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MODULAR DISTRICT HEATING PLANNING AS A DEVELOPMENT TOOL: A PROJECT REPORT

Energy Task Force of the Urban Consortium
for Technology Initiatives

City of Columbus, Ohio
Department of Development
Planning Division

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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 professional from nineteen Consortium jurisdictions, has sponsored over one hundred energy management and technology projects in thirty-two Consortium member jurisdictions 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 five projects each, with each unit managed by a selected Task Force member. A description of the units and projects included in the Sixth Year (1984-1985) Energy Task Force Program follows:

UNIT -- LOCAL GOVERNMENT OPERATIONS

Energy used to support public facilities and services by the nation's local governments in 1983 totaled approximately 1.4 quadrillion BTU's. By focusing on applied research to improve energy efficiency in municipal operations, the Energy Task Force helps reduce operating costs without increasing tax burdens on residents and commercial establishments. This Sixth Year unit consisted of six projects:

- Baltimore, Maryland - "Wastewater Treatment Process Integration: Energy Operations and Cost Optimization"
- Detroit, Michigan - "Computer Control for Municipal Water Distribution: Design for Energy Cost Savings"
- Memphis, Tennessee - "Transportation Management for Business Relocation and Expansion: A Strategy with Federal Express Corporation"
- Philadelphia, Pennsylvania - "Incinerator Residue Dewatering Transfer Trailer"
- Phoenix, Arizona - "Thermal Storage Strategies for Energy Cost Reduction"
- Washington, DC - "Energy Monitoring and Control in Municipal Facilities: System Development and Testing"

UNIT -- COMMUNITY ENERGY MANAGEMENT

Of the nation's estimated population of 232 million, approximately 60 percent reside or work in urbanized areas. The 543 cities and counties that contain populations greater than 100,000 consumed a total of 49 quadrillion BTU's in 1983. Applied research sponsored by the Energy Task Force helps improve the economic vitality of this urban community by aiding energy efficiency and reducing energy costs for public services and the community as a whole. This Year Six unit consisted of four projects:

- Chicago, Illinois - "Neighborhood Energy Conservation Project: Building Community Capacity for Conservation Services"
- Denver, Colorado - "Refuse Combustion for Power and Thermal Energy: Planning for Urban Development and Solid Waste Management"

- New Orleans, Louisiana - "Incident Prevention and Response for Hazardous Materials: A Decision Support System"

- New York, New York - "Retention and Expansion Program for High Energy Use Businesses"

UNIT -- INTEGRATED ENERGY SYSTEMS

Effective use of advanced energy technology and integrated energy systems in urban areas could save from 4 to 8 quadrillion BTU's during the next two decades. Urban governments can aid the realization of these savings and improve capabilities for the use of alternative energy resources by serving as test beds for the practical application of new and integrated technologies. This Year Six unit consisted of five projects:

- Albuquerque, New Mexico - "Residential Space Heating with Wood: Efficiency and Environmental Performance"

- Columbus, Ohio - "Modular District Heating: Feasibility Analysis"

- Houston, Texas - "The Impact of Source Separation on a Waste-to-Energy Project"

- Milwaukee, Wisconsin - "Resource Recovery from Urban Yard Wastes: Feasibility Assessment"

- San Francisco, California - "Planning for Energy Efficiency in New Commercial Buildings: Evaluation Methods during Design"

UNIT-- PUBLIC/PRIVATE FINANCING AND IMPLEMENTATION

City and county governments often have difficulty in carrying out otherwide sound energy efficiency or alternative energy projects due to constraints in the acquisition of initial investment capital. Many of these investment constraints can be overcome by providing means for private sector participation in innovative financing and financial management strategies. This Year Six unit consisted of five projects:

- Hennepin County, Minnesota - "Shared Savings Applied to Low Income Homeowners"

- Kansas City, Missouri - "Kansas City Warm Room and Superinsulation Project"

- St. Louis, Missouri - "Financing Options for Superinsulated Housing"

- San Antonio, Texas - "Measures and Investment Options for Community Energy Conservation: Strategies with a Municipal Utility"

- San Jose, California - "Energy Management and Tracking System as a Software Package"

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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In the course of this project, the Danish Board of District Heating in collaboration with Public Technology, Inc. and the U.S. Department of Energy made it possible for representatives of a number of cities funded by the Energy Task Force of the Urban Consortium, including Columbus, to visit district heating installations and product manufacturers in Denmark. This visit provided substantial insight into the potential for district heating as adapted from Danish into U.S. experience. We are indebted to Mr. Barry Shance; to Mr. Mogens Larsen, Chairman of the Danish Board of District Heating; to Mr. Lennart Larson, Alderman and Deputy Mayor of the City of Odense; and to Mr. Erik Rasmussen, Secretary of the DBDH, for their hospitality and instruction during the study tour of Danish cities.

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Chapter 1. Overview

ABSTRACT

In 1984, the City of Columbus, building on the results of previous district heating assessments funded by both the U. S. Department of Housing and Urban Development and the Danish Ministry of Energy, began a survey of the potential for district heating systems in its downtown and riverfront areas. Of particular interest was the potential for refurbishing an old municipal electric plant on the northwest fringe of the downtown as a heat source for a riverfront area targeted for redevelopment.

This report describes the background, assumptions, methodology, and conclusions of that assessment. It must be said at the outset that some questions remain unanswered. The scope of the present study did not permit a full engineering evaluation of the state of the equipment at the old Municipal Light Plant and therefore cannot be the sole basis for a recommendation to proceed with a project. Beyond the issue of technical feasibility, however, were broader questions which the study attempted to answer. First, could district heating concepts developed successfully in Denmark be successfully applied to Columbus? The answer to the first question is affirmative. A second, more fundamental issue was whether district heating could be used to support development or redevelopment efforts in an environment characterized by sturdy growth but without reference to a centralized plan.

