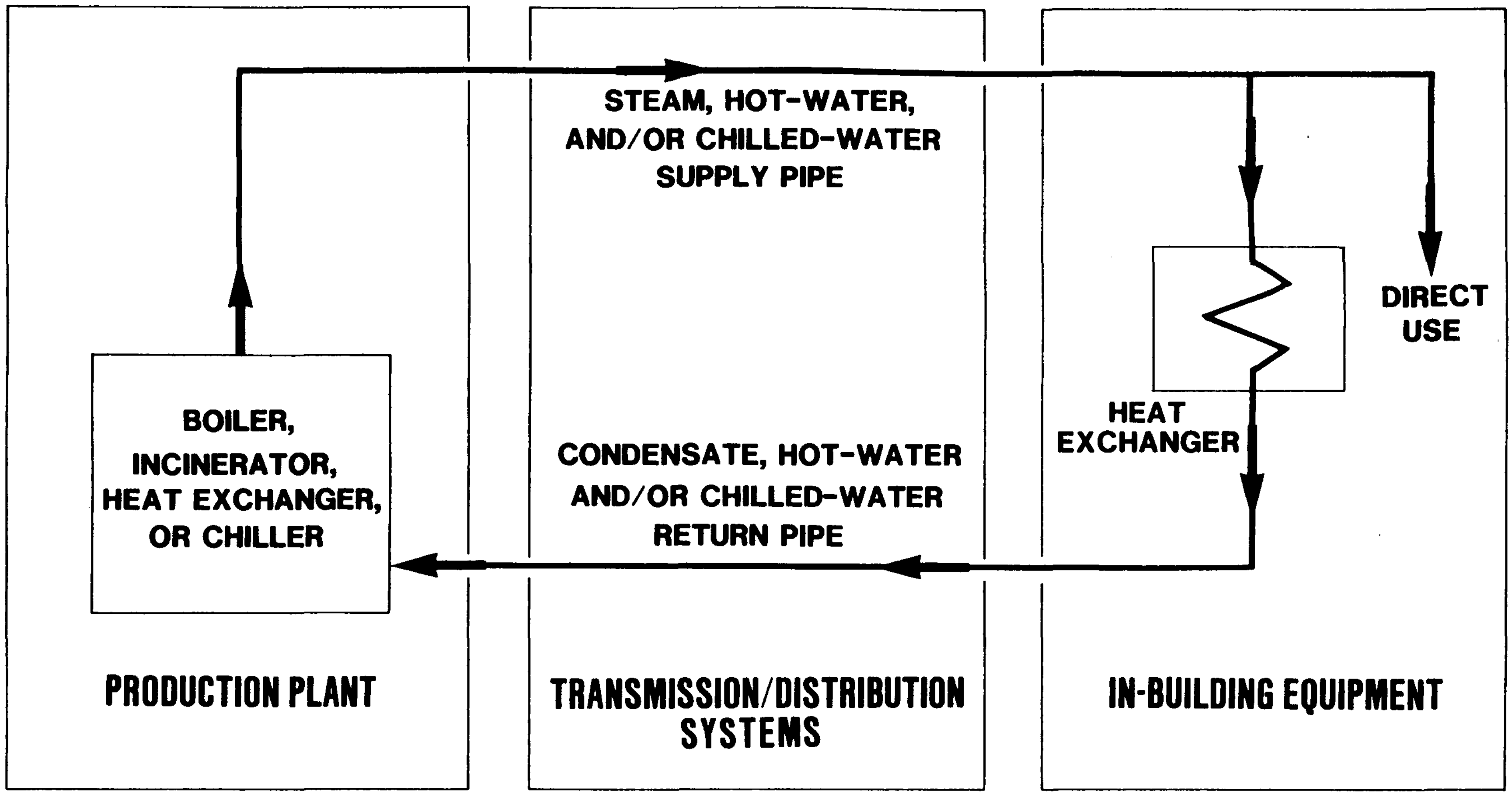
Once problem areas have been identified, one can begin exploring technical, economic and institutional options available for correcting these problems. As with the two previous phases of research, options should be categorized according to the generation, distribution and end-user portions of the system. This process is outlined in Figure 3.

Generation System. One of the major problems encountered with older steam systems is high operating costs, stemming primarily from fuel-related costs. These costs can be reduced by either substituting a low quality fuel for a high quality fuel or improving the efficiency with which the fuel is converted to useful heat. The result in either case will be a reduction in the costs required to generate heat; the exact amount will depend on either the cost differential between the original and substituted fuel or the efficiency improvement achieved.

Substituting a low quality fuel such as coal or municipal solid waste, for a more expensive, high quality fuel such as natural gas or fuel oil, could be achieved by either retrofitting an existing power station or substituting power stations. Either approach will raise technical, economic, environmental and regulatory issues. For example, converting a natural gas generating unit to use coal will probably increase the emissions of sulfates and particulates.

Figure 3

TECHNICAL RENOVATION OPPORTUNITIES



Production Plant

- Substitution of fuel source
- Integration of cogeneration
- Maintenance and repair of heat generating equipment

Transmission/Distribution Systems

- Capital improvement and preventive maintenance
- Steam to hot water conversion

In-Building Equipment

- Alter existing demand to balance load
- Increase customer base by adding diverse loads
- Retire unnecessary equipment

As a result, expensive pollution-abatement equipment will be required, increasing overall conversion costs. Moreover, district heating systems located in cities that do not cuurently meet federal and state air quality standards will face considerable legal obstacles in switching to cheaper, lower quality fuels such as coal.

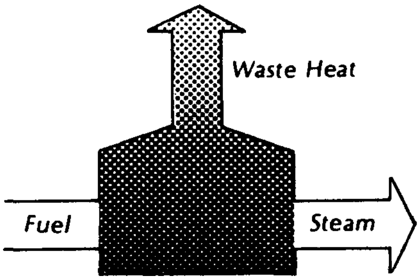
Improving the efficiency of heat production can be achieved by either fine tuning the existing boilers, or installing a cogeneration unit to replace existing single-purpose steam boilers. Boiler tuning is fairly straight forward; all preventive maintenance programs should emphasize adjustment and repair of burners, controls, etc. Cogeneration is the sequential production of both electricity and heat from a single process. A schematic of a typical cogeneration configuration is presented in Figure 4. Due to its high overall efficiency, cogeneration reduces the amount of fuel that must be consumed to meet electrical and thermal needs. Electricity produced by the cogeneration unit can be sold, thus reducing the revenue requirements associated with the heat. To date, most cogeneration systems have been installed by industries and institutions that have large internal heating and electrical needs; the technology is, however, becoming a more common component in modern district heating systems. Cogeneration was the preferred choice for thirteen of the twenty-eight proposed district heating systems under HUD's 1981 general assessment program.

The costs associated with a cogeneration installation will include equipment purchase and installation totaling approximately $1,000 to $2,000 per installed kilowatt. Environmental issues will be encountered relating to increased localized air emissions and noise levels. Special noise and pollution abatement measures may be required. Moreover, local planning regulations may preclude the installation of a power plant within either a commercial or mixed use zoned district.

Distribution System. The principal problem area relating to the distribution system concerns the amount of heat which is lost as the steam is transmitted from the central plant to the end-users. These losses occur because of corroded and outmoded components, including pipes, insulation and traps; they

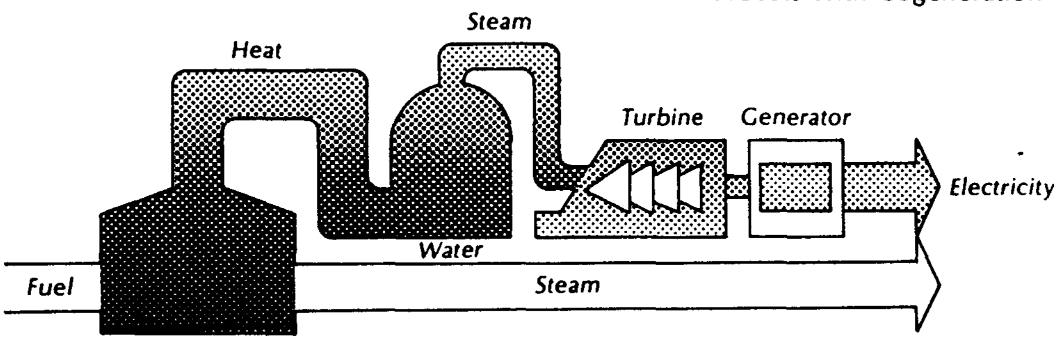
Figure 4

TYPICAL COGENERATION CONFIGURATION



Process Without Cogeneration

Process With Cogeneration



can be reduced by instituting a capital improvement and preventive maintenance program to repair and protect the existing system, and by undertaking a system conversion from steam to hot water.

A capital improvement and preventive maintenance program would include repair and replacement of leaky pipes and faulty traps and valves, and the insulation of poorly-insulated pipes and valves, particularly easy-to-access sections located in the vaults. The costs will vary, depending upon both the age and accessibility of the components. Moreover, the maintenance program should include an annual inspection of all system components.

Conversion of the distribution system to convey low-temperature (250^{0} F) hot water as opposed to steam can be achieved either on a wholesale or incremental basis. Incremental conversion involves replacing portions of steam main with hot water as the need for replacement occurs. The heat in the steam can be transferred to hot water through a heat exchanger, and this hot water can convey the heat to the buildings -- provided that they are capable of utilizing hot water. Thus hot water islands can be created, with the ultimate goal being the conversion of the entire system. Incremental conversion is preferred for larger systems, due to the high costs involved in main replacement. Plans for converting the system to hot water should be directly incorporated into the main replacement program.

Wholesale conversion involves a one-time, system-wide replacement of the entire distribution system. This is generally possible only for small systems due to the high capital costs involved. In 1982, the City of Willmar, Minnesota installed 20,000 feet of hot water distribution piping to convert more than one half of the city's steam district heating system to hot water.

<u>End-Users</u>. A poor load profile is common among many older steam systems. This requires the system owner to maintain generating capacity which is under-utilized during a large portion of the year. The system owner should not, however, view the existing thermal demand profile as a fixed variable. There is significant flexibility to shape the load in the interest of a more efficient district heating system. One way involves working with the existing customer base to reduce the system peak thermal demand. By providing

time-of-use rates, the system owner can alter the load profile by encouraging customers to modify their heat demand schedule. This could reduce the peak demand for heat, thereby enabling the owner to retire unnecessary equipment.

Customers which require high pressure steam for process purposes normally impose the requirement that the entire system be designed for, and provide steam at high pressures. These customers generally represent a relatively small percentage of total system demand. The owner can reduce both system demand and steam distribution losses at a modest cost by providing a substitute heat source for these high pressure steam users. This would allow for a reduction in the steam delivery pressure and hence, a reduction in heat losses. Moreover, customers located at the far end of an inefficient portion of main, and representing a small percentage of the system's total sales, could be converted to an alternate heat source so as to reduce generation and distribution losses. This measure may often be more cost-effective than investing in costly main replacement.

Another way to reduce the amount of fixed costs allocated to each customer is to increase the number of customers. New customers demanding heat during off-peak hours (e.g. hospitals and residences) can be added to the system to make more efficient use of existing boilers and distribution piping, and hence to distribute the fixed costs and system losses over a greater number of customers. This may serve to reduce steam rates. However, costs of connection must be taken into consideration by the owner when selecting potential customers.

INVESTMENT ANALYSIS

Once technical merit has been determined, energy management options must undergo an investment analysis. It is one thing to identify options for either solving or reducing prevailing problems in system operations. It is quite another matter to implement these options without giving due consideration to the investment criteria of the system owner. This will vary considerably depending on whether the owner is a public body, utility, nonprofit corporation, or private firm.

A first consideration is high risk. An option might have technical merit and look good on paper. However, if it is a relatively recent innovation with no proven track record, an element of risk is involved that must enter into the investment analysis. An example would be installing a fuel cell operated cogeneration system. Moreover, cost estimates necessary for performing the investment analysis will be extremely uncertain.

Generally, system owners are reluctant to enter into high risk situations associated with new or untried materials or technologies. They will require an extremely high return on their investment to overcome this reluctance. As a result, technical innovations which do not have industrywide acceptance are unlikely to be seriously considered by the system owner, despite their perceived merits, unless financial subsidies or performance guarantees are provided by either the government or industry.

Even a proven track record does not ensure that the system owner will be convinced of the merits of the energy management option. Salesmanship is a key ingredient in investment analysis. Improving steam system operations involves competing for limited available capital with other programs and investment options. Questions likely to arise will include: Is the investment a wise expenditure of funds, given the present financial situation of the system? Are there better uses for the limited investment capital at the owner's disposal? Will capital investments not only improve system operations, but increase overall steam sales? These are questions that must be answered as part of the overall investment analysis. For instance, an energy management option that improves system operations will be of little value to the owner if customers continue to leave the system.

There are a variety of investment methods that are used to evaluate energy management options. Simple payback, cost of conserved energy, net present value, internal rate of return and life cycle cost analysis are examples of commonly accepted investment tools. The specific method used will tend to vary depending on who owns and operates the system. Generally, the net present value and internal rate of return methods provide the decision maker with a more methodologically correct formula for analyzing the option against a standard criteria for investment; however, they also are subject to greater error since both rely more heavily upon uncertain future cash flows and interest rates. Irrespective of the tool chosen, minimum criteria for investment acceptability should be established at the outset (e.g. 5 year payback, 25 percent internal rate of return).

Energy management options which satisfy the investment criteria of the owner should then be examined for policy implications. Technical solutions to problems usually have a range of associated impacts, relating to the environment, energy resources, the local economy, political feasibility, etc. Though these issues are more subjective, and less quantifiable than are technical and investment criteria, they must be addressed if the program is to receive widespread community support.

Environmental issues include the projected impacts upon local (and possibly regional) air quality; water quality; use of water, energy and other natural resources; and land use. Since district heating renovation may involve extensive construction, and possibly conversion from a relatively clean-burning, high-grade fuel to a less-expensive, "dirtier" fuel, adverse air quality impacts may ensue. On the other hand, system renovation should lead to either reduced energy consumption or a substitution of local energy sources for imported energy sources.

Local economic issues include the impact of reducing local monetary expenditures to outside energy suppliers, the creation of jobs relating to system construction, and secondary job impacts on the local economy. Institutional considerations include identification of the array of public and/or private agencies likely to be involved in the approval process leading to upgrading the district heating system. Political issues are likely to emerge from options that, though technically feasible, face potential community opposition; e.g., siting a municipal solid waste plant near a residential neighborhood.

The criteria to be used in evaluating the renovation options should be carefully defined. The importance attached to each of these criteria is a function of local priorities; as an example, some counties may place a greater emphasis on energy use impacts than on air quality issues. As a further complication, it will not always be entirely within the purview of the city or county to independently make these trade-offs; when this is the case, regional, state and federal agencies that have specific authority for various issues should be consulted.

Once the evaluation process is complete, a "Comprehensive Policy Rating" should be assigned to each option. Figure 5 outlines a tabular format method that can be used for prioritizing investment options.