The third question raised by the study was that of the City's own possible role in further district heating development. The answer to this question hinged on the ability of potential private developers, political officials, and administrators to work out the basis for a joint public/private effort to fund the next stage of development--including the engineering, marketing, organizational, financial, and legal work necessary to prepare a "bankable" project. No conclusion is possible at the time of this writing. However, it appears that if district heating does develop in Columbus, it will require a relatively larger private-sector role than has been the case in most other U.S. cities with modern or refurbished district heating systems.

In outlining the methodology used by the consulting team, every effort has been made to clarify the reasons for decisions made on system size, configuration, and service coverage. It is not intended that this study should serve as a complete guidebook to the process of district heating development; the Columbus experience is still too incomplete to fulfill such a function. But it is hoped that the project report will provide some useful lessons to other American cities beginning to evaluate the costs and benefits of district heating development.

PROJECT PURPOSE

The purpose of the project funded by the Urban Consortium Energy Task Force in 1986 was to test the applicability to Columbus of a modular, small-scale development concept for district heating systems in the downtown/riverfront area. Although the City of Columbus has been involved in district heating planning projects going back to 1981, it was not clear until 1984 that district heating would prove economically feasible either in the downtown or in other areas of the city. In 1984, a Danish firm working under the terms of an agreement between the Danish Ministry of Energy and the City of Columbus presented a report and proposal to the Mayor which suggested that district heating would in fact be feasible under certain assumptions about scale of projects, sources of heat and types of fuel, and application of hot-water district heating technology. The suggestions made by the Danish firm, Harry and Mogens Larsen Consulting Engineers, were based on their experience in developing municipal and institutional district heating systems in Denmark, where district heating systems are generally recognized as among the most cost-efficient and reliable in the world.

One basic question to be answered by this year's research effort was to determine whether district heating concepts developed effectively in Denmark could be successfully applied to one or more projects in the Columbus environment. An attempt was made to compare the institutional, economic, technological, and other factors which have influenced the achievements of Danish systems with the environment known to exist in Columbus and other U.S. cities.

A secondary question to be answered was whether district heating could be used to support urban development or redevelopment--in an environment where development is occurring at a rapid pace but without reference to a centralized plan. We believed that in such an environment, a modular or incremental approach to district heating as advocated by the Danes might make sense. Part of the purpose of this study was to determine whether district heating could be initiated in one or more of the potential downtown or riverfront development areas where it would tend to serve new developments as well as existing structures. A related purpose, in the long run, was to determine whether district heating could act as a significant incentive to help direct public and private investment into areas where the City felt that growth is both likely and desirable.

A final purpose to be served by this study was to determine the potential for private investment to supplement or replace the development initiative formerly assumed by local government. Typically, where district heating systems have developed in U.S. cities in the last decade, the local government--often supported by Federal grants and loans such as Urban Development Action Grants or Community Development Block Grants--would undertake the leadership role. In contrast, for a number of reasons described in this report it was never expected that the City of Columbus would become the major owner or investor in a district heating system. In such a situation, district heating investments would have to show a rate of return sufficient to attract private capital. As an alternative, the feasibility of a not-for-profit or consumer cooperative type of enterprise was also investigated.

At the conclusion of the study, several uncertainties remained. Among them was the matter of whether the basis of a public/private partnership to undertake further district heating development could be successfully negotiated in Columbus. Moreover, it was still uncertain what the impact of Federal tax legislation would be on local infrastructure investments of this type.

REPORT ORGANIZATION

This report is intended to give a complete picture of the background and current (mid-1986) status of district heating efforts in Columbus. Chapter Two reports on previous studies undertaken in Columbus and reviews the Danish "model" for district heating development. This chapter further assesses the impact of several other factors on future district heating development potential: specifically, current downtown development and the potential consumer base; the new trash-burning Municipal Electric Plant as a district heating source; and the general utility rate environment, with regard to competitive fuels and electrical generation.

Chapter Three surveys the process used to assess district heating potential in the downtown riverfront area, and with the aid of tables and maps, shows how decisions on the location and potential service coverage of the system were made by consulting engineers. This chapter also describes the methods used to analyze system economics and determine overall competitiveness with heating fuel alternatives.

Chapter Four suggests possible strategies by which further district heating development could be carried out in Columbus, and outlines the decisions confronting the City in determining its own future development role.

Chapter Five presents an overview of recommendations and suggestions for application for other cities based on the Columbus experience. The suggestions for application represent a summary of the major arguments and conclusions of the entire study, organized into topical areas.

Chapter 2. Background and Concept

INTRODUCTION

This chapter reviews the history of district heating assessments in Columbus, then evaluates the Danish district heating experience upon which recent studies have been predicated. The fundamentals of Danish district heating success are examined for their applicability to Columbus. Finally, the Columbus environment itself is discussed, particularly in relation to downtown development trends and to the construction and operation of the new trash-burning power plant--factors which will shape and constrain the development of district heating systems in Columbus.

1981-82 HUD Study

District heating systems are not unknown to Columbus. Institutional and governmental facilities have been major users of district heat. The Ohio State University has a steam system which has been in operation since the 1920's, generally credited with savings of more than $22 million during a seven-year period in which energy prices skyrocketed. And in downtown Columbus, a central steam system is used to heat the state capitol and three state office buildings.

In 1981, the City of Columbus was one of twenty-eight cities to receive a grant from the U.S. Department of Housing and Urban Development to assess the potential for district heating throughout the city. Consultants on the project were teams from the Ohio State University and Battelle Columbus Laboratories. The study took a wide-ranging look at the potential for district heating throughout the city, using a model developed by Argonne National Laboratory. It focused on the potential for a large-scale steam system linking the downtown with the OSU campus. Based on an economic analysis of several different engineering scenarios, the study concluded that "Columbus offers few concentrations of heat load sufficient to justify district heating systems."[1]

This conclusion is probably an oversimplification of the findings. What is clear, however, is that the high initial investment costs of a new large-scale cogeneration plant were difficult to carry through the early years of system development with relatively low revenues. Combined with the high piping costs of the steam system considered in the model, the need to include both high- and low-grade thermal users, the limitations of the Argonne model regarding alternative rate structures, as well as the relatively low density of the target area, such high investment costs cast doubt upon the economic feasibility of district heating within the study area.