FINANCING

The availability of investment capital, and the costs associated with obtaining that capital, is of critical concern to an owner contemplating system renovation. Financing requirements for maintaining, upgading and replacing system components can easily run into the millions of dollars. Generally, the choices available are internal investment, traditional financial markets, government grant and loan assistance, third party investors, or a hybrid financial package. The decision will most likely rest on both the present financial status of the system owner and the anticipated return on investment likely to occur from undertaking any given measure.

The system owner, particularly a utility, may have substantial financial resources at its disposal for funding a comprehensive district heating renovation program. In this case, the expenditures would be obtained in any number of ways, including internal capital improvement appropriations, the creation of a financial subsidiary, or reliance on the traditional financial market. If the utility has a favorable bond rating, generally AA or better, it should be able to acquire investment capital at a preferred interest rate.

If the system owner is a municipality, acquisition of investment capital may pose more of a problem. Most local governments are hardpressed to draw funds from municipal capital improvement budgets. Revenue and general obligation bonds are a possible option, but both cities and states have tightened guidelines for bond issuance. Federal and state grants can be obtained for preliminary planning and feasibility studies, but generally not for hardware

Figure 5

IMPACTS

OPTION	FINANCIAL INDICATOR	TECHNICAL				ENVIRONMENTAL					ECONOMIC				INSTITUTIONAL			COMPREHENSIVE POLICY RATING
		INSTALLATION	OPERATION	SAFETY RISK	RELIABILITY	AIR QUALITY	NOISE/AESTHETICS	ENERGY	LAND	WATER	CITY/REGIONAL	MUNICIPAL OPERATIONS	UTILITY	END-USER	CITY	UTILITY	STATE/FEDERAL	

acquisition. Federal Urban Development Action Grants (UDAG) might be available if the locality can show a direct relationship between system renovation and local economic development.

System owners might be able to interest a limited partnership to provide the financing necessary to implement a comprehensive energy management and renovation program. In many instances, federal tax laws provide limited partnerships with financial incentives sufficient to justify investments in energy management technologies. These incentives are generally not available to the system owner, especially if the owner is either a utility or public body. An example would be the purchase, installation and operation of a cogeneration unit by a limited partnership to provide heat to a municipally owned district heating system. Revenue would be derived from both the sale of electricity to the utility and the sale of heat at a discounted rate to the district heating system. In addition, the limited partnership can derive revenue from federal and state tax credits, equipment depreciation and other allowable deductions.

Third party financing does not require any initial capital outlay on the part of the system owner. This provides a significant incentive to owners who, though interested in system renovation, cannot finance the necessary improvements on their own. Negotiating a third party financing arrangement can be extremely time consuming, however, owing to the complexities in federal and state tax laws. The Internal Revenue Service will not issue an opinion as to the legitimacy of a particular tax shelter until well after the contractual agreements have been completed. Finally, existing federal tax laws, which have led to the development of limited partnerships for energy investments, are currently under Congressional scrutiny.

SUMMARY

The six-phases described in this chapter represent a logical approach to examining the feasibility of energy management measures designed to renovate old steam-based district heating systems. It is necessary that a planning approach be designed so that local officials can work with various members of the local community to identify system problems and develop solutions to these problems. Regardless of whether research is delegated to staff or a consultant, establishing a citizens committee is crucial to obtaining community consensus on this issue. In addition, the owner must be willing to fully participate in this process. Otherwise, the committee's work will have very little influence on future decisions regarding system operations.

Collecting and organizing information related to the system's operations is a prerequisite to identifying problem areas of the system. This information will pertain to the generation, distribution, end-user and economic aspects of the system. Problem areas will generally relate to the fuel source; the age and condition of the generating and distribution equipment; and the heat consuming characteristics of the customers. Once problems have been outlined, energy management options must be found for either solving or mitigating these problems. For older steam systems, these options will generally include fuel source substitution; undertaking a preventive maintenance and capital improvement program for the generation and distribution systems; and reducing waste and leveling the demand at the end-user level.

Technical solutions inevitably impact areas which operate outside traditional investment analysis. As such, energy management options must not only be evaluated according to technical and investment criteria, but also public policy merits. Options which meet an owner's investment criteria and have either a neutral or positive influence on public policy should then be recommended for implementation. At this point, financing becomes a key issue. Possible financing sources include the system owner, the state and federal governments, and third party investors. Present federal and state tax laws make third party financing an attractive option that merits serious consideration. This is especially so if the owner is a public body.

3

SAN FRANCISCO : A CASE STUDY

CHAPTER III -- SAN FRANCISCO: A CASE STUDY

BACKGROUND

In 1980 the San Francisco Department of City Planning staffed an energy section under grant funding to develop an energy element for the City's Master Plan. The Mayor, with the support of the Board of Supervisors, appointed a fifteen member committee, drawn from diverse backgrounds within the community, to advise the City in its formulation of an energy policy and development of an energy management program. In April 1982 the Citizens Energy Policy Advisory Committee (CEPAC) issued its final report; the San Francisco City Planning Commission adopted the CEPAC report as the action program for implementing the Energy Policy component of the Master Plan. As part of the work program, staff was directed to assess the potential use of integrated energy systems, such as cogeneration, district heating and waste heat systems.

In October 1982 the Mayor appointed a technical advisory committee to assist staff in evaluating district heating and cooling technology. Specifically, the Mayor directed the District Heating and Cooling Committee to develop recommendations concerning the technical and economic feasibility of renovating two older district heating systems operating in San Francisco.

The Committee convened in January, 1983. A work program and time schedule were reviewed and adopted at the January meeting. The Committee was to meet on a monthly basis; agenda materials were sent to members prior to each meeting to increase the effectiveness of the meetings. The first few months of Committee activity were directed at obtaining documentation on system operations. This was followed by an assessment of system problems and a review of technical renovation options.

Staff prepared a draft report in September, which outlined the pros and cons of various strategies; several of these were selected by the Committee for further documentation and refinement. A second draft report was presented for

Committee review in December, at which time recommendations were agreed upon and the report endorsed. The report then underwent public review; comments received were discussed and, in most instances, incorporated into the document. The final report was submitted to, and endorsed by, the Mayor in March, 1984. With the Mayor's endorsement, city departments are presently carrying out the Committee recommendations.

PLANNING

An advisory committee structure was selected for two reasons. First, the Mayor's Office made it clear from the outset that it would consider only those recommendations that had the near unanimous support of the community. As a result, it was necessary to bring together the various interest groups - system owners, system users, consulting engineers, and architects - in order to obtain a community consensus on specific issues. An advisory committee structure was seen as an appropriate vehicle for accomplishing this objective.

Second, the Mayor directed staff to report back in one year with findings and recommendations on the two steam systems. The time constraints imposed by this schedule necessitated outside technical assistance. At the same time, the study was to be conducted primarily by staff, since one of the major objectives of the Energy Task Force is to develop in-house staff expertise on various energy issues. Rather than employ an outside consultant, staff decided to utilize the talents and resources of an advisory committee to assist in much of the technical and financial aspects of the work program.

The Committee was initially comprised of eight members, including the Mayor's Office (project manager); the Department of City Planning (Committee chair, and staff); Pacific Gas and Electric Company (PG&E -- the owner of the larger system); Building Owners and Managers Association (BOMA -- representing a large number of system users); the Association of Energy Engineers (AEE -- representing engineering consultants); the American Institute of Architects (AIA -- representing architects and providing state regulatory expertise); and Lawrence Livermore and Berkeley National Laboratories (LLNL and LBNL -- providing technical expertise). A representative of the Department of Public

Works (DPW -- operator of the municipal system) was added as a ninth member in March. Two staff interns performed selected research functions.

INFORMATION ACQUISITION

San Francisco's two district heating systems both date from the early 1900's. One system is owned and operated by Pacific Gas and Electric Company (PG&E), while the other is owned and operated by the municipality. Figure 6 outlines the service area for each of these systems. General profiles of the systems are provided in Table 4. Both systems use steam boilers to convert natural gas into thermal energy for distribution to end users.

Municipal District Heating System. The Civic Center Power Plant has been providing steam to municipal buildings within the Civic Center since 1915. Seven buildings receive steam for space and water heating; two of these also require steam for sterilization equipment. Spent steam (condensate) is returned to the power plant for re-use by the boilers. The highest steam loads are morning (6 - 9AM) warm-up loads. The peak hourly steam load is approximately 5 to 6 times the average hourly load, and generally occurs on a Monday morning in January. City Hall represents the largest steam user, accounting for an estimated 52 percent of total system consumption.

Annual fuel costs for the Municipal system have increased by 710 percent over the past decade, from $0.06 million in FY 1973-74 to $0.47 million in FY 1982-83. Fuel currently represents 64 percent of the total system operating costs. Natural gas is purchased from PG&E at commercial rates. The California Energy Commission expects natural gas prices in the PG&E service territory to increase by 2.5 percent annually over and above inflation through the year 2000. Should this occur, and should immediate steps not be taken to improve the economics of the system, fuel costs for the municipal system will exceed $0.85 million by the end of 1990 (assuming a general inflation rate of 6 percent). Figure 7 illustrates this dramatic cost increase over the past decade, and projects fuel costs through 1990, assuming that operations continue with no-change.

Figure 6

SAN FRANCISCO DISTRICT HEATING SYSTEMS

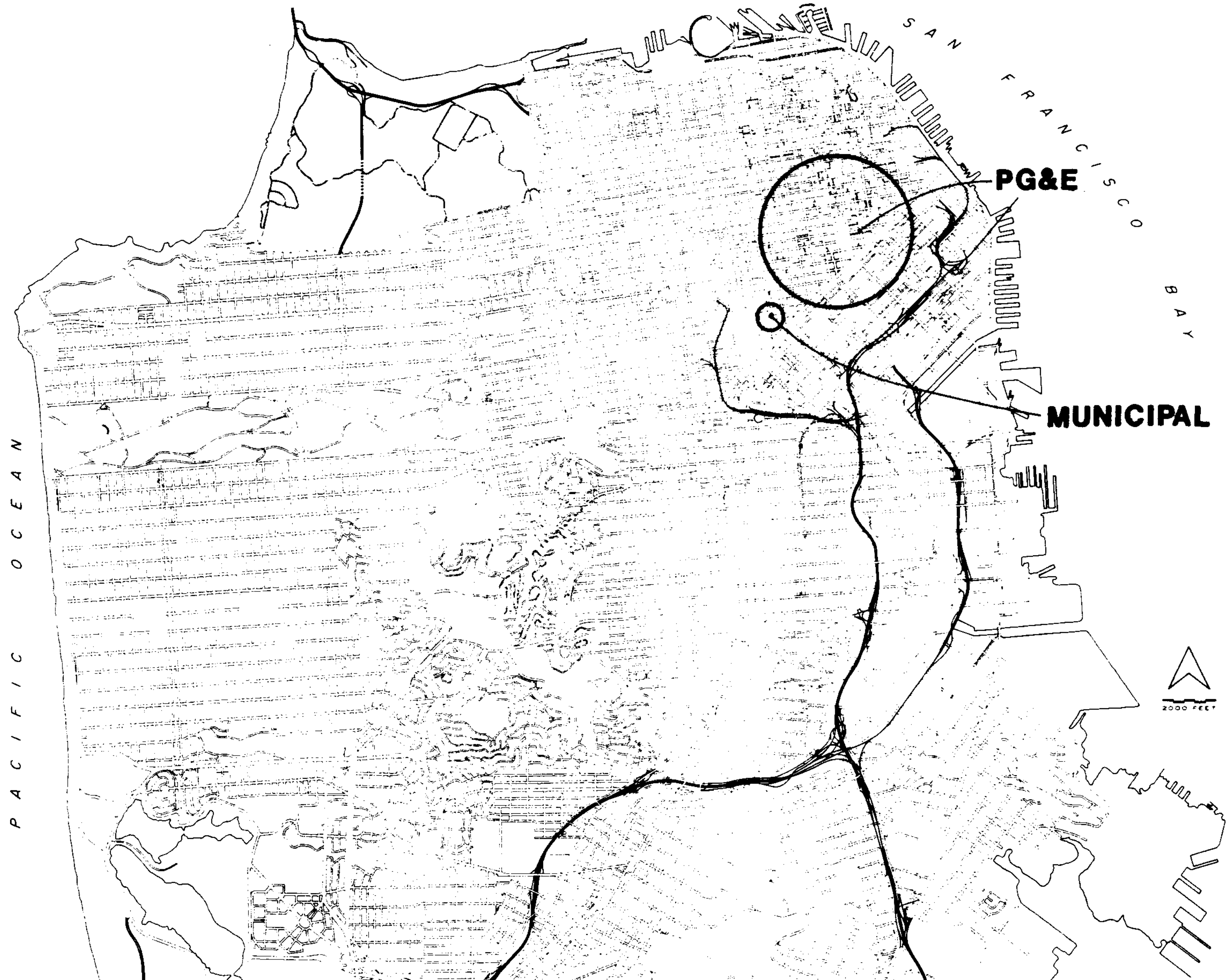


Table 4

Profile of San Francisco's District Heating Systems

	MUNICIPAL	PG&E
Fuel (Back-up)	Natural Gas (Fuel Oil)	Natural gas (Fuel Oil #2)
Number of Boilers	One Station 2 @ 25,000 Lbs./hr.	Two Stations; Station S: 2 @ 65,000 lbs./hr. Station T: 5 @ 50-100,000 lbs./hr.
1982 Generation ('000's lbs.)	51,289	689,000
Capacity Factor	12%	19%
Generation Efficiency	68% (estimated)	77.4%
Distribution Length	0.6 Miles	11 Miles
Distribution Efficiency	70% (estimated)	70%
Service Area	0.03 Sq. Miles	0.63 Sq. Miles
Number of Customers	7 Municipal	226 -- Mostly Commercial
1982 Operating Costs	$700,000	$7,133,000
1982 Profit	N/A	-$616,000

Pacific Gas and Electric District Heating System. PG&E has been the only supplier of steam to buildings in downtown San Francisco since it acquired the Great Western system in 1930. The PG&E system consists of two generating facilities. Station T, which contains five steam boilers, is base-loaded (i.e. operated around-the-clock), while Station S, which contains two steam boilers, is operated as a peaking plant.

The system currently serves 226 customers in the financial and retail districts. Steam is reduced in pressure in almost all buildings for space and water heating purposes. In a few cases, steam is used at higher pressures for absorption chilling and retail processes (e.g. laundries and kitchens). The spent steam (condensate) is reduced in temperature at or below 140° F, and discharged into the City storm sewer system.

The highest steam loads are morning warm-up loads (6 - 9 AM); the peak hourly steam load is approximately 3 to 4 times the average hourly load, and generally occurs on a Monday morning in January. The demand for steam is concentrated among a very small number of customers, located primarily in the eastern section of the system. Approximately 10 percent of the customers account for approximately 75 percent of the total system demand.