The efforts of this study, however, brought Columbus to the attention of Danish engineers and subsequently of the Danish Ministry of Energy, which was seeking a U.S. city in which to assess and demonstrate the transferability of district heating engineering concepts perfected in Denmark. In December 1982, an agreement was signed between the Danish Ministry of Energy and the City of Columbus. Under this agreement, the consulting engineering firm of Harry and Mogens Larsen was contracted by the Royal Danish Government to conduct a Conceptual Project Study focusing on prospects for feasible district heating projects in the whole of Columbus.

The 1983-84 HML Study

Harry and Mogens Larsen (HML) consultants, drawing on extensive experience in the design of Danish district heating projects, began their investigation of Columbus district heating potential in 1983. Their three-volume report was completed and presented to the Mayor by the Danish Ministry of Energy in August, 1984. It identified three areas for feasible start-up district heating projects, selected, according to the report, " on the basis of providing different examples of potential, assessment, and development."[2]

The "Project Area South" envisioned utilizing some of the short-term potential for waste heat recovery from Columbus's new trash-burning power plant in two possible sites--first, to supply heat to the nearby expansion of the City Workhouse (prison), and second, to supply heat to a low-density residential area of Grove City, a suburb southwest of Columbus. This was the first time that anyone had seriously proposed the trash-burning power plant as a source of district heat to nearby areas, and it was the first time that the new Workhouse had been identified as a potential user. At the time of the HML report, it was not thought feasible to recover any more than 15MW of heat from the plant, amounting to only 5MW per turbine. The plant had not been designed with back-pressure turbines which could make full use of its heat potential.

A "Project Area North" focused on the potential of recovering heat from process waste water at the Anheuser-Busch brewery, located in the rapidly developing commercial, residential, and light industrial area of northeastern Columbus. This project envisaged heat recovery from the brewery's waste water stream by means of large heat pumps and also proposed future use of "waste" heat from a small cogenerating power station which would be built specifically to serve brewery operations.

And finally, a "Project Area Central" suggested, but did not specify in detail, a number of potential projects which would support the City's own redevelopment efforts in the downtown/riverfront area. The HML Conceptual Study stated that "investigation of...downtown Columbus did not produce an immediate start-up project" due to the rapidly changing planning environment at the time. However, HML evaluated the prospects for district heating in the area as "excellent". The important issue for the riverfront/downtown area was seen to be timing -- that is, the capacity and location of a district heating project would depend largely on the pace of redevelopment in the area. Some of the possible development projects for the riverfront/downtown area included a multi-purpose convention and activity center; a mixed-use commercial/residential complex on the site of the old State Penitentiary; and restaurant, hotel, and museum facilities along the riverfront.

The Danish study concluded:

> "It seems likely that a downtown district heating project could best get underway...by "capturing" the initially-developed properties by means of strategically-located mobile or transportable boilerhouses, gradually linking them together, developing and 'plugging in' the permanent heat sources as they become available,

and moving the mobile heat station or stations on to newer and temporarily isolated consumer properties." [3]

This statement summarizes the Danish district heating approach of "Start small, but think big." This is the concept that Danish engineers have sought to apply in Columbus, where it has become known as the "modular" or "incremental" approach to district heating development. Before exploring the circumstances under which this approach was developed for Columbus, it is necessary to examine more fully the concept of district heating as it developed in Denmark.

DISTRICT HEATING DEVELOPMENT IN DENMARK

There are a number of reasons why district heating has established itself so well in the Danish market, some more obvious than others. For example, a cold climate and one of the world's highest standards of living are two of the more obvious. Less obvious are the Danish tradition for collective participation, the practical resourcefulness shown by the nation's engineer-developers, the supportive attitude of its municipal governments towards local initiative, and the helpfulness of the "non-interference" policies of the national government.

Without the development of cost-conscious engineering practices and the appeal of annual cost savings to the consumer, however, none of these factors would have been likely to create much more than mild interest in district heating in Denmark. Ultimately, cost savings provided the needed attraction to the consumer and practical engineering methods and new materials provided the means of making such savings available.

It should be pointed out that contrary to popular belief in the United States, the successful establishment of district heating in Denmark was accomplished without government subsidy and without any deliberate national policy to promote district heating. Development began in the late 1950's and gathered momentum through the 1960's, well prior to the oil crises of 1973 and 1978. During this period fuels were plentiful and cheap. The economic advantages of district heating were derived mainly from using lower cost heavy fuel oil or waste heat recovered at power stations or from industrial processes.

The introduction and initial success of district heating also coincided with the change-over in many Danish homes to central heating from oil stoves. It was an opportune moment to connect homes to a district heating system in order to avoid both the inconvenience and cost of installing a boiler in one's house.

Historically, Denmark lacked natural energy resources and was heavily dependent upon fuel imports. In 1973, for example, more than 90 percent of Denmark's energy consumption was based on imported oil. The oil price shocks of the 1970's were therefore felt much more strongly in Denmark than in the United States. The effects of these successive crises merely provided further incentives for the expansion of district heating in Denmark. In fact, the existence and inherent potential of district heating systems became one of the tools of the Danish government in its efforts to counter the impact of rising oil prices on the national economy. After the first crisis of 1973, immediate steps were taken to curb energy usage and to formulate a national energy policy--in which district heating systems were to play a vital role.