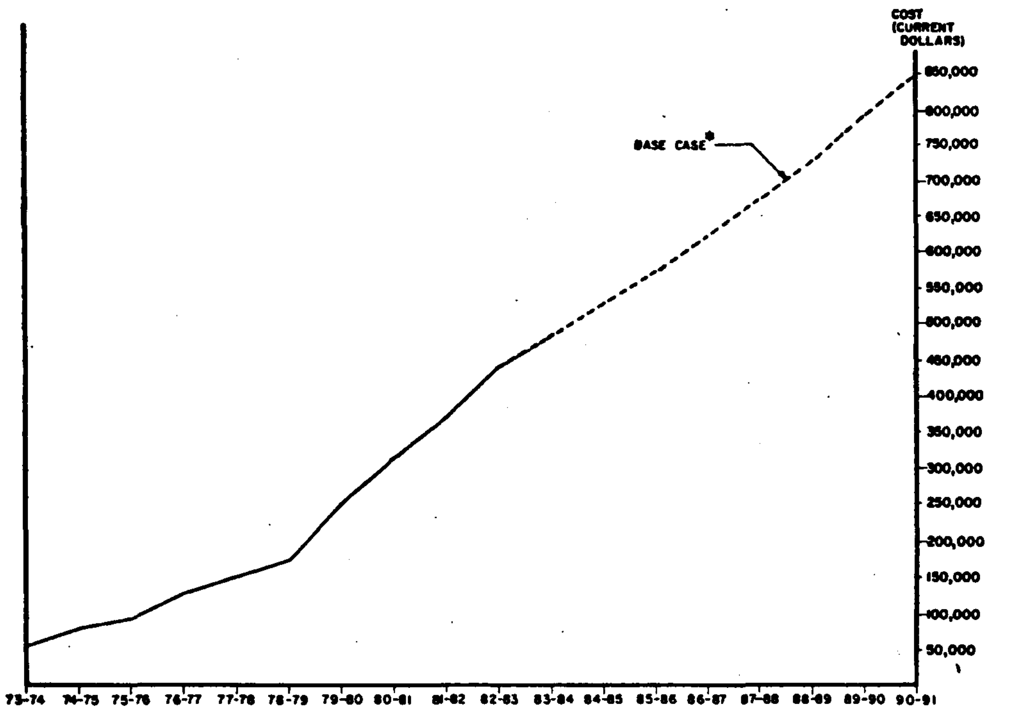
Annual operating costs for the PG&E system in 1982 amounted to $7.13 million. Of this, fuel costs accounted for 75 percent, operation and maintenance accounted for 19 percent, and administration accounted for 6 percent. Steam sales in 1982 generated $5.46 million in revenues, resulting in after-tax losses to PG&E of approximately $0.61 million. This represents a continuing pattern of deficit operations for the system over the past several years. Unless actions are taken immediately to improve the operating efficiency of the system, the revenue/expenditure gap is expected to increase significantly by 1990. The expenditure side of this situation is illustrated in Figure 7.

PROBLEM IDENTIFICATION

The Committee was able to use documentation obtained on the operating characteristics of both the PG&E and Municipal steam systems to highlight the major problems encountered by these systems.

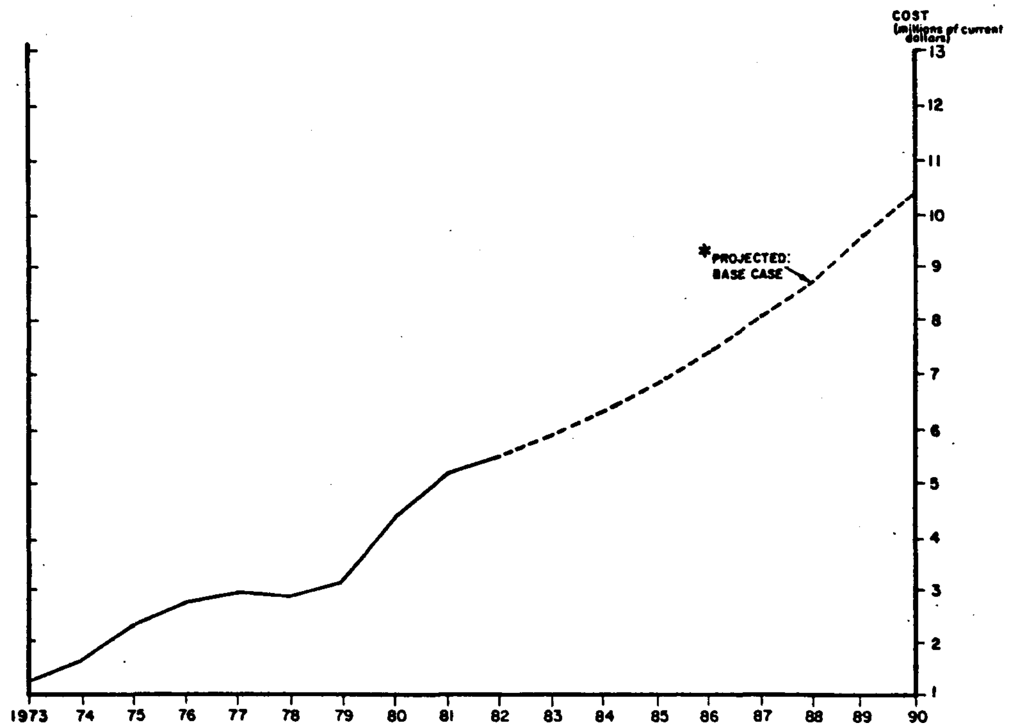
Figure 7

HISTORICAL AND PROJECTED FUEL COSTS FOR THE MUNICIPAL STEAM SYSTEM



* PROJECTIONS BASED UPON CALIFORNIA ENERGY COMMISSION ESTIMATE OF 2.5 % AVERAGE ANNUAL REAL RATE OF NATURAL GAS PRICE INCREASE, INFLATION AT 6%, AND ANNUAL CONSUMPTION OF 75 BILLION BTU'S.

HISTORICAL AND PROJECTED FUEL COSTS FOR THE PG&E STEAM SYSTEM.



*PROJECTIONS BASED UPON CALIFORNIA ENERGY COMMISSION ESTIMATE OF 2.5 % AVERAGE ANNUAL REAL RATE OF NATURAL GAS PRICE INCREASE, INFLATION AT 6%, AND STEAM SALES OF 480 MILLION POUNDS PER YEAR.

Fragmented Management. The responsibility for managing the Municipal steam district heating system is not clearly delineated. Within the Department of Public Works, the Bureau of Building Repair has responsibility for day-to-day operations. The Bureau of Engineering provides technical assistance to the Bureau of Building Repair. No one agency, however, has overall management responsibility. There is a lack of planning for long-term maintenance and inadequate recordkeeping concerning system repairs. The system's "physical history" is not available, which makes it difficult to plan for future capital improvement needs.

The PG&E steam district heating system represents a miniscule portion of the utility's assets and operating budget. The rate base for the steam system is approximately $2.5 million, as compared with several billion for both the electric and gas departments. Moreover, the marketing of steam is in direct competition with gas and electricity for providing heat. As a result, the steam system is a low corporate priority item.

This is reflected in the present fragmented management structure. The generating component of the steam system is the responsibility of the electricity department, while the distribution component of the steam system is the responsibility of the gas department. System marketing activities is the responsibility of a separate marketing department. This disaggregated management structure places the steam system at a clear disadvantage when competing with both the electric and gas departments for limited financial resources.

Fuel Costs. Fuel costs for both the Municipal and PG&E steam systems represent approximately two-thirds to three-quarters of annual operating costs. This is due primarily to the systems' reliance on natural gas, purchased by both systems at retail rates. Thus, no fuel savings are offered to buildings connected to the systems; nor are these buildings insulated from future natural gas price increases. Alternate fuel sources, such as heavy crude oil and coal, are available; however, environmental problems associated with these fuels have, to date, preempted their use in San Francisco.

Generation and Distribution Problems. The combined efficiency of the generation and distribution networks is estimated to be 49 percent for the Municipal system and 58 percent for the PG&E system; approximately one half of the energy content inherent in the fuel source is actually delivered to the system users. Each system has either generation or distribution problems that accounts for this low efficiency rating.

The Municipal steam boilers, which are approximately 70 years old, are operating at fairly low efficiency levels. The annual average efficiency of the boilers is between 65 and 70 percent, approximately 10 percentage points below current industry standards. The valves, feedwater pumps and other boiler components are also in need of repair or replacement.

The distribution portion of both the PG&E and municipal systems is approximately 70 percent efficient, approximately 13 percentage points below current industry standards. This low efficiency rating can be attributable to ineffective insulation, corroded pipes, inefficient or no return of condensate, and inoperative traps.

The primary insulating materials for both the Municipal and PG&E systems are asbestos and redwood staves and shavings. These materials are far less effective at preventing heat loss to the surrounding environment than other insulating materials currently available. There are sections of pipe in both systems which have developed leaks over the years. Specific leakage locations are difficult to pinpoint, but their presence is evidenced by large steam losses occurring throughout the distribution system. The amount of heat being lost through the distribution system is magnified by the current practice of maintaining system pressures at high levels, regardless of steam demand.

The PG&E system does not return condensate to the power plant; hence, significant amounts of low-grade heat, water and chemicals are wasted. The Municipal system does have a condensate return system; however, it is subject to excessive leakage. Many of the steam traps in the Municipal system are inoperative, resulting in an additional amount of steam losses.

Buildings. Buildings connected to the Municipal system use steam relatively inefficiently. This is due to several factors. All of the buildings were constructed when energy was not a factor in architectural design. Consequently, they use more energy, i.e. Btu's per square foot of occupancy, than comparable structures built under California's statewide energy design standards (Title 24). The HVAC equipment itself is fairly old and less energy efficient than state of the art systems. Finally, the building occupants generally have poor energy habits. For instance, it is fairly common for steam radiators (which provide heat to the perimeters of most of the buildings) to be operating, while windows are open to vent excess heat. To date, the City does not have an employee energy awareness program.

The number of PG&E system customers has been declining steadily since 1933, reaching an historic low of 226 in 1983; steam use, both system-wide and on a per-customer basis, has been declining since reaching an historic peak in 1973. PG&E has repeatedly expressed an interest to the California Public Utilities Commission (CPUC) over the past two decades to get out of the steam business. The CPUC has responded by placing a condition that would allow PG&E to get out of the steam business only if the utility provides a substitute heat source for all present customers. PG&E has estimated that the costs of complying with this provision would cost in excess of $40 million.

A recent survey conducted by the Department of City Planning suggests that economic considerations are one reason several customers have recently terminated or curtailed use of steam from PG&E; given present steam system operations, the economics strongly favors using on-site systems to provide space and water heating, cooling and processed heat. (See Appendix B) Moreover, many of the customers and energy engineering firms surveyed expressed a lack of faith in PG&E's corporate commitment to the steam system. There is a strong feeling among some steam customers that, were it not for the CPUC condition on substitute heat sources, PG&E would terminate its involvement in steam operations.

TECHNICAL RENOVATION OPPORTUNITIES: AN INVESTMENT ANALYSIS

Based on problems highlighted by the research analysis, the Committee concluded that neither the Municipal nor the PG&E steam system was providing energy either efficiently or economically to existing users. Given this conclusion, the Committee reviewed several technical options to improve overall system performance: implementing an energy management program, installing new steam boilers, replacing the steam boilers with hot water boilers, integrating a cogeneration unit into the boiler network, system intertie, incorporating central chilling, and system decommissioning.

Each of the options identified was first evaluated according to its technical merits. Options deemed technically inappropriate were eliminated from further consideration. Examples of technically inappropriate options included central chilling, and using the Municipal loop as a heat storage plant for PG&E off-peak cogenerated steam.

The remaining options were then analyzed from a financial investment perspective. Simple payback was used as the principal indicator of financial merit for the Municipal system, since it is one with which most policy makers in San Francisco are familiar. Simple payback, as used in this analysis, is defined as the number of years in which the investor's financial investment would be recovered, where all first-year costs are net of what would otherwise be required to continue system operations with no change. If an option showed a simple payback of ten years or more, it was eliminated from further consideration. The replacement of the existing Municipal steam boilers with new steam boilers was eliminated on this basis.

Levelized cost avoidance was used as the principal indicator of financial merit for the PG&E system. Levelized cost avoidance is defined as a constant, annual cost avoidance, the present value of which is equivalent to the present value of the actual stream of escalating cost avoidances; it is analogous to an even payment loan. The actual stream of cost avoidances was assumed to increase 8.5 percent per year (California Energy Commission estimates of 2.5

percent average natural gas price increase through the year 2000, plus a 6 percent inflation rate). Future cash flows were discounted at a 10 percent rate over a 30 year period.

The levelized cost avoidance, net of PG&E's revenue requirements for the measures, yields a surplus which can be returned directly to the system's customers in the form of reduced steam rates. In the absence of any improvements to present system operations, the levelized steam rate was estimated to be $33.50 per thousand pounds over the next 30 years (the current steam rate is $13.14 per thousand pounds).

Table 5 presents the results of the financial analysis undertaken for both the Municipal and PG&E steam district heating systems. Figure 8 displays projected system fuel costs if Committee recommendations are undertaken.

Options which met the financial investment guidelines were then evaluated for their Comprehensive Policy Rating. Comprehensive Policy Rating (CPR), as used in this study, was based on a defined set of criteria: technical issues, use of energy and natural resources, pollution and noise emissions, economic consequences and political feasibility. Table 6 outlines the CPR. The criteria were, in most instances, given equal weight in determining the overall ranking. In some cases the impacts or uncertainties associated with a given option were sufficient to rule out further consideration. As an example, the financial and political problems associated with decommissioning either the Municipal or PG&E steam system were sufficient to render this option unattractive overall. Because of this, the final ranking order of options was not always simply the sum total of impacts.

The recommendations which follow are those that would, in the aggregate, provide constructive improvements to the operation of both the Municipal and PG&E systems. They are presented in order of importance, based upon their CPR. A technical report is available from the Energy Group, Department of City Planning, that provides detailed economic analysis for each of the Committee recommendations.

Table 5

Financial Analysis of Municipal System Options
(All Values in 1984 $ million)

Description	Symbol*	Preventive Maintenance/ Capital Improvements	Cogeneration	Cogeneration Conversion of Dist'n System	System Decommissioning	Hot Water Boilers; Conversion of Distribution System	System Inter-tie/ Cogeneration	High Pressure Steam Boilers
ABSOLUTE INITIAL INVESTMENT	Io	0.25	6.56	8.30	2.60	3.03	1.73	1.29
ABSOLUTE	O_1	-0.23	-0.23	-0.23	-0.05	-0.05	-0.05	-0.23
ANNUAL	M_1	-0.03	-0.06	-0.07	-0.02	-0.04	-0.01	-0.03
COSTS	F_1	-0.38	-1.59	-1.60	-0.30	-0.31	-0.51	-0.39
(Year 1)	E_1		+1.74	+1.87				
	C_1		+0.46	+0.46				
	TOTAL	-0.64	+0.33	+0.43	-0.37	-0.40	-0.57	-0.65
NET	O_{1n}	0	0	0	+0.18	+0.18	+0.18	0
ANNUAL	M_{1n}	0	-0.03	-0.04	+0.01	-0.01	+0.02	0
COSTS**	F_{1n}	+0.06	-1.15	-1.16	+0.14	+0.13	-0.07	+0.05
(+ or - de-	E_{1n}		+1.74	+1.87				
notes net	C_{1n}		+0.46	+0.46				
savings or costs)	TOTAL	+0.06	+1.02	+1.13	+0.33	+0.30	+0.13	+0.05
NET PAYBACK (yrs) (ABS. INV./ FY COSTS)		0.25/ 0.06 = 4 to 6	6.56/ 1.02 = 6 to 8	8.30/ 1.13 = 7 to 9	2.60/ 0.33 = 9 to 11	3.03/ 0.30 = 10 to 12	1.73/ 0.13 = 13 to 15	1.29/ 0.05 = 25 to 27

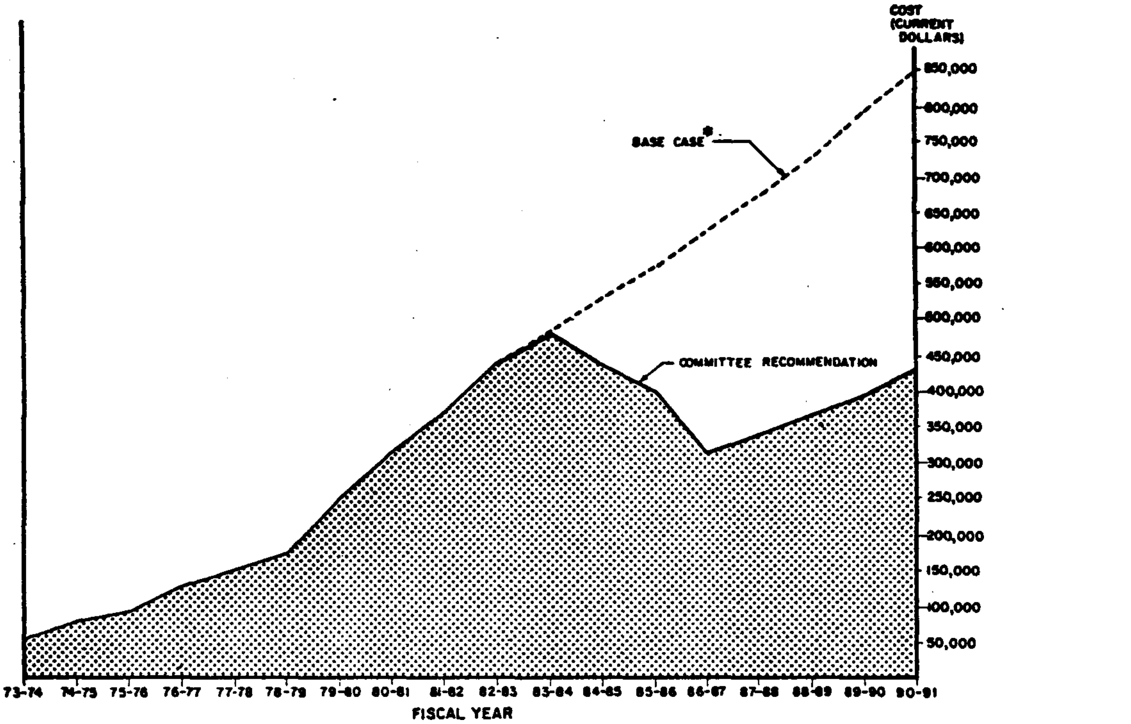
* O_1 = First Year Operating Costs; M = Maintenance; F = Fuel; E = Electricity Revenues; C = Capacity Revenues.
** These figures are net of the costs for the existing operations. The annual costs of the existing steam system are $0.23 million for operation; $0.03 million for maintenance; and $0.44 million for fuel.

Financial Analysis of PG&E System Options
(All Values in 1984 $ million)

Description	Abandonment/ Replacement of Portions of Main	Replace Traps; Insulate Exposed Main	Centralized Cogeneration	Decentralized Cogeneration	Expansion of Customer Base	Pressure Reduction	Hot Water Conversion Wholesale	System Decommissioning
Capital Expenditure	12.14	0.18	30.00	Assumed $0.0, But TBD	NA	TBD	$19.64	$50.00
First-Year Cost Avoidance/Revenues	1.99	0.22	21.33	0.70	NA	TBD	$ 1.32	$0.61
First-Year Costs	0.00	0.00	12.98	0.00	NA	TBD	TBD	$0.00
First-Year Net Cost Avoidances/ Revenues	1.99	0.22	8.35	0.70	NA	TBD	$ 1.32, But TBD	$0.61
Levelized Pre-Tax Net Revenues	4.60	0.57	14.74	1.77	NA	TBD	$ 2.61	$1.55
Levelized Pre-Tax Revenue Requirements	1.62	1.62	4.02	Assumed $0.0, But TBD	NA	TBD	$ 2.61	$6.65
Levelized Surplus	2.98	2.96	10.72	Assumed $1.77 But TBD	NA	TBD	$ 0.00	-$5.10
Steam Rate Reduction (Levelized $/ M Lbs.)	6.16	1.15	22.33	3.69	NA	TBD	$ 0.00	NA
Percentage Reduction of Estimated Levelized Rates	.18	.03	.67	0.11	NA	TBD	0.00	NA

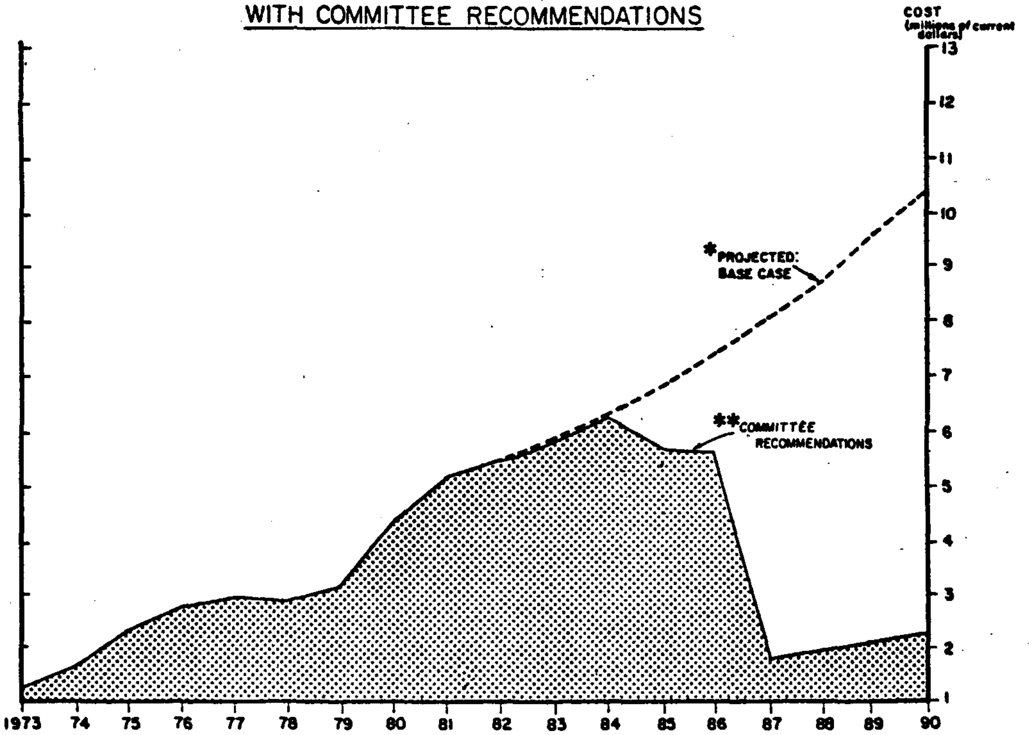
Figure 8

HISTORICAL AND PROJECTED FUEL COSTS FOR THE MUNICIPAL STEAM SYSTEM WITH COMMITTEE RECOMMENDATION



*PROJECTIONS BASED UPON CALIFORNIA ENERGY COMMISSION ESTIMATE OF 2.5 % AVERAGE ANNUAL REAL RATE OF NATURAL GAS PRICE INCREASE, INFLATION AT 6%, AND ANNUAL CONSUMPTION OF 75 BILLION BTU'S.

HISTORICAL AND PROJECTED FUEL COSTS FOR THE PG&E STEAM SYSTEM. WITH COMMITTEE RECOMMENDATIONS



*PROJECTIONS BASED UPON CALIFORNIA ENERGY COMMISSION ESTIMATE OF 2.5 % AVERAGE ANNUAL REAL RATE OF NATURAL GAS PRICE INCREASE, INFLATION AT 6%, AND STEAM SALES OF 480 MILLION POUNDS PER YEAR.

** ASSUMES THAT EXCESS WASTE HEAT PRODUCED BY COGENERATION UNIT (INSTALLED IN 1987) IS TRANSFERRED AT NO COST TO THE STEAM SYSTEM.

Table 6

Municipal System -- Comprehensive Policy Rating

IMPACTS*

OPTION		TECHNICAL				ENVIRONMENTAL					ECONOMIC				INSTITUTIONAL			
	FINANCIAL INDICATOR**	INSTALLATION	OPERATION	SAFETY RISK	RELIABILITY	AIR QUALITY	NOISE/AESTHETICS	ENERGY	LAND	WATER	CITY/REGIONAL	MUNICIPAL OPERATIONS	UTILITY	END-USER	CITY	UTILITY	STATE/FEDERAL	COMPREHENSIVE POLICY RATING
Preventive Maintenance Capital Improvement	4-6	-	+	+	+	+	+	+	0	+	+	+	-	+	+	0	+	1
Cogeneration	6-8	-	-	-	+	+	-	+	+	+	+	+	0	+	+	+	+	2
Cogeneration; Conversion of Distribution System	7-9	-	-	-	+	+	-	+	+	+	+	+	0	+	+	+	+	3
Hot Water Boilers	10-12	-	-	-	+	+	0	+	0	+	+	+	0	+	+	0	+	4
PG&E Intertie/ Cogeneration	13-15	-	+	+	0	0	+	0	0	-	+	+	+	+	0	+	0	5
System Decommission	9-11	-	+	-	-	-	-	+	-	+	+	+	-	+	-	0	-	6

* See the following legend for description of rating system.
** Estimated payback in years.

PG&E System -- Comprehensive Policy Rating

IMPACTS*

OPTION		TECHNICAL				ENVIRONMENTAL					ECONOMIC				INSTITUTIONAL			
	FINANCIAL INDICATOR **	INSTALLATION	OPERATION	SAFETY RISK	RELIABILITY	AIR QUALITY	NOISE/AESTHETICS	ENERGY	LAND	WATER	CITY/REGIONAL	MUNICIPAL OPERATIONS	UTILITY	END-USER	CITY	UTILITY	STATE/FEDERAL	COMPREHENSIVE POLICY RATING
Abandonment/Replacement of Main	6.16	-	+	+	+	-	-	+	-	+	+	0	+	+	+	+	+	1
Replace Steam Traps/ Insulate Exposed Main	1.15	-	+	+	+	+	+	+	+	+	+	0	+	+	+	+	+	2
Centralized Cogeneration	22.33	-	-	-	+	+	-	+	+	0	+	0	+	+	+	+	+	3
Decentralized Cogeneration	3.70	-	-	-	+	+	-	+	+	0	+	0	+	+	+	+	+	4
System Expansion	NA	-	-	0	+	+	+	+	+	-	+	0	+	+	+	+	+	5
Pressure Reduction	NA	-	-	+	+	+	+	+	+	+	+	0	+	+	+	+	+	6
Hot Water Conversion	NA	-	-	+	+	+	+	+	+	+	+	0	+	+	+	+	+	7

* See the following legend for description of rating system.
** Levelized rate reduction in $/thousand pounds of steam (In absence of these measures, levelized steam rate is estimated at $33.50/thousand pounds).

Legend for Table 6: Comprehensive Policy Rating

IMPACT CATEGORY	DESCRIPTION
Technical	
Installation	Would the installation of the project equipment be less difficult (+), as difficult (0), or more difficult (-) than the existing equipment?
Operation	Would the operation of the project equipment be less complex (+), as complex (0), or more complex (-) than the existing equipment?
Safety Risk	Would the operation of the project equipment pose a lessor (+), equal (0), or greater (-) risk to safety than the existing equipment?
Reliability	Would the project equipment provide heat with a greater (+), equal (0), or lessor (-) degree of reliability than the existing equipment?
Environmental	
Air Quality	Would the proposed project result in an enhancement (+), no change (0), or violation (-) of local and regional air quality standards?
Noise/ Aesthetics	Would the proposed project result in decreased (+), no change (0), or increased (-) noise levels and aesthetic effects?
Energy	Would the proposed project result in a decrease (+), no change (0), or increase (-) in the amount of energy needed to provide energy services?
Land	Would the proposed project result in a decrease (+), no change (0), or increase (-) in the amount of land needed to provide energy services?
Water	Would the proposed project result in a decrease (+), no change (0), or increase (-) in the amount of water needed to provide energy services?
Economic	
City/Regional	Would the proposed project improve (+), not affect (0), or adversely affect (-) the economic strength of the City of San Francisco and the Bay Area?
Municipal	Would the proposed project improve (+), not affect (0), or adversely affect (-) the economic strength of City operations?
Utility	Would the proposed project improve (+), not affect (0), or adversely affect (-) the economic strength of the utility?
End-User	Would the proposed project improve (+), not affect (0), or adversely affect (-) the economic standing of the system users?
Institutional	
City	Would the proposed project enhance (+), not affect (0) or conflict with (-) the energy policies in the San Francisco Comprehensive Plan?
Utility	Would the proposed project enhance (+), not affect (0) or conflict with (-) the energy policies of PG&E?
State/Federal	Would the proposed project enhance (+), not affect (0) or conflict with (-) the energy policies of the State of California and/or Federal Government?

Management Commitment. The Department of Public Works should remain the agency responsible for overall operations of the Municipal steam system. However, the steam system will continue to experience serious economic and energy efficiency problems until such time as energy management is instituted as a regular work program function. DPW should extend its management by objective approach to program planning to include energy management. First of all, energy management should be given line item status in the budgetary review process. Second, the Bureau of Building Repair and the Bureau of Engineeering should jointly prepare annual, five and ten year objectives for the steam system, along with operational plans to implement these objectives. Finally, recordkeeping procedures should be established to document the system's "history", including an accounting of all expenditures made on the steam system, manpower requirements, and descriptions of work completed to date. These records should be maintained in a central file for easy access.

PG&E must demonstrate a public commitment to long term operation of its steam system. Commitment could take the form of a strategic plan that: (1) states an intent to continue system operations; (2) outlines concrete steps to improve system operations; and (3) establishes a firm yet flexible financial program for funding system improvements over a ten year period, updated on a five year basis. Adoption of such a plan would indicate to existing customers that the utility is committed to providing competitively-priced steam over the long term.

Preventive Maintenance/Capital Improvements. Both steam systems, particularly the Municipal system, should institute a comprehensive preventive maintenance program. Such a program would serve two purposes: reduce the total amount of system down-time arising from component breakdowns; and reduce heat losses occurring in the generation and distribution components of the system.