Following the introduction of emergency legislation in 1974, the first comprehensive plan for energy development was presented in 1976. This plan put a heavy emphasis on reducing energy consumption for space heating. Since 1975, a variety of grant programs have been introduced to encourage energy conservation investments by homeowners, including connection to district heating systems. A special law restricting energy consumption in buildings was passed in 1981. Most important, perhaps, was the Danish Heat Supply Act, which came into effect on September 1, 1979. Under this act, each municipality and county is required to submit a detailed heat plan for the approval of the Ministry of Energy. The heat plan must:

--describe and schedule the appropriate heat supply system (i.e. gas, electric, district heating, etc.) for each district or zone within the municipality and county;

--outline heat supply alternatives, including, for example, proposals for heat recovery from refuse incineration, or for surplus heat recovery from industries for use in district heating schemes; and

--describe the economic and energy consequences of the plan.

Each heat plan is then subjected to sensitivity analysis and used as the basis for determining the best mix of heat supplies for the jurisdiction.

These measures and the Danish public's response have had a marked effect on energy consumption and the national balance of payments. Although the real value of energy has increased 250 percent from 1972 to 1982, and while heated floor space has increased 25 percent in the same period, total energy consumption for heating has declined by 30 percent.[4]

District heating has played a large role in this national effort. By 1983, district heating systems had expanded in Denmark to serve about 40% of total non-industrial heating demand. There are about 350 systems throughout the country of 5 million people, of which 50 are municipally owned (see Table 1). The rest operate as consumer cooperatives. A national goal is to increase district heating penetration to 50% of the non-industrial market by the year 2000. The municipal and county heat plans are used to guarantee that areas of high density are targeted for district heating development, while areas of lower density may be served by natural gas, or by electrical or renewable energy systems for very low density areas.

The following features of Danish district heating development have been variously credited for the success of the technology and its penetration into the consumer market, which is the highest among Western nations:[5]

Standardization

Standardized characteristics in thermal media (hot water or steam) and in transmission and distribution links allow for the development of systems that can be interconnected over time and distance. Hot water is the standard medium for Danish systems, normally at pressures below 95 psi and at supply temperatures of 176 - 194 degrees F. Hot water systems have several advantages over steam systems, including greater capability to transmit heat over long distances (more than 60 miles from a

TABLE 1.

Summary of Danish District Heating (1981)

Population	--	5.2 million total (1.5 million in Copenhagen
Housing	--	2.0 million housing units (60% single family; 40% multifamily)
Annual Energy Demand (including electricity)	--	570 trillion BTU
Annual Heat Demand (excluding electricity)	--	190 trillion BTU
District Heat Supplied (42% of heat demand)	--	80 trillion BTU
Total District Heating Systems (transmission and distribution)	--	350 systems nationwide (300 cooperative; 50 municipal)
Length of Double Pipe Grid (excluding service branches)	--	5,800 miles nationwide
District Heating Load Factor (nationwide average)	--	43 per cent
Delivered Heat Price Range (varies based on local distribution system)	--	$ 5 to $10 per million BTU

*Source: District Heating and Combined Heat and Power Systems: A Technology Review (IEA, 1983) central station compared to a maximum 2 or 2 1/2 miles for steam); greater simplicity and fewer maintenance problems; capability for heat storage in accumulators for periods of peak demand; and greater ability to exploit sources of waste heat. For its greater efficiency and flexibility, hot water is normally the choice for new district heating systems.

Simplicity

As outlined by Danish district heating engineers and contractors, Danish systems are designed to be adequate for the job at hand rather than elaborate and overcomplicated. Pains are taken to avoid oversizing systems and pushing up the initial capital costs. The basic approach is to design a system which can build up a customer base and begin producing revenue at the earliest date. When revenues expand and economics improve, the system itself can be expanded.

Many Danish district heating systems are designed for direct customer connections with no heat exchangers. This has the advantage of minimizing consumer costs for connecting with the system.

Town Planning and Record-keeping

Urban planning is generally more accepted and advanced in Denmark than in the U.S. and imposes greater constraints upon developers. Construction of new buildings is largely in conformance with multi-year development plans. This greatly assists district heating systems to plan system expansion into development areas.

Records of utility drawings are more easily available and are probably better coordinated at the municipal level in Denmark than in the U.S. This aids the district heating design engineers in their efforts to limit installation costs by routing mains so as to avoid most unforeseen hindrances. (It should be noted that district heating is credited with bringing about considerably better co-ordination between Danish utilities; as a result, municipalities are able to maintain better records.)

High Prices for Competitive Fuels

Although it is very difficult to compare fuel prices between Denmark and the U.S., it is certainly true that the absolute price of fuels is higher in Denmark than in the U.S. The relative difference between the cost of fuels is somewhat difficult to establish. Table 2 compares the cost in 1985 to Danish consumers of different types of heating systems with different fuel sources. It indicates that district heating produced from a combined heat and power plant (as in Odense) can be up to 32 percent less expensive than a gas-fired individual heating system, and up to 43 percent cheaper than an oil-fired individual system. In this kind of environment, district heating is in such a strong competitive position that Danish systems do not currently need aggressive marketing strategies. Rather, most consumers will simply connect whenever district heating hook-ups are available. In many Danish district-heated towns and cities there are in fact waiting lists for hook-up.

TABLE 2.

Annual Consumer Cost Comparisons: District Heating Versus Individual Central Heating in Denmark

		Investments	Cost of Financing	Standing Charge	Heat Consumption Charge	Metering Electric Service, Etc.	Total	Cost Per Million BTUs	
		D. Kr.	D. Kr.	D. Kr.	D. Kr.	D. Kr.	D. Kr.	D. Kr.	(Index)
District Heating	Combined heat and power coal-fired (Odense)	23,750	3,180	1,283	2,530	214	7,207	115.7	57%
	"Heat Only" coal-fired (Assens)	13,420	1,797	1,884	5,508	134	9,323	148.9	73%
	"Heat Only" oil-fired (Elborg)	11,130	1,490	2,596	8,540	73	12,699	202.9	110%
Individual Central Heating	Oil	23,180	3,103	-	8,494	1,100	12,697	202.8	100%
	Natural gas	16,000	2,142	-	7,482	1,100	10,724	171.3	84%
	Electric heated								

Single family detached house, existing buildings
- gross area: 130 sq. meters
- annual heat consumption: 62.6 million BTUs

D. Kr. = Danish Kroner
Exchange Rate (11-6-85): $1.00 U.S. = 9.44 Kr.

September, 1985

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Not-for-profit Ownership Arrangements

The not-for-profit ownership of district heating systems in Denmark is another possible element of their success. Consumer confidence in consumer-owned systems is high--whether the systems are owned directly by consumers, as in cooperatives, or indirectly, as in municipally-owned systems. In the case of municipal systems, district heating, like other municipal services, is something that consumers come to expect as a public amenity. Municipal systems are not subsidized by the municipalities, but are expected to pay their own way.

Resource Management Ethos

At least a certain portion of the success of district heating in Denmark must be ascribed to a public ethos which supports efficient management of limited resources. Denmark is a country in which trash separation and recycling are popularly accepted, in which people consider bicycling an acceptable mode of travel to work, and in which conservation of land and other scarce resources is a way of life. Such attitudes can in part be attributed to national economic necessity: the country must make the best and most efficient use of the resources it possesses as well as those which it obtains from the world market. This means that Denmark must apply intellectual and technological resources, in which it is rich, to conserve energy resources, in which it is poor. Public support for district heating is merely one demonstration of this national attitude.

In order to place the foregoing discussion in a true perspective, it would also be appropriate here to point out two disadvantageous conditions under which Danish district heating has nevertheless developed so successfully:

Low Density Supply Areas

With the exception of downtown Copenhagen and the relatively small central business districts of three or four other cities, Danish district heating systems tend to supply areas of a much lower building and load density than is generally thought possible for the development of similar systems in the United States. The effect of this lower density urban development is to increase the capital investment needed for the distribution mains system, which also represents the largest single portion of the total investment in any district heating system. Greater investment means higher costs, which in turn are reflected in higher charges to the customer--making it more difficult for district heating to be competitive.

High Costs of Financing

The costs of financing are traditionally much higher in Denmark than in the United States. Not only are Danish interest rates almost always two or three percent higher than current U.S. rates, but most loans are financed through bond issues requiring interest to be paid on 120 to 130 percent of the capital amount actually borrowed. The effective interest paid is therefore probably closer to the double of U.S. rates. Again, it is ultimately the consumer who supports the resulting higher charges--which increases the difficulties of competition still further.

It was one of the purposes of this research and development effort to test whether district heating concepts perfected in Denmark could be successfully applied in the Columbus environment. In reality, the question becomes one of whether or not a technology perfected in Denmark could be successfully transplanted to the Columbus environment, where pre-conditions for district heating success are necessarily different than in Denmark, and where the use of the technology outside of college campuses and military installations is largely unknown.

DOWNTOWN COLUMBUS: DEVELOPMENT TRENDS

The 1983-84 study by Harry and Mogens Larsen Consulting Engineers indicated a reasonable potential for district heating development in downtown Columbus. It is important to take note here of the trends at work in determining the shape and character of downtown development. The pattern of downtown development as it appeared in 1984-85 had significant consequences for district heating prospects in the downtown area.[6]

Following World War II, Columbus began to experience, as did many other U.S. cities, the powerful decentralizing trends which have since led to a growth of housing, commercial, and industrial activity in outlying areas and suburbs. A report published by the Division of Strategic Planning in 1984 noted that

> Downtown is no longer the center for manufacturing or wholesale trade and it has lost its dominant role as the major center for retail trade and professional services....The industrial and wholesale employment base has gradually shifted from the locations in and or near the downtown to locations in outlying areas where there are large tracts of available land with good freeway access. Employment in retail trade and professional services has also shifted from the downtown to the growing fringe area of the city.[7]

Nevertheless, in spite of the demographic shift to the suburbs, employment in certain sectors of the downtown has grown. In 1980, about 77,400 people were working in the downtown; in 1983, almost 83,200 people were employed there. Forecasts call for more than 100,000 downtown workers by the year 2000. The growth in employment is to be found predominantly in the finance, insurance, and real estate sector, as well as in the transportation, communications, and utility sector of the economy. Employment in public administration, always important in Columbus, is expected to remain stable. Such growth in downtown employment is expected to contribute to the demand for downtown office space which has increased at an average of 200,000 square feet per year between 1979 and 1984.

A renewed interest in downtown development has recently come to the top of the agenda for city authorities and major downtown interests and developers. According to a panel of the Urban Land Institute,

> ...An overwhelmingly positive attitude reigns regarding the potential for all types of development in downtown Columbus. Most residents seem to take pride in the growing skyline and in the emerging preeminence of the city, as demonstrated by the new downtown parks and office buildings, and by the expanded cultural opportunities. In addition, broad agreement exists that downtown residential development in particular would be a positive step.[8]

A number of new office buildings are underway in the downtown area, as well as several large mixed-use commercial developments which are either entering construction or are in the development phase. Notable among these is the City Center (Capitol South) Mall, to be developed by the Taubman Company, which is planned as a major retail center for the mid-Ohio region. Other large and currently underutilized sites near the downtown riverfront are currently targeted for development.