Several preventive maintenance and capital improvement measures have been identified for the Municipal steam system: replacement of the steam feedwater pumps; improved water treatment program; identification and replacement of portions of the steam main which are corroded to the point of ineffectiveness; removal of asbestos dust from the vaults (this poses a health hazard to workers and prevents proper maintenance of the equipment in the vaults);

installation of meters throughout the system; and replacement and/or repair of system components which are responsible for excessive heat losses. The latter would involve insulating exposed mains in the vaults, replacing faulty steam traps, and installing thermostat controls on manual radiators to reduce heat losses within the buildings. Approximate costs for several measures are presented in Table 7. The resultant payback would be 4 to 6 years, assuming that this program could attain a 15 percent reduction in fuel consumption.

Table 7

Capital Improvement and Preventive Maintenance Measures -- Municipal System

Water Treatment	$ 20,000
Conversion of Electrical System from DC to AC	$ 50,000
Motor-Driven Feedwater Pumps	$ 50,000
Replace Boiler Valves	$ 30,000
Leak Detection/Distribution System	$ 5,000
Condensate Meter Installation (2 Buildings) and Connection (7 Buildings)	$ 7,000
Remove Asbestos from Vaults	$ 5,000
Insulate Exposed Main in Vaults	$ 10,000
Replace Steam Traps on Distribution Loop	$ 3,000
Repair and Replace Ineffective Main	$ 50,000
Install Steam Flow Meters	$ 20,000
Install Thermostat Controls on 100 Radiators	$ 10,000
TOTAL	$253,000

PG&E has embarked on a capital improvement program that is designed to reduce steam losses throughout the distribution system. Specific elements of this program which have been initiated include a system-wide replacement of steam traps, and the insulation of exposed piping and valves in the vaults. Table 8 presents the levelized cost avoidance of this program. Should this cost avoidance, net of revenue requirements, be distributed to existing steam customers, there will be a 3 percent levelized reduction in steam rates.

Table 8

PG&E Program to Replace Steam Traps and Insulate Exposed Main

1.	Total Capital Expenditure in 1984$	$0.18 million
2.	First-Year Cost Avoidance Due to Reduced Energy Losses	$0.22 million
3.	Levelized Pre-Tax Cost Avoidance	$0.57 million
4.	Levelized Pre-Tax Revenue Requirements	$0.02 million
5.	Levelized Pre-Tax Surplus	$0.55 million
6.	Levelized Steam Rate Reduction (as a % of $33.50) . .	3%

A portion of the the PG&E capital improvement program has yet to be financed. Measures planned include the abandonment of uneconomic portions of main (where steam losses are high and sales are low), and the replacement of portions of main where steam losses are high, but where replacement is more cost-effective than abandonment. Based upon cost and energy savings estimates provided by PG&E, along with maintenance savings estimates developed by the Committee, the levelized pre-tax surplus (levelized cost avoidance net of pre-tax revenue requirements) would be $2.98 million. This could be apportioned to PG&E customers in the form of a 18 percent levelized reduction in the estimated levelized steam rate of $33.50/M lbs. over the next 30 years ($6.16/M lbs. levelized reduction -- assuming that sales remain at approximately 480,000 thousands of pounds). A portion of the surplus could also be used to offset system losses to PG&E; if this latter course is chosen, the surplus will be reduced by approximately 50 percent, since it is subject to taxes. Table 9 summarizes these results.

Table 9

PG&E Proposed Program to Abandon and Replace Portions of Main

1.	Total Capital Expenditure in 1984$	$12.14 million
2.	First-Year Cost Avoidance Due to Reduced Energy Losses	$ 1.45 million
3.	First-Year Cost Avoidance Due to Reduced Maintenance .	$ 0.54 million
4.	Total First-Year Cost Avoidance	$ 1.99 million
5.	Levelized Pre-Tax Cost Avoidance	$ 4.60 million
6.	Levelized Pre-Tax Revenue Requirements	$ 1.62 million
7.	Levelized Pre-Tax Surplus	$ 2.98 million
8.	Levelized Steam Rate Reduction (as a % of $33.50) . .	18%

Committee findings indicate that PG&E should re-evaluate its main abandonment program, updating estimates for both costs and cost avoidances. Moreover, PG&E should consider the joint effects which system improvements, such as replacing steam main with hot water main and increasing the customer base on existing lines, could have in reducing the ratio of steam lost to steam sold in these areas. It may be preferable that PG&E make capital improvements to, and continue to operate particular sections of the system than to abandon them.

Cogeneration Integration. Cogeneration provides the only short term method for reducing the high fuel costs associated with both the Municipal and PG&E steam district heating systems. Due to its high overall efficiency, cogeneration can reduce the aggregate amount of fuel that must be consumed to produce an equivalent amount of electricity and heat through conventional means.

The investment costs associated with integrating a cogeneration unit into the steam systems involve the purchase and installion of the cogeneration equipment, a backup boiler (for the Municipal system), and accessary equipment. The net variable costs include additional fuel and maintenance requirements for the cogeneration system, above what would otherwise be required to produce this heat by the existing steam boilers. The revenues associated with the cogeneration system would be derived from the sale of electricity and capacity to the utility, and steam sales (for the PG&E system).

A preliminary payback analysis was performed for a 2.8 MW gas turbine/steam turbine combined-cycle cogeneration unit for the Municipal system. The system would operate at its maximum capacity; all of the electricity produced would be sold to the utility. Exhaust heat would be fed to a heat recovery steam generator, which would produce steam for use in an extraction-condensing steam turbine. Additional electricity would be produced, providing additional revenues; waste heat would be extracted on an as-needed basis for use by the Municipal steam system.

Installation of this cogeneration system, including back-up, would cost approximately $6.56 million. If operated at an 85 percent capacity factor, it would produce an estimated first-year revenue of $2.20 million from the sale of electricity and capacity to the utility. First year net operating costs, above what would be required for new steam boilers, would be approximately $1.15 million for the fuel, and $0.03 million for maintenance. This system would have a payback of 6 to 8 years. The analysis is summarized in Table 10.

Table 10

Summary of Cogeneration Payback Analysis -- Municipal System

1. Initial Investment:	($6.56 million)
2. First-year Electricity Revenues:	$1.74 million
3. First-year Capacity Revenues:	$0.46 million
4. Net Fuel Costs	($1.15 million)
5. Net Maintenance Costs	($0.03 million)
6. Net Operation Costs	$0.00 million
7. Payback = $6.56/(1.74 + .46 - 1.15 - .03)	6.40 years

Cogeneration integration into the PG&E steam system could take place on a centralized and/or decentralized level. PG&E is now exploring the feasibility of installing a 37 MW cogeneration unit into the steam system. The electricity produced by this system would be transferred to the electric grid, and the waste heat would be directed through a waste heat recovery generator to produce steam for the central steam system. Revenues earned above the utility's allowed return for the investment would be used to reduce steam rates to a level that the utility feels is competitive with on-site heating systems.

The Committee conservatively estimated that the total installed cost of a General Electric gas turbine (the LM 5000 -- indicated as the preferred option by PG&E), including equipment, installation, allowance for funds used during construction, etc., would be approximately $30 million. The LM 5000, nominally rated at 32,760 kilowatts, could be expected to produce 31,100 kilowatts (net of auxiliary loads), with an 85 percent capacity factor. The steam produced from the waste heat could satisfy approximately 80 percent of the heat requirements of the thermal grid; the remainder would be satisfied by the back-up boilers. Revenues, generated from electricity and capacity transfers to the electric department, would amount to approximately $13.37 million (first year) and $4.22 million (levelized), respectively. Cost avoidances for fuel, operation and maintenance would amount to $3.73 million in the first year. The fuel requirements of the cogeneration unit would be approximately $11.96 million for the first year. Additional first-year costs for the cogeneration system include $1.02 million for operation and maintenance.

The levelized net pre-tax revenues/cost avoidance for the LM 5000 cogeneration unit is estimated at $14.74 million; the pre-tax levelized revenue requirements is estimated at $4.02 million. This results in a pre-tax levelized surplus of $10.72 million, which could reduce steam rates by approximately 67 percent ($22.33/M Lbs.) of the estimated 30 year levelized steam rate of $33.50/M Lbs. These figures are based on assumptions regarding system lifetime (30 years); nominal escalation rates for fuel, avoided costs and labor (8.5 percent); and future cash flows discounted at a 10 percent rate. A summary of this analysis is presented in Table 11.

Table 11

Summary of Analysis of Cogeneration Unit for PG&E Station T
(Assuming Abandonment and Capital Improvements Performed Prior to Integration)

1.	First-Year Electricity Revenues	$13.37 million
2.	First-Year Fuel Cost Avoidance	$ 3.13 million
3.	First Year Operation and Maintenance Cost Avoidance	$ 0.60 million
4.	First-Year Fuel Costs for Cogeneration	($11.96 million)
5.	First-Year Maintenance Costs for Cogeneration . . .	($ 0.60 million)
6.	First Year Operating Costs for Cogeneration	($ 0.42 million)
7.	First Year Pre-Tax Net Revenues/Cost Avoidance . .	$ 4.12 million
8.	Levelized Pre-Tax Net Revenues	$10.52 million
9.	Levelized Pre-Tax Capacity Credits	$ 4.22 million
10.	Total Levelized Net Revenues	$14.74 million
11.	Annual Revenue Requirements For Cogeneration Unit .	($ 4.02 million)
12.	Levelized Surplus	$10.72 million
13.	Steam Rate Reduction	$22.33/M Lbs

Both PG&E and steam customers would benefit from this project. The cost avoidances associated with this option are of sufficient magnitude that PG&E could allocate a portion of the surplus to offset its losses on the steam system, perhaps to the point where PG&E could earn the allowed return on rate base (this portion of the surplus would be taxed). The customers would be offered steam rates which are lower than both existing rates and competitive forms of heat ($10.40 per million Btu's).

An alternate cogeneration option involves the installation of on-site units in downtown office buildings which are or will be connected to the PG&E district heating system. Through on-site power generation, a building owner could satisfy all or a portion of the thermal and electrical needs of the building, and sell the excess electricity and waste heat from the cogeneration unit to the utility for use in the electric and thermal grids, respectively. The system could be operated by the building owner, the utility or a third party. By placing an economic value on the waste heat, the economic attractiveness of on-site cogeneration would be enhanced. For its part, the utility may be able to lower the operating costs of the steam system by purchasing this waste heat at a rate which is lower than current heat production costs, provided that such action is allowed or encouraged by the CPUC.

A preliminary economic analysis of this option, based upon a firm waste heat supply of 40,000 pounds per hour (generated collectively by several small cogeneration units), indicates that annual natural gas consumption could be reduced by approximately 52 percent, or roughly 4.5 million therms. Assuming that the price paid for this steam would be set at the cost of natural gas, on a heat equivalency basis, first year costs for the system could be reduced by approximately $0.70 million. This translates into a levelized pre-tax savings of $1.78 million per year for the system, and $3.72 per thousand pounds if distributed to the customers in the form of reduced steam rates. Table 12 presents a summary of this analysis.

Table 12

Decentralized Cogeneration for PG&E Steam System

1. Annual Pounds of Steam Sold to Grid	350 MM Lbs.
2. Energy Savings	453 MM Lbs. of Steam Equivalent.
3. Net Energy Savings	103 MM Lbs. of Steam Equivalent
4. First-Year Value of Heat Sold to Grid	$2.39 million
5. First-Year Cost Reduction for System	$0.70 million
6. Pre-Tax Levelized Cost Reduction for System	$1.78 million
7. Cost Reduction	$3.72/M Lbs.

Additional costs not factored into this analysis involve the identification of office building managers or third parties willing to own and operate a cogeneration unit; negotiation costs between cogenerator, utility and the CPUC; metering and administrative costs associated with buy/sell arrangements and time-of-day rates; reliability concerns related to sudden outages of cogeneration units; and the establishment of an optimum level of heat which the utility would be willing to purchase.

Steam to Hot Water Conversion. Both PG&E and the City should evaluate conversion of their respective distribution systems from steam to hot water. Most modern district heating systems in Europe and the United States use hot water as a heat transfer medium.

The Municipal system could be converted on a wholesale basis without much difficulty, owing to its relatively small size. Buildings would have to be equipped with hot water-to-steam heat exchangers. Additional costs would be associated with the purchase, installation and operation of pumps, and the replacement of the two high pressure steam sterilizers by electric sterilizers. The net annual savings that would result from system conversion include reduced fuel requirements, because of increased efficiency of heat distribution, and reduced manpower requirements for operating the hot water boilers as opposed to the high pressure steam boilers.

A preliminary financial payback analysis of this option was performed for the Municipal steam system, with the "base-case" being the continued operation of the existing steam boilers. The total costs for the conversion, including 15 percent for engineering and design, and 15 percent for contingency, was estimated at $3.03 million. The annual energy savings will be approximately 23,750 million Btu's, with a first-year dollar equivalency of $0.14 million. Electricity to operate the pumps will cost approximately $0.01 million in the first year. Dollar savings resulting from a reduction in manpower requirements was estimated at $0.18 million in the first year. The net payback of this scheme was estimated at 10 years. The analysis is summarized in Table 13.

Table 13

Summary of Hot Water Boiler Payback Analysis -- Municipal System

1. Boiler Purchase and Installation Costs	$1.29 million
2. Balance-of-System Purchase and Installation Costs:	
a. Distribution System	$0.99 million
b. Hot Water-to-Steam Heat Exchangers	$0.22 million
c. Electric Sterilizers	$0.06 million
d. Pump	$0.04 million
e. Engineering Design and Overhead	$0.20 million
f. Contingency	$0.23 million
Sub-Total	$1.74 million
3. Total Initial Costs	$3.03 million
4. First-year Dollar Savings:	
a. Energy	$0.13 million
b. Maintenance	($0.01 million)
c. Labor	$0.18 million
Total	$0.30 million
5. Payback $3.03/$0.30	10 years

The Committee investigated the economics of converting the Municipal distribution system from steam-to-hot water in conjunction with the integration of a cogeneration unit. Conversion at this point in time would eliminate the costs of installing boilers. The annual cost avoidances, over and above that expected for the cogeneration option, includes additional electricity revenues generated from a greater amount of steam flowing through all turbine stages.

The combined payback for this option is estimated at 7-9 years. Although this appears to be an attractive investment, an incremental analysis indicates that the additional expenditure required to perform this conversion is not cost-effective; the payback on the marginal $1.73 million is much greater than 10 years. The major reason is the fact that there are no labor cost savings associated with a combined cogeneration/ hot water conversion project.

Converting the PG&E distribution system from steam to hot water could take place in conjunction with its program to replace deteriorated sections of main. In addition to the costs already mentioned for the Municipal systems, PG&E would need to install a two-pipe system to replace the existing one-pipe system. Nevertheless, the Committee felt that the potential benefits to both the end users and the utility justified recommending that PG&E undertake a comprehensive engineering and economic study.

System Expansion. Should a cogeneration unit be installed in either of these systems, an ample supply of inexpensive waste heat would be available for marketing purposes. The Municipal system would benefit by an increased customer base since the greater steam demand would justify the installation of a larger, more economic cogeneration unit. End-users would benefit by being able to save money on their fuel bills. Connection should occur whenever the investment required for connection, i.e. for distribution piping, would be more than offset by a reduction in energy, operations and maintenance costs.