Downtown/Riverfront Development

At the same time that the HML report regarding district heating potential was being submitted, downtown development had become a priority of the new administration under Mayor Dana G. Rinehart. During 1984, the City of Columbus prepared to launch into a major redevelopment effort in its downtown area. This effort was intended to enhance both the city's attractiveness and potential for economic development. The Mayor focused attention on the Scioto River which curves through the downtown area past some of the city's most striking new buildings, creating some of its most pleasant open spaces and dramatic vistas. A Riverfront Task Force was created, uniting some of the most important organizations and personalities involved in downtown development. By the end of 1984, a Riverfront Plan had been drafted by the Division of Strategic Planning. In its introduction, the Plan states:

> The segment of the Scioto River which flows through downtown Columbus offers a unique opportunity for private investment and public enjoyment. The city's quality park and pedestrian access program has provided a riverfront setting prime for private development. The setting is further enhanced by an intact infrastructure service system and riverfront land area owned almost entirely by public agencies, thereby creating a very friendly environment for development....The project's setting and market potential provide an atmosphere inherently attractive for development.[9]

By the end of 1985, a Riverfront Community Improvement Corporation had been developed, with the mandate to serve as agent for the City to promote and coordinate development in the riverfront area. Among the properties available for development or redevelopment are the Central High School site (see Map 1, "Potential Development Areas"); the site of the Ohio Penitentiary; and other vacant land owned by the City and County along the northern riverbend. Based on the proximity of the Old Municipal Light Plant to these sites, a significant opportunity for district heating development was noted by HML Consulting Engineers in their 1984 report. They recommended that the City focus on the potential for reactivating the old plant, (located in the northwest quadrant of Map 1), which had been inoperative since 1975.

Decentralized Development

Downtown Columbus therefore presents a number of new developments underway, together with significant potential for re-development of underutilized land along the riverfront and elsewhere. Up until now, such development has flourished within an environment of public sector support for, and minimal interference in, the locational and architectural choices of downtown developers. This has led to a situation in which many projects are being planned and implemented by private developers but without reference to an overall growth strategy. Recently the limitations of this approach to downtown growth have become apparent to both public and private sector leadership. According to the Urban Land Institute report,

> Not many big cities can continue to prosper for long without some degree of coordinated public/private planning on a formal basis.... Rarely today does a community of more than

> 300,000 population, such as Columbus, lack a formal, well-coordinated development planning process. Also, rarely does a big-city downtown lack some form of land development, marketing, and urban design guidance, not to mention a professionally staffed organization trained to deal with developers, architects, real estate brokers, and consultants on downtown matters.[10]

The Urban Land Institute Panel expressed "an overwhelming need for coordination of the many development initiatives, marketing ventures, and implementation strategies now underway in downtown Columbus," and recommended an organization "representing all community sectors" which should be set up to coordinate major planning efforts.[11] Although the Chamber of Commerce and other downtown interests have begun to explore such a solution, it is likely that district heating will continue to develop in an environment characterized by minimal central planning and coordination of effort. The major disadvantage of such an environment, from the viewpoint of district heating, is that it is very difficult to determine where and when new development will occur. This increases the difficulty of estimating heat loads to be served by the system, of calculating system economics, and generally of assessing costs and revenues.

One of the major purposes of this research effort was to determine whether a district heating project or projects could be successfully developed under such conditions. The risk here was that district heating might be perceived as just another development project among a whole host of other desirable projects (such as Capitol South) competing for the attention of planners and developers. However, if district heating could be successfully promoted as <u>fundamental</u> to future downtown development--as a tool to help determine the nature and path of future downtown development into areas like the riverfront--then district heating might gain additional credibility and attention.

A further critical test of the district heating development effort in 1985 was its ability to attract private investment. Whether or not district heating projects could attract any investment, either public or private, would depend in large measure upon circumstances having little to do with the merits of district heating per se. A critical factor in the search for public and private support for district heating was the performance of the new Municipal Electric Plant, a trash-burning facility located less than four miles south of the downtown. It is necessary to look more closely at that plant and its history to understand its impact upon district heating development issues.

THE TRASH-BURNING POWER PLANT

The Trash-Burning Power Plant, officially known as the "Municipal Electric Plant," presents both significant opportunities and problems for the concept of district heating in Columbus.

The City has its own electrical distribution system serving about 7500 customers, but had no generating capacity after the old Municipal Light Plant was deactivated in 1978. Prior to 1975, the City had already begun construction of shredding stations in order to improve landfill operations. Experiments with coal-refuse mixtures were conducted by the Columbus-based Battelle Laboratories. These experiments indicated that burning a mixture of coal and shredded refuse would minimize the usual corrosive effect of chlorides in the refuse.

Based on this information, the City obligated funds for a feasibility study of a resource recovery electric plant, which was completed in November 1975. A general obligation bond issue was placed on the ballot in November 1976, but for lack of any organized support, failed to win approval by a narrow margin. After City Council placed the issue on the ballot again, the plant was approved by a two-to-one margin in the fall of 1977, and construction began in November 1979.

The plant was designed with a capacity of 90 MW (megawatts), to burn a mixture of 80 percent refuse and 20 percent coal. It contains six boilers, each of which can generate up to 165,000 pounds of steam per hour at 700 psi and at a temperature of 725 degrees F. Refuse is discharged into spouts and then blown over a grate by preheated air. Some of the refuse burns in suspension and some on the grate.[12]

Three 30-megawatt turbine generators can be turned by the steam, generating power at 13,800 volts. Each condensing turbine is independently operated with individual condensers and circulating water systems.

The plant does not use a cooling tower, but rather pumps the condenser water discharge into an adjacent 180-acre lake. It is estimated that a minimum of 400 million BTU/hour is recoverable from the exhausted steam. This amount of heat could serve the equivalent of eight thirty-seven-story buildings, of about 1 million square feet per building. However, this would require addition to the plant of back-pressure turbines or modification of the existing turbines to back-pressure units.

Problems

The plant began operations in 1983, but almost immediately certain design problems became apparent. A screw-type fuel feed system was not able to handle certain items (such as bedsprings) which could clog the fuel feed lines and shut down processing. Also, the coal, which was intended to be mixed with refuse in combustion, burned more efficiently at a different temperature. (This was resolved by burning refuse and coal separately, using the coal only for backup in case of other problems. It is not clear what long-term effect this will have on boiler corrosion.) Globules of melted glass from the refuse adhered to the grates and caused problems with maintenance and ash handling. The ash-disposal system did not work as it was supposed to. Shredding stations broke down and could not handle the normal volume of trash. Modifications to correct these design problems were partly responsible for a sizeable cost overrun. The plant, projected to cost $118 million, now has cost the city almost $200 million. Income taxes must subsidize the power plant debt obligations to the tune of about $18 million in 1985.

Originally, the plant's revenues had been projected to cover all its operating and debt expenses. However, with the modifications in handling and incineration of refuse, the total generating capacity of the plant, originally estimated at 90 MW, has been more recently operating at about 60 MW. The plant had a projected capacity to handle 3,000 tons of refuse per day. Now, 2,000 tons per day seems a more realistic goal. Columbus itself produces only about 1,000 tons, with only four suburban communities contributing to the total. Presently, the City charges a tipping fee of only $8.00 per ton. A proposal is before City Council to raise or lower fees to compete more effectively with the Franklin County landfill. It is estimated that this change would raise an additional $2 million per year in revenue.

The impact of these events on district heating development has been two-fold: financial and political. First, the drain on income-tax revenues and the burden of general obligation debt made it unlikely that the City government would be able to assume further obligations for additional energy-related or resource recovery projects, even if the administration and council fully supported the effort. Politically, it was to be expected that any energy-related proposals which involved City investment would be viewed with caution and skepticism.

Further consequences of these long-standing power plant problems for district heating are anticipated. Because of the limitations placed on public sector involvement, planners and consultants working on the project have assumed from the outset that district heating, in order to be successful in Columbus, would have to be able to attract significant private-sector involvement--especially in the area of financing. Although this is not impossible, it means that district heating would have to be able to offer investors a rate of return at least in the range of 20-25 percent. In the U.S. at present, there are several examples of district heating systems owned and operated by private developers. In most cases, however, these are systems that have been acquired, more or less intact, from electric utilities that had not maintained them profitably. There are few, if any, examples of multi-user district heating systems that have been started "from scratch", using a formula of mainly private investment and/or private ownership.

Opportunities

In spite of these difficulties, the Municipal Electric Plant represents a significant asset to the City as well as to potential district heating developers. Most large cities are now having to consider resource recovery plants because of the burden of locating and managing new landfills. Columbus has obviously taken a step into the future and, it can be argued, is therefore much further along the "learning curve." Instead of having to bargain with surrounding counties for new dumping grounds, Columbus is already recovering electricity from its wastes. If a plant of similar capacity were to be built starting today, it is estimated that it would cost $300 to $350 million.

Following the successful completion of modifications (now in effect), there is little doubt that the trash-burning power plant could be successfully used as the basis for a district heating system. This was the conclusion of a Danish engineering team hired by the Danish Ministry of Energy to assess district heating potential in Columbus. The plant is, by Danish standards, well within the range of high-load consumer areas such as downtown. HML Consulting Engineers determined that a short-term potential existed for 15 MW of heat to be extracted (either through an intermediate "bleeding" process or else directly from the boilers) with only a minor effect on electrical generation. The first phase consumer for this heat would be a County workhouse located about 1500 feet north of the power plant. The peak load necessary from the power plant would be about 12.3 million BTU/hour.

A preliminary design for this small-scale system was completed by HML engineers. Beginning in 1983, negotiations had begun between the City (which owns the plant) and the County (which owns the Workhouse) for the purchase of heat. The City proposed to guarantee the County that it would supply heat at no more than 90 percent of the costs of heating with natural gas. The City also anticipated that it could locate more customers in that area, including other new and proposed state and county correctional facilities, thus improving the payback period and increasing revenues. A total capital cost of around $900,000 was estimated for this first-step project.

The project was delayed for more than a year by reluctance of City officials to commit themselves to a contract with the County or to additional capital expenditures before the Municipal Electric Plant had established itself as a reliable electrical and thermal producer. However, in 1985 and 1986, several proposals were received from prospective developers and engineering companies offering to design and develop district heating systems. These proposals were contingent upon certain commitments from the City, including the sale of thermal energy from the new Municipal Electric Plant. Such proposals are now being evaluated by the City. The new County Workhouse is already occupied, and its heating system has been constructed in such a way that direct district heating connections for future hot water hook-up have already been installed.

Conclusion

The existence of the refuse-burning Municipal Electric Plant in Columbus therefore presents district heating developers with both obstacles and opportunities. Past problems with the plant have created both political and financial barriers that any potential district heating project will have to overcome. These barriers are not insignificant. Nevertheless, the plant also represents a worthwhile effort to recover electricity from the waste stream. If useful heat could also be recovered from the plant, this could represent a supplemental source of revenue for the City as well as a future source of low-cost heat for development activities, both at the site of the plant as well as in the downtown area.

PROJECT ECONOMICS: UTILITY RATES

Based on the Danish experience, district heating would appear to have an advantage in situations where the alternative fuel (usually either heavy fuel oil or natural gas) is significantly more expensive to the consumer than the equivalent heating value of centrally generated steam or hot water. In Denmark, for example, district heating customers can realize from 30 to 40 percent savings in annual heating costs (see Table 2).

Alternatively, district heating systems may also have a competitive advantage if they can show that their life-cycle costs are in the long run less than the comparable costs of individual gas or oil-fired systems. (Life-cycle costs would include, in addition to fuel, both operations and maintenance as well as the consumer's share of capital investment). Savings derive from the capital-intensive nature of district heating systems, which enables them to use lower-cost fuels to produce heat. Life-cycle fuel costs as a percentage of total system costs are generally much less in a district heating system, over the long run, than the comparable costs of fuel for individually-owned systems. Thus the district heating system in effect capitalizes much of the long-run fuel costs and assures that fuel costs will remain relatively stable over the life of the project. This life-cycle cost advantage might be marketable to potential consumers even if the delivered price of district heat were at or near the current price of alternative fuels.