PG&E could undertake an aggressive marketing program to connect additional buildings to the system in parallel with capital improvements to the system, integration of cogeneration, and replacement of steam mains with hot water mains. Increasing the number of steam customers would reduce the fixed capital costs (cogeneration unit, piping, boilers, administration) allocated to each customer. New customers should be located either adjacent to the existing system, or in an area where the expected demand is sufficient to justify expansion of the system. In the latter case, low temperature hot water should be the preferred heat transfer medium.

System Pressure Reduction. In the PG&E system, the losses associated with the distribution system accounts for approximately 23 percent of the total system contribution. Heat is lost primarily through conduction and radiation, leaks, losses through traps, and losses inside of buildings. The first three causes, conduction, radiation, and leaks, are related to system pressure. Reducing the steam pressure is one relatively low-cost route to reducing distribution system losses.

System pressure reduction could be approached either through a one time, permanent adjustment to the system so that system pressure need not exceed a particular level throughout the entire year, or through reducing system pressure only when there is no demand for high pressure steam. The latter approach, which involves reducing pressure at selected times, seems to be the most appropriate strategy for the PG&E system, since it may be costly to convert all customers currently requiring higher pressure steam.

The energy and dollar savings resulting from reducing steam pressure must be weighed against the costs associated with replacing the deaerater and boiler controls, which currently require steam at pressures of 80 psig and greater. The Committee recommended that PG&E undertake an inventory of the high pressure steam requirements of its customers, investigate the costs associated with the modification or replacement of the related boiler devices which require high pressure steam, and estimate the savings which will result from a system-wide pressure reduction.

FINANCING

Once energy management options were identified and priorities established, the Committee reviewed the issue of financing. It was the Committee's opinion that an effective district heating renovation program could be financed if local decision-makers work cooperatively with businesses, the utility, local lending institutions, and state and federal agencies. Several actions have already been taken to secure financing for many of these recommendations.

Municipal System. The Department of Public Works (DPW) submitted a district heating operations and maintenance program for the FY 1985 municipal budget. Some of the items included under this maintenance package are water treatment, conversion of the electrical system, purchase of motor-driven feedwater pumps, installation of condensate meters in the buildings, insulation of exposed main in the vaults, and removal of asbestos from the vaults.

Municipal funds, in the amount of $35,000, have been secured for a cogeneration study of the steam system, to be undertaken by a consultant under the supervision of the Bureau of Energy Conservation. The study has three primary tasks: (1) audit buildings connected to the Municipal steam system to identify opportunities for reducing heat demand; (2) examine the distribution system to identify opportunities for reducing steam losses; and (3) evaluate the economic merits of a cogeneration system sized to serve the reduced steam load resulting from implementation of the first two steps. The California Energy Commission will reimburse the City for the costs of the study, should cogeneration prove infeasible.

PG&E System. The Energy Group of the Department of City Planning has recently received $80,000 from the Unitied States Department of Energy (USDOE) to develop a plan during 1984 for encouraging the use of on-site cogeneration units in downtown office buildings connected to PG&E's district heating system. If the decentralized cogeneration study is successful, funding for demonstration projects is likely to be available from either the building owners or third party investors.

Funds for system improvements to the PG&E steam system are normally budgeted on an annual basis. Estimates of financial requirements are prepared by the utility's San Francisco Division in advance, and submitted to various levels of management for review and approval. Funds for the insulation of exposed main in the vaults has already been budgeted. It is presumed that the financial resources associated with the abandonment of uneconomic portions of main and capital improvement program can also be obtained from internal sources. The cogeneration system currently under review may have different requirements; a financing decision for the system is pending.

SUMMARY

The City and County of San Francisco, with the assistance of a technical advisory committee, spent the past year evaluating two older steam systems that are presently operating in different parts of the city. The main purpose of the study was to determine whether or not these systems were a valuable local energy supply source and, if so, to ascertain what should be done to improve their overall operating condition. At present, neither the Municipal nor the PG&E steam systems can be considered energy efficient. These systems have serious problems that place them at an economic disadvantage with on site boiler systems. Examples include fragmented management, high operating costs, deteriorating components, declining sales and inefficiencies in operations.

The Committee reviewed options to improve system operations, as well as options to shut down the systems altogether. These options were examined from the standpoint of end users, system operators, and overall societal concerns.

Criteria used in this evaluation included technical and economic feasibility, energy efficiency, environmental compatability, and political acceptability.

The Committee concluded that district heating could play an important role in San Francisco's energy supply system. This conclusion, however, is conditioned upon the efficient use of exhaust heat from a cogeneration facility. As an energy technology, district heating meets the City's energy goals, as stated in the Energy Element to the City's Master Plan, of increasing the efficiency with which energy is used, diversifying the present balance of resource supplies, and fostering the development of local energy resources.

The Committee recommendations provided a policy framework which supports the continued use of both the Municipal and PG&E steam systems. Recommendations of major importance included the implementation of a systematic preventive maintenance program, integration of cogeneration with steam operations, selected expansion of the customer base within the existing service areas, and eventual conversion of the distribution network to hot water. Actions are already being taken to implement Committee recommendations.

4

LESSONS LEARNED AND SUGGESTIONS FOR APPLICATION

CHAPTER IV: LESSONS LEARNED AND SUGGESTIONS FOR APPLICATION

This project was undertaken to develop a procedure by which local governments could examine old steam-based district heating systems. Once developed, the procedure would enable a city or county to identify and evaluate renovation opportunities for improving system performance. The procedure designed by the City and County of San Francisco encompasses six principal phases: general planning; information acquisition; problem identification; renovation opportunity selection; investment evaluation; and financial analysis. The procedure was then applied to two older steam systems presently operating in San Francisco. Application of the procedure to the San Francisco systems led to further refinements, and recommendations for use by other jurisdictions.

LESSONS LEARNED

Advisory Committee Structure. The primary purpose of the San Francisco study was to prepare recommendations to the Mayor on the merits of renovating two older steam systems. It was a considerable task to locate, obtain and analyze the information needed to develop reliable recommendations on the two systems. One of the principal lessons learned from this experience is that the research, analytical and administrative requirements of conducting such a study can overwhelm the limited staff capabilities of most cities and counties. The advisory committee structure that was used to both assist and guide staff in the conduct of this study proved invaluable in this regard.

A significant amount of information was obtained on district heating in general, and on San Francisco's steam systems in particular. This information was useful not only for the current study, but also for follow-up work on the systems. The very process of obtaining this information involved Committee interaction with representatives of the community, including various government agencies, utility representatives, engineering consultants, architects, building owners, local policy-makers, and citizens at-large. As a result, the study received a fair amount of local publicity. This publicity served to raise the overall level of local awareness regarding district heating as a possible energy supply option.

The increased level of awareness enabled the Committee to actively solicit funding support - both within city government and from outside sources - for policy options under review. The City was able to obtain a loan guarantee from the California Energy Commission for a cogeneration/district heating feasibility study. Capital improvement funds for the Municipal steam system have been secured from the FY 1985 municipal budget. The Mayor's Office has received a grant from the Urban Consortium for Technology Initiatives to investigate the feasibility of integrating cogeneration with the PG&E district heating system.

Information Limitations. Acquiring specific information on system operations proved extremely difficult. Due to proprietary concerns, PG&E was reluctant to provide the information needed to conduct a detailed analysis of various policy options. It is difficult for one government entity (e.g. City Planning) to institute change within another government entity (e.g. DPW) over which it has little or no control; it is even more difficult to effect the operations of an outside organization (e.g. PG&E). The study results might have been more complete if an explicit agreement between PG&E and the Committee had been made from the beginning, including an assurance to PG&E that materials provided to the Committee would be kept in confidence. Alternatively, inclusion of the California Public Utilities Commission (CPUC) as a Committee member might have resulted in greater access to utility information, since the CPUC has significant control over a broad spectrum of utility activities.

A comprehensive recordkeeping system for Municipal steam operations simply did not exist. Since the Municipal system's "physical history" was not available, it was difficult to develop a comprehensive needs assessment. For instance, the Municipal system is not adequately metered. The power station is equipped with a gas meter which measures standard cubic feet of gas consumed by the boilers, and is read once per eight hour shift. The meter is equipped with a volume/pressure recorder (which records hourly natural gas consumption), but this has not been in operation since the winter of 1981-82, and then only for a relatively short period of time. There are no steam meters measuring boiler output; the amount of steam produced on a per hour basis can only be roughly determined based upon eight hour gas consumption and estimates of the boiler efficiency. The amount of steam used within each building is not known with any certainty since demand meters are not used. Without an understanding of how much is being used in the buildings, it was not possible to determine precisely the amount of heat either lost in the distribution system or wasted by end-users.

Financing Issues. San Francisco's research on municipally owned older district heating systems revealed a common problem: a lack of sufficient funding to properly maintain and operate these systems. Financing will continue to be a major problem area, given the local budgetary constraints imposed by federal and state funding cutbacks, local taxpayer reluctance to accept additional burdens, and increased competition for local dollars from city departments that provide what is deemed "essential services". As such, much of San Francisco's research effort was directed at developing third party financing arrangements to improve the performance level of the municipal steam system. The municipal cogeneration study that is currently underway will specifically focus on alternate ways of financing system installation, beyond traditional municipal debt obligations.

A great deal of information is available on third party "creative" ownership and financing arrangements for alternate energy technologies, including district heating systems. The Energy Task Force has recently undertaken a thorough study of third party financing options for local energy management programs. It would be prudent for a city or county to seriously consider these options regardless of the present state of the municipal budget. Two general criteria should guide such a review. Financing arrangements should involve minimal initial capital outlay requirements on the part of the municipality. Secondly, financing arrangements should be structured so that dollar savings generated from the investment become the principle means for meeting and debt obligation.

Technical Support. Much of the analysis performed by staff was done without the benefit of a computer. A personal computer, in conjunction with a part-time programmer, would have expanded the staff analytical capabilites. Alternatively, computer services could have been rented from PG&E or one of the national energy research laboratories. Given the time constraints, it was not possible for staff either to consider a greater number of policy options, or to conduct sensitivity studies on options given changes in various variables, e.g. fuel price escalation rates, avoided costs of cogenerated electricity, etc.

SUGGESTIONS FOR APPLICATION

Cities and counties should find the procedure developed by the City and County of San Francisco to be a useful guide for analyzing old steam-based district heating systems. It will be necessary to modify the procedure somewhat, based on site specific issues that arise in the context of studying a particular system. In the final analysis, the decision to either shut down or renovate an older district heating system should only be initiated once the procedure has been completed, so that final recommendations on this merits of district heating to the overall community are substantiated.

There are three general rules that should be followed when a city or county undertakes a study of an older steam district heating system.

Involve System Owners and Public Decision-Makers. The system owner(s) should be actively involved in the district heating review process from the very beginning. If the system is municipally owned and operated, there should be little problem in getting local decision makers to consider Committee recommendations, once the economic and overall policy merits of pursuing a certain course of action have been outlined. If the system, however, is owned and operated by someone other than the municipality conducting the study, there is likely to be a concern that a "hidden agenda" is involved.

The specific intent and objectives of the study should be clearly spelled out to everyone involved in the study, but particularly to the system owner.

Otherwise, the owner will be reluctant to actively cooperate with either the local decision-makers or the Committee in providing information concerning system operations. Without this cooperation, Committee recommendations are not likely to have much political weight in setting policies concerning system operations, even if the Committee has obtained all the documentation necessary to support its various recommendations.

Assess Customer Needs and Attitudes. A district heating study must consider the needs of the system users. These needs should be assessed on a case-by-case basis since each system, and the area which it serves, is somewhat unique. Building owners subscribe to a district heating system for any number of reasons: lower initial costs, reduced operating costs, reliability of service, reallocation of space normally alloted to a boiler room for revenue-generating purposes, greater flexibility in architectural design, familiarity with and acceptance of the district heating technology. Building owners leave a district heating system for other reasons: lower operating costs, familiarity and acceptance of on site boiler systems, concern over steam quality and reliability of service, distrust of the owner's commitment to long-term system operations, and a general distrust of or need to feel independent from a central system.

These factors will vary in relative importance from location to location and end user to end user. They will, however, influence the relative merits of various options under consideration. Policy recommendations designed to reduce annual fuel costs will not increase the marketability of the system if customers are primarily concerned with issues of long-term owner commitment.

An effective means of identifying these factors, and determining their relative importance, is to conduct a customer survey. This survey would include system users and non-users located within the service area. Survey questions should focus on general impressions of the district heating system, as well as the reasons behind decisions to either connect to the system or use an alternate form of heat. Personal interviews should be conducted whenever possible. A summary of a survey which was conducted by the San Francisco Department of City Planning for the PG&E system is presented in Appendix B.

Leverage Local Political and Regulatory Influence. Local decision makers generally have the means at their disposal to influence both public and private policy directions with respect to district heating technology. The leadership provided by the Honorable Mayor Latimor of St. Paul, Minnesota was instrumental to that City's success in getting a new district heating system off the ground. An appeal from a Mayor, with support from the local political body, can be extremely effective in influencing a particular course of action taken by the owner of a district heating system. Of course, such an appeal must be backed by sound investment and financing proposals.

Most local governments have a public review process to assess various impacts resulting from new development proposals. This review enables local governments to issue or deny permits for land use development depending on the perceived impact on community health, safety and welfare. Through this review process, cities and counties can address development related energy issues by imposing mitigation measures as a condition for permit approval. For instance, a requirement could be imposed that a developer's decision to either connect to a district heating system or install on-site boilers must be justified by both economic and energy efficiency criteria. This requirement would support a district heating capital reinvestment program by directing new customers to the system.

Most large cities and counties have legal counsel whose responsibility is to review utility programs and rate cases for the purpose of determining their effects on both government operations and the local community. Staff can appeal before the state regulatory agency during rate case hearings affecting steam system operations. For example, a request could be made to the regulatory body that the owner of a district heating system demonstrate a long-term commitment to the system before being allowed to increase steam rates to customers. Commitment could be demonstrated by a program that ensures optimal operating efficiency and the adoption of a comprehensive plan for system maintenance and overhaul. Should the owner seek regulatory approval to install a cogeneration unit, either a written and/or oral appeal could be made before the regulatory agency on the merits of the project.

APPENDICES

A

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APPENDIX A: REFERENCES

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B

END USER SURVEY

EXECUTIVE SUMMARY

In July 1983, the Energy Group, Department of City Planning, conducted a survey of selected buildings in downtown San Francisco regarding their choice of space and water heating systems. Specifically, the survey focused on buildings that were either on or adjacent to the Pacific Gas and Electric Company's (PG&E) central steam district heating system. Building owners in this area are thus able to select central steam in addition to a conventional heating system i.e. on-site gas boilers. Recently, however, some buildings under construction have opted for electrical heating systems.

The survey was conducted in conjunction with a district heating study undertaken by a Mayoral-appointed Committee. As part of this study, the Committee evaluated the merits of PG&E's steam district heating system, which serves 226 predominantly commercial customers in the downtown retail and financial districts (Figure 1). Survey results assisted the Committee in making recommendations to the Mayor on the feasibility of renovating the PG&E steam system.

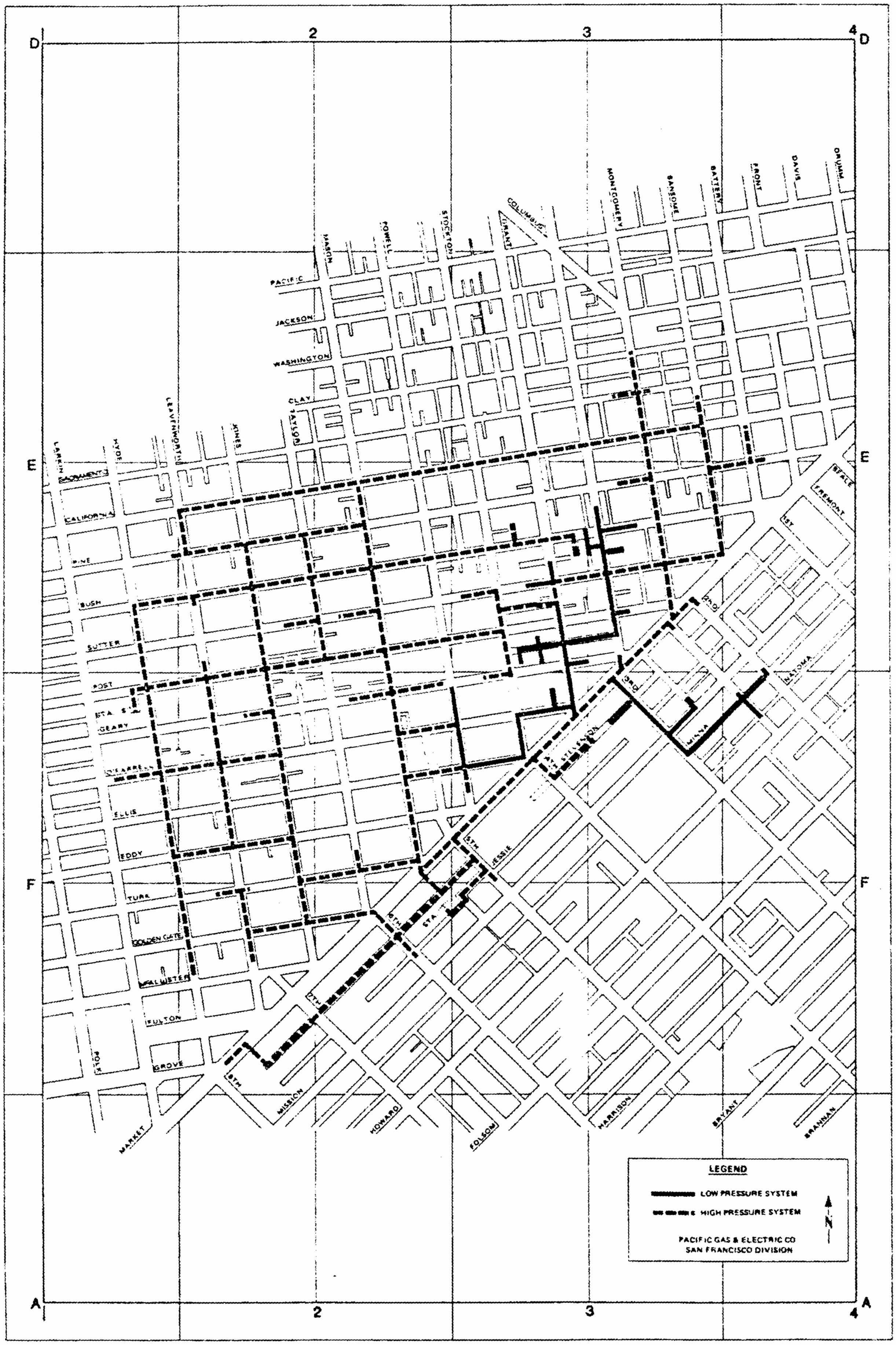
The Energy Group, with the assistance of Committee members, prepared the survey questionnaire. The survey was administered through either personal or telephone interviews with managers and engineers of 33 downtown buildings located within the PG&E district steam service area. The first part of the survey solicited information on building characteristics: square footage, primary use, energy consumption, and heating, ventilation and air conditioning systems. Leasing arrangements were analyzed as as to their influence on the distribution of energy-related expenses. The second part of the survey focused on two specific issues: the importance of various criteria in the decision to choose a particular heating system and the importance of various actors in the decision-making process.

Roughly 60 percent of the buildings surveyed subscribed to PG&E steam; the representation of buildings was weighted towards larger office buildings. The major criterion for building selection was that a decision regarding the

Figure 1

PG&E Steam System

STEAM DISTRIBUTION MAP



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building's heating system had been made in the past ten years, and that PG&E steam was an option available at the time the decision was made.

The survey revealed a number of criteria that influence the selection of a building heating system. Economics emerged as the single most important factor mentioned by survey respondents. For many buildings, however, an economic analysis was not undertaken as part of the decision making process. For those buildings whose owners had conducted an economic analysis, the survey revealed widely divergent decisions depending on the type of economic analysis performed. The two methods most often used were simple payback and life cycle cost analysis.

There were other factors besides economics that influenced the selection of a heating system: government regulations, site constraints, and miscellaneous issues. In addition, a variety of actors influenced the selection of a heating system: developer, engineering consultant, architect, building manager, leasing agent and building contractor. Survey results were inclusive as to whether professional orientation dictated a preference for one specific heating system.

The survey failed to reveal distinct trends regarding the use of gas-fired boilers versus PG&E steam by office buildings. Recently completed office buildings have installed on-site gas boilers; others have opted for PG&E steam. Three of the four office buildings in the study that have recently changed their heating system converted from gas-fired boilers to PG&E steam. Several other buildings surveyed, however, are seriously considering a conversion from central steam to boilers.

Hotels were also included in this survey. A general trend away from PG&E steam to boiler systems has emerged for hotels based on economic criteria. The Holiday Inn recently switched from PG&E steam to individual boilers. Two other hotels have converted part of their operations -- steam absorption chillers (Stanford Court) and a laundry (Hilton Hotel) -- from central steam to electricity and on-site boilers, respectively. The Ramada Renaissance, under construction, opted for gas-fired boilers over PG&E steam. Though the recently completed Meridian Hotel went with PG&E steam, it did so for reasons other than economics.

SURVEY RESULTS

Most downtown office buildings have the choice of either natural gas boilers or PG&E steam to meet space and water heating needs. The Energy Group, Department of City Planning, recently completed a building survey to determine the manner in which decisions are formulated concerning the selection of a particular heating system.

The survey revealed various criteria that go into this decision making process. For the purpose of discussion, these criteria have been divided into four categories: economic considerations, government regulations, site constraints and miscellaneous issues. The type of heating system ultimately chosen also depends on who is responsible for making the selection. The major players identified through this survey were the developer, engineering consultant, architect, building manager and construction contractor.

ECONOMICS

Survey respondents most often mentioned economics as the major criterion in the selection of a heating system. Economics, as used in this survey, includes both initial installation or investment construction costs and annual operating costs for fuel, labor and maintenance.

Initial Costs. The initial costs associated with a gas boiler system involve the purchase and installation of boilers, a gas supply line, a boiler stack and internal heat distribution system. In some cases, additional expenses are incurred for such items as structural supports for a roof-top boiler and excavation for a basement boiler. Providing space for a boiler system also has an oppportunity cost attached to it, since this space is not able to generate revenue income to the owner.

The initial costs associated with a central steam hook-up involve construction of a steam line connection into the building, the purchase of steam valves and an internal heat distribution system. In some cases, an additional expense is incurred for construction of a pipeline connection to the central distribution grid. Until the 1970s, PG&E assessed a plant reinforcement charge on new customers whose steam demand necessitated an increase in plant capacity.

Unless the steam line connection is very high, the front-end costs for a boiler system are usually greater than for PG&E steam service. It is not surprising, then, that initial costs savings was mentioned as a major factor in affirmative decisions to purchase PG&E steam. One third of all respondents with PG&E steam ranked initial costs as the major issue that entered into their decision on the choice of a heating system.

An additional advantage associated with PG&E steam is greater flexibility in architectural design for new buildings. Moreover, building space otherwise required for the location of mechanical equipment is available for other purposes. Most survey respondents, however, indicated that the opportunity costs assigned to boiler space was not a major criterion in the selection of a heating system.

Annual Operating Costs.

Fuel. A comparison of the rates and rate increases for PG&E steam and natural gas from 1974 to 1983 is provided in Table 1. Many of PG&E's largest steam consumers selected service prior to 1974, when steam rates were only slightly higher than fuel rates for on-site heat generation using natural gas boilers (assuming 65% annual average efficiency of on-site boilers). Representatives of these buildings cited the relatively low price of steam as an important factor in their decision to connect to the steam system. Though steam rates have risen less dramatically than gas rates over the last 8 years, the absolute difference between the two has increased. This is primarily due to the fact that PG&E produces steam from a high quality fuel source (i.e. natural gas), and distributes the steam at less than optimal efficiency.

Most respondents agreed that annual fuel costs are now lower with gas boilers than with PG&E steam. However, the magnitude of the difference depends on the

TABLE 1

COMPARATIVE COST OF GAS AND STEAM - 1974-1983

YEAR	NATURAL GAS			SUPPLIED-STEAM		
	GAS (2) $/THERM	HEAT (3) $/THERM	% INCREASE PREV. YR.	STEAM(2) $/M LBS.	HEAT (4) $/THERM	% INCREASE PREV. YR.
1974	.066 -.072	.102-.111		1.55-2.73	.148-.286	
1975	.117 -.129	.180-.198	77.5	2.44-3.62	.233-.345	33.2
1976	.170	.262	27.9	3.11-4.52	.296-.431	35.1
1977	.218	.335	27.9	4.17-5.35	.398-.510	24.9
1978	.236	.363	8.4	4.70-5.83	.448-.561	11.1
1979	.269	.414	14.0	5.26-6.44	.502-.615	10.7
1980	.446	.686	65.7	9.84-10.23	.939-.976	71.4
1981	.461	.709	3.4	11.56	1.103	+15.2
1982	.530	.815	15.0	11.19	1.068	-3.2
1983	.608	.935	14.7	11.86	1.131	+5.9

ASSUMPTIONS

1) All figures are in current dollars

2) Gas and steam rates are weighted averages for a given year. Figures for 1983 are as of July 1.

3) Effective boiler efficiency is 65 percent.

4) Effective heat content of steam is 1,048 BTU/lb. This is derived from the heat content of 5 psig saturated steam (1156 Btu's/lb.) net the heat content of 140^{o} F saturated water (108 Btu's/lb).

efficiency of the boiler system. Many of the respondents used steady state operations as the criterion to judge boiler efficiency. The steady state efficiency for most boilers averages 75-80 percent. Average annual operations, however, is more relevant for determining the costs associated with providing heat to a building. The average annual efficiency for most boilers is 55-75 percent. As such, analyses that utilize steady state efficiencies, as opposed to annual average efficiencies, will favor on-site boilers over PG&E steam.

Labor and Maintenance Requirements. Labor and maintenance costs for an on-site boiler normally include salaries for operating personnel, general maintenance and repairs, chemical treatment and equipment insurance. Most boiler owners could not come up with a precise dollar figure for annual labor and maintenance costs, due primarily to uncertainty regarding labor requirements for system operation.

Most of the steam customers surveyed noted that savings associated with labor and maintenance requirements were an important factor in the selection of PG&E steam. All but one respondent cited higher personnel requirements associated with having a licensed boiler operator at a cost of $30,000-$60,000 dollars per year. One respondent mentioned the difficulty of finding qualified and competent boiler technicians. A few respondents were under the impression that high-pressure boilers, which require 24-hour, 7-day supervision, constitute the alternative to steam service. Most downtown office buildings, however, are well suited to the use of low-pressure boilers; these do not require full time supervisory personnel. This misconception may influence a decision in favor of central steam.

Few economic analyses conducted by building owners included costs for labor and maintenance. None of the respondents with on-site boilers believed that switching to PG&E steam would reduce personnel requirements, and none considered labor and maintenance requirements as an important factor in their decision to choose boilers. This finding is in contrast to the attitude of respondents with PG&E steam.

Initial and Annual Operating Costs: A Comparison. Most of the respondants used simple payback when comparing the economics associated with gas-fired boilers versus PG&E steam. Payback, in this case, was calculated as the number of years required for the annual operating savings associated with natural gas boilers to offset the initial investment costs associated with the boilers and boiler-related equipment.

An owner interested in a relatively short payback period should select PG&E steam, since the net annual savings associated with on-site boilers normally takes several years to offset the initial boiler costs. This was especially true of buildings that have variable air volume (VAV) internal heat distribution systems. VAV systems, currently considered to be state-of-the-art, are far more energy efficient than the terminal reheat and dual duct systems commonly used in the past. Buildings constructed in the past few years which utilize VAV tend to have significantly lower heating loads, and thus lower fuel costs, on a per square foot basis than older buildings which employ other HVAC systems. This would lengthen the payback associated with the purchase, installation and operation of an on-site boiler.

Leasing arrangements also influence the relative importance placed on operating costs in the decision-making process. With relatively few exceptions, leases have an escalation cause which allows the building manager to pass-on increased operating costs, including energy costs, to building tenants.

Leasing arrangements serve as an economic disincentive to install on-site boilers rather than connect to the PG&E steam system, since higher steam operating costs are passed on to tenants. Several respondents noted that increased operating costs are unlikely to either lead existing tenants to vacate or to discourage prospective tenants since heating is only a small percentage of total energy demand, and since energy costs are a small percentage of total rent.

These factors would lead one to believe that speculative developers, interested in a short-term investment, would opt for PG&E steam due to its relatively low first costs and the fact that operating costs can be passed on to tenants. Developers of corporate headquarters and regional offices, and hotel developers would opt for on-site gas boilers, since they would be responsible for payment of utility costs and, therefore, would factor into their decision the lower operating costs of a gas-fired boiler over the life of the system.

However, no such correlation emerged for office buildings from the survey. Several speculative office buildings have chosen on-site boilers, while many corporate headquarters use PG&E steam. Office buildings with VAV systems use both PG&E steam and on-site boilers. Respondents may say economics was a major factor in their choice of a particular heating system; their actions, however, do not fully support this claim. Clearly, there are other factors besides economics which enter into the decision making process.

The economic behavior of hotel owners, on the other hand, was fairly predictable. Hotel respondents who considered economics as a determining factor in the selection of a heating system selected on-site boilers. This is probably due to the fact that utility costs constitute a higher percentage of hotel operating costs than office buildings, while heating comprises a major percentage of total energy costs. Only one hotel surveyed (Meridian) chose PG&E steam; the decision was based more on a familiarity with central steam than economics. Many older hotels that used PG&E steam have converted to on-site boilers as part of an overall building renovation program.

GOVERNMENT REGULATIONS

Local and state regulatory controls influence selection of a building heating system. The San Francisco Planning Code restricts the placement of accessory structures such as a boiler on the roof of a building, when the building already exceeds the allowable height limit. This would affect building retrofit situations, where the owner is interested in installing an on-site boiler but is prevented from placing the boiler in the basement due to structural limitations. Due to height controls, the Qantas building on Union Square was prevented from installing boilers on the roof.

State energy standards for new buildings, known as Title 24, can limit the design options available to a developer. If the performance method of complying with the standards is used (i.e. buildings must adhere to an energy budget, expressed as Btu's/square foot/yr.), the high distribution losses associated with the PG&E system place it at a disadvantage with on-site boilers. On-site boilers can deliver an equal amount of heat to a building using less source Btu's than PG&E steam. Both the Bank of Canton and San Francisco Federal Savings selected on-site boilers over steam for this reason. The architects for 345 California had to choose an alternate glazing material which would enable the building to use steam and still meet the Title 24 energy standards.

SITE CONSTRAINTS

Structural limitations. Overall, approximately 50 percent of the buildings surveyed had serious structural limitations that factored into a decision to select PG&E steam. For example, both the Foremost McKesson and Citicorp buildings had depth limits imposed by the underlying bedrock that prohibited the placement of boilers in the basement. The architectural design selected for the Transamerica headquarters preempted the use of on-site boilers; installing a stack in the building would have presented major engineering difficulties. Architectural considerations prohibited the location of mechanical rooms in middle floors of the Citicorp building.

Building Retrofit Versus New Construction. There can be a significant difference in the importance attached to various factors involved in the selection of a heating system, depending upon whether the building is new or existing. Much more flexibility exists for new construction than with existing buildings in terms of altering space usage, modifying building structure, and adapting other HVAC components to suit a particular heat system. With an existing building using PG&E steam, lack of room for locating a boiler or boiler stack may serve as a deterrent to boiler conversion.

Distance From the Steam Lines. Buildings located adjacent to the existing steam grid normally incur only a modest fee for connecting to the system. However, buildings for which an extension of the grid is required are held responsible for the cost of the pipeline extension which would be required to service the load. Sometimes the cost involved does not significantly diminish the attractiveness of PG&E steam to the building. For example, the Bank of America paid approximately $0.25 million to have the high-pressure steam main extended down Montgomery Street. In many cases, however, the high cost of the line extension outweigh the advantages offered by PG&E steam. Both Five Fremont and the Bechtel buildings installed boilers due to the high initial costs associated with installing a steam service line.

MISCELLANEOUS ISSUES

Corporate Commitment to the Steam System. Many respondents were uncertain whether or not PG&E was committed to long-term operation of the steam system. One engineering consultant, who has worked on several downtown buildings, felt that PG&E would like to get out of the steam service business. As a result, this consultant would not recommend PG&E steam to his clients. Several other respondents share this impression. The belief that the PG&E steam system might not be maintained was offered as a major reason why boilers were selected for 350 California Street.

Steam Quality and Reliability. Steam chemical quality, steam heat content, and steam reliability were issues mentioned by respondents as influencing their decision on a heating system. Regarding the chemical quality of the central steam, steam is generally corrosive and, unless treated, will cause scale build-up in pipe systems, heat exchangers, coils, and other equipment. Several respondents complained about the "dirtiness" of PG&E steam, although the frequency of complaints has diminished over the past few years as PG&E has improved the chemical quality of its steam. Only one respondent (Hanford-Freund) mentioned the poor quality of steam as a significant factor in the decision to install boilers .

Survey respondents connected to the PG&E steam system reported that the steam received was often "wet", i.e. it carried an excessive amount of condensate. As such, these customers are paying for steam which has a lower heat content than dry steam at the same temperature and pressure. None of the respondents cited reliability as an overriding factor in the choice betwen PG&E steam and gas; nevertheless, it was a consideration in a number of instances. All of the steam customers surveyed were satisfied with the reliability of the steam system. However, some respondents unwarrentedly thought that PG&E was capable of switching to a wide variety of fuels in the event of a natural gas shortage.

PARTICIPANTS IN THE DECISION-MAKING PROCESS

Among survey respondents, there was a wide variation in both the decision-making criteria used in the selection of a heating system and the degree of importance given to selected criteria. Differences also surfaced between new construction and building renovation. Furthermore, the survey did not reveal a consistent pattern of behavior among those participating in the decision making process. The professional orientation of the decision maker did not seem to dictate a bias in favor of one system or another.

Developers. The building developer generally played a role in all decisions involving the construction of the building. The developer usually determined both the economic criteria to be used and the emphasis placed on various other factors in the selection of a heating system. One would speculate that the developer will be influenced by differing decision-making criteria depending on whether the building is to be a short versus long-term holding, or corporate headquarters. For instance, the opportunity cost of money differs among these various real estate investments. One would expect that developers of corporate headquarters would have an economic bias towards life cycle versus initial costs. Such a bias would favor the selection of on-site boilers rather than PG&E steam. The building survey results were inclusive on this issue.

Engineering Consultants. Engineering consultants played a major role in the choice of heating systems for both new and recently retrofited buildings. In some cases, the engineering consultant made the decision independently; in other cases, the engineer and the developer shared the responsibility. Approaches to selecting heating systems varied greatly among engineering firms, and even among consultants within a given firm. In addition, survey results showed that consultants differed in their estimates of boiler efficiency and the quality and reliability of PG&E steam service.

Architects. The building architect generally played a secondary role to the engineering consultant on heating system decisions. Architects surveyed did not present a uniform opinion on the merits of one system over the other. In some instances, however, building design issues were a determining factor in the selection of a heating system. As cited earlier. a preliminary design for the Bank of Canton building included both PG&E steam service and substantial glazing. The building could not meet Title 24 energy standards and also include both of these elements. Since the architect did not want to sacrifice glazing area, on-site boilers replaced steam service for the building.

Building Managers and Leasing Agents. Most of the survey respondents were building managers. Their influence on heating system decisions was restricted to building renovation projects. Leasing agents were employed by some developers to handle operating and leasing matters. In a few instances these agents played a role in heating system decisions. One engineering consultant remarked that the professional orientation of building managers and leasing agents would tend to favor the higher labor and maintenance requirements of on-site boilers versus steam. Survey results were inclusive on this issue.

Construction Contractors. Respondents were of the opinion that construction contractors may play a minor role in the selection of a heating system for the building. According to one respondent, construction contractors prefered boilers because they provide more business for piping and stack equipment. With "design-built" construction, where contractors provide both architectural and engineering designs, there might be a trend towards boiler installation. This was not confirmed by the survey.

BUILDINGS PARTICIPATING IN THE
PG&E STEAM SYSTEM SURVEY

PG&E STEAM CUSTOMERS

Building Name	Address	Contact
Bank of America	555 California Street	Mike Dineen, Fred Smuthers
Citicorp	One Sansome Street	Bill Carey, Per Sonandar
Continental Insurance	100 Pine Street	David Hardin
Crocker Tower		Bill Roberts, Carl Jordan
Crown Zellerbach	One Bush Street	Gordon Mosley
Equitable Life	120 Montgomery Street	Fred A. Grimes, Marlon Howard
	595 Market Street	Ken Willis
Foremost McKesson	One Post Street	Michael Franklin
Hilton Towers Hotel	Mason & O'Farrell Streets	George Mac
Humboldt Bank	785 Market Street	Dave Rathie
Meridien Hotel	760 Market Street	Lyman Jee, Les Miller
	155 Sansome Street	Steve Sabin
Pickwick Hotel	85 Fifth Street	Jacques Nouaux, Vince Howarton
Standard Oil	225 Bush Street	Dick Tolleson, Ben Capozzi
Standard Oil	555 Market Street	Dick Tolleson, Ben Capozzi
Standard Oil	575 Market Street	Dick Tolleson, Ben Capozzi
Stanford Court Hotel	905 California Street	John Tellinghuisen
Transamerica	600 Montgomery Street	John J. DeVries
	345 California Street	Per Sonander
Qantas	Union Square	Robert Voelz
Hartford	650 California Street	Robert Voelz
Hong Kong Bank	Sansome & Pine Streets	Tom Simonson

BUILDINGS PARTICIPATING IN THE
PG&E STEAM SYSTEM SURVEY

INDIVIDUAL BOILER OWNERS

Building Name	Address	Contact
Bank of Canton	555 Montgomery Street	Clifton Brinkley, Mack Takahashi
Elevated Shops	150 Powell Street	Alexander Mitchell
	Five Fremont	Bert Bomersine
Hanford-Freund	47 Kearny Street	Peter Davis
Holiday Inn	480 Sutter Street	J. Gagnon, R. Woods
J. Harold Dollar	351 California Street	Dave Rathie
MacDonald Products	340 Pine Street	E. B. MacDonald
Mills	220 Montgomery Street	Norman Allen
Monadnock	681 Market Street	Jeff Vance, Elise Vitale
	111 Sutter Street	Bill Roberts, Bob George
Renaissance Hotel	111 Pine Street	Larry Lau, B. Brown
Robert Dollar	311 California Street	Dave Rathie
Shell	100 Bush Street	Fred Schwabenland
San Francisco Federal	Post & Kearny Streets	Mack Takahashi
Bechtel	50 Beale Street	Tom Simonson
	350 California Street	Fred Smuthers

SURVEY OF BUILDING HEATING SYSTEMS

BUILDING IDENTIFICATION

1. Building Address: ______________________ Building Name: ____________
2. Name of Respondent: __________________ Position: ________________
3. Contact Person(s):

   Owner: ______________________________ Telephone #: ______________

   Manager: ____________________________ Telephone #: ______________

   Chief Engineer: ______________________ Telephone #: ______________

BUILDING PROFILE

4. Primary Building Use (Please Check Correct Use):

   ___Hotel ___Office ___Laundry ___Restaurant ___Other Retail

   ___Mixed Office/Retail ___Mixed Office/Residential ___Residential

   ___Other (Specify) ______________________________

5. Building Area: Gross_____Ft.^{2}; Usable_____Ft.^{2}; Rentable_____Ft.^{2}
6. Number of Stories: _____

BUILDING ENERGY USE

7. Percentage of Total Annual Operating Costs Allocated to Energy:___%
8. Average Annual Energy Use:

   a) Electricity:____________KWHR's; _______KW's

   b) Gas:__________Therms

   c) PG&E Steam:__________'000's of Pounds

9. Are the Utility Costs Recouped Through::

   ___Escalation Clause ___Back-charge to Tenant ___Other (Describe on Back)

HVAC SYSTEM

10. Type of Cooling System Used:

    ___ Electric Capacity __________Tons

    ___ Steam Absorption Capacity ______________Tons

    ___ Other (Specify)__________________

11. Type of Heating System Used:

    ___PG&E Steam ___Gas Boiler ___Other(Specify)__________________

12. Type of Ventilation System :

    ___Reheat ___Dual Duct ___Multizone ___Variable Air Volume

13. Please Describe Your HVAC System on the Back of This Page. Be Sure to Include any Conservation Measures Which You Have Undertaken Within the Last Ten Years.

PAGE 2 -- PG&E STEAM CUSTOMERS ONLY

RESPOND TO ITEMS 14 THROUGH 20 ONLY IF YOU SUBSCRIBE TO PG&E STEAM

P G & E STEAM CUSTOMERS ONLY

14. Year in Which Building Connected to PG&E Steam:________

    As a: ___New Building ___Retrofit of an Existing Building

15. Uses Currently Being Made of Steam:

Use	% of Total (Please Estimate)
a.) Space Heat	________%
b.) Hot Water	________%
c.) Air Conditioning	________%
d.) Open Jet Steam (e.g. laundry, kitchen)	________%

16. Are You Able to Utilize Heat From the Condensate for Water Preheating or Other Purposes?

    ___Water Preheating ___Other (Specify)______________________

17. Annual Operating and Maintenance Requirements:$__________

18. Was the Decision to Connect to the PG&E System Made By:

    ___Owner ___Manager ___Developer ___Engineer

19. Please Indicate The Past (P) and Current (C) Relative Importance of the Following Factors as Regards the Decision to Provide Heat to Your Building.

Factor	PAST Degree of Importance			CURRENT Degree of Importance		
	High	Moderate	Minimal	High	Moderate	Minimal
a) Physical Limitations	____	____	____	____	____	____
b) Reliability	____	____	____	____	____	____
c) Alternative Uses for Boiler Space	____	____	____	____	____	____
d) Annualized Costs	____	____	____	____	____	____
e) Initial Cost	____	____	____	____	____	____
f) Operation and Maintenance Requirements	____	____	____	____	____	____
g) Quality of Steam (Energy Content, Pressure, etc.)	____	____	____	____	____	____
h) Other (Specify) ______________	____	____	____	____	____	____

If a Formal Analysis Was Performed to Compare These Factors, Please Forward Results

20. Are There Improvements Which Could Be Made to the PG&E Steam Service? Include any Comments Which You May Have About the Service in General.

PAGE 3 -- BUILDINGS WITH INDIVIDUAL BOILERS ONLY

RESPOND TO ITEMS 21 THROUGH 26 ONLY IF YOU HAVE YOUR OWN BOILER SYSTEM

INDIVIDUAL BOILER OWNERS ONLY

21. Please Describe The General Operating Characteristics of Your Boiler(s):

    a) Age:_________Years

    b) Rated Output:______________Pounds/Hour

    c) Type: ___Fire-tubed ___Water-tubed ___Other (Specify)_________________

    d) Output: ___Steam ___Hot Water @_____psig

    e) Estimated Boiler Efficiency: ____%

    f) Initial Cost: $_____________

    g) Estimated Average Annual Non-fuel Operation Requirements:

    ___________Man-hours ____________$/Man-hour

    h) Average Annual Maintenance Requirements:$____________

22. Uses Currently Being Made of Heat:

Use	% of Total (Please Estimate)
a) Space Heating	________%
b) Water Heating	________%
c) Air Conditioning	________%
d) Open Jet Steam (e.g. in laundry and kitchen)	________%

23. When Options Were Being Considered for Providing Heat to the Building, Was Steam from PG&E a Consideration? Why or Why Not? Please Append.

24. Who Made the Decision to Install Gas Boilers:

    ___Owners ___Developers ___Managers ___Other (Specify)_________________

25. Please Indicate The Past (P) and Current (C) Relative Importance of the Following Factors as Regards the Decision to Provide Heat to Your Building.

Factor	Degree of Importance		
	High	Moderate	Minimal
a) Reliability	____	____	____
b) Alternative Uses for Space Which Would Otherwise Be Allocated to the Boiler Room	____	____	____
c) Annualized Costs	____	____	____
d) Initial Cost	____	____	____
e) Quality of Steam (Energy Content, Pressure, etc.	____	____	____
f) Operation and Maintenance Requirements	____	____	____
g) Other (Specify)			
____________________	____	____	____

If a Formal Analysis Was Performed to Compare These Factors, Please Forward Results

26. Are You Satisfied With the Decision to Install Gas Boilers? Please Explain.

REPORT AND INFORMATION SOURCES

Additional copies of this report, "Renovation Opportunities for Steam District Heating Systems: A decision Process in San Francisco", are available from:

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For further information on the methods and results of the project described in this report or for information on the overall energy management programs in the City and County of San Francisco, please contact:

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