In Columbus at the beginning of the current study (mid-1985), natural gas was the fuel of preference for more than 80 percent of the city's space-heating consumers. Table 3 indicates that prevailing natural gas costs for large-volume users are less than $6.00 per thousand cubic feet (MCF). It is necessary to note that the costs given are those per British thermal unit (BTU) of input. In reality, depending upon the boiler efficiencies of individual users, the cost per unit of heat output is somewhat higher. For example, a user of 10,000 MCF per month may be paying only $5.47 per million BTU's (MMBTU) of gas purchased, but if his boiler and heating system operate at only 65 percent efficiency over the year, he is actually paying $8.42 per MMBTU for useful heat.

According to the Ohio Consumer's Counsel, the average residential gas customer in Columbus paid about $6.12 per MCF of gas in 1985. This is a decline of 8.3 percent from 1984.[13] In fact, twelve of fourteen cities surveyed in Ohio and surrounding states experienced decreases in gas bills because of lower fuel prices. Overall, gas payments in the Midwest dropped 4 percent in 1985.

In the near-term future, the price of gas is more likely to decline than to increase. This is at least partially a result of the recent plunge in crude oil prices. Energy User News reported on January 27, 1986 that some large industrial customers with dual-fuel capabilities would soon find it beneficial to switch from

TABLE 3

Natural Gas Prices, Columbus, Ohio (1985)

Residential and Small Commercial Schedule

Monthly Consumption MCF	Total Costs $	Cost per MCF $/MCF	Costs per Btu. Input $/Mill. Btu.
25	164	6.56	6.37
50	325	6.50	6.31
100	646	6.46	6.27
500	3,216	6.43	6.24
1,000	6,430	6.43	6.24
1,475	9,476	6.43	6.24

Industrial and Large Commercial Schedule

Monthly Consumption MCF	Total Costs $	Cost per MCF $/MCF	Costs per Btu. Input $/Mill. Btu.
1,475	9,484	6.43	6.24
2,000	12,444	6.22	6.04
5,000	29,121	5.82	5.65
10,000	56,315	5.63	5.47
15,000	83,509	5.57	5.41
20,000	110,703	5.54	5.38

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gas to residual fuel oil. This means that gas prices will have to decline in order to remain competitive. Over the past twelve months in the U.S., spot market wellhead gas prices have fallen by more than 30 percent from an average of $3.00 per MMBTU to less than $2.00.[14]

Perhaps even more significantly, Columbia Gas of Ohio has already indicated its willingness to begin acting as broker for low-cost gas from independent producers (so-called "self-help" gas). Although it is not yet aggressively marketing such gas to major downtown office buildings, Columbia has suggested that it both can and will do so if it feels that its present customer base is threatened by district heating competition. Such low-cost gas has been acquired by Columbus Public Schools for as low as $4.85 per MCF through an independent broker, but purchases of full-tariff gas to meet peak volume needs have raised the average price to $5.20 to $5.30 per MCF. Special rates even lower than this may be offered by Columbia to very large dual-fuel (both gas and fuel oil) users who meet certain strict conditions. However, for the majority of downtown customers, gas prices are now about $5.80 per MCF and may drop over the next two or three years to about $5.60 per MCF, coincidental with any further drop in oil prices.

Local electricity rates are also important in assessing district heating feasibility. In Columbus, electrical space heating is not common and will probably not be competitive with gas or oil for either large or small consumers. However, it is generally agreed that there is no shortage of generating capacity within the American Electric Power (AEP) system, of which Columbus and Southern Ohio Electric is a part. Consequently there is no pressing demand for additional generation capacity in the form of cogeneration plants. This is reflected in the buy-back rates which C&SOE pays for cogenerated power, which varies from 2.4 cents per KWH (off peak) to 2.6 cents per KWH (on peak). These relatively low buy-back rates adversely affect the economics of cogeneration. If new thermal sources need to be installed to serve a downtown district heating network, their viability may well depend on the existence of a market for sales of electricity as well as for heat.

Columbus has a municipal electric utility serving about 7500 customers--which is a potential market for a district heating cogenerator. The trash-burning Municipal Electric Plant does not produce all of the power needed for its own system at present. It is now purchasing power from other systems at an average price of only about 1.9¢ per KWH. This figure represents a rough estimate of the price that a district heating cogenerator could therefore expect to receive for power produced.

SUMMARY

This chapter has discussed not only the Danish concept of district heating which is being adapted to the Columbus environment, but also has assessed some of the basic economic, political, and developmental conditions which can be expected to influence the eventual success of district heating. By this time, there is little doubt that the technology of district heating will work in Columbus. Work done both by the City of Columbus as well as by HML Consulting Engineers has indicated that potential district heating sources exist both in the downtown and elsewhere, and that potential customer loads either exist or can be developed. Of the remaining issues to be resolved, the question of economic feasibility ranks highest. Columbus is not among the Midwestern cities with the highest utility rates, and the recent performance of the world oil market indicates that the price of natural gas, which is to some extent a market substitute for oil, may become even more competitive in the short run.

There are also some political barriers that district heating in Columbus must overcome. Although Columbus citizens have in the past supported both the concept of resource recovery and the construction of a refuse-burning power plant, the escalating costs of the plant as well as unforeseen functional problems have not only sapped political support for City involvement in energy projects, but have also created an additional burden of public debt.

On the positive side, the Municipal Electric Plant represents a significant asset from which revenues can be recovered in the form of thermal sales. City officials say that technical improvements to trash and ash handling processes at the plant are now paying off. More trash is being burned and less power is having to be purchased from other sources. An institutional customer in the vicinity of the power plant has already been identified, and there is potential to further develop the customer base in that area. In addition, the City owns its own municipal electrical distribution system, which can serve as a market for electricity that may be produced from cogenerating plants.

Columbus is also undergoing a boom in downtown office construction, and community leaders currently support a long-range commitment to downtown and riverfront development. This opens a "window of opportunity" for obtaining new customers for a potential district heating system, as well as for using district heating as part of a package of development incentives to counterbalance the powerful attractiveness of suburban areas to developers. Although downtown development is proceeding in an environment not characterized by strong centralized growth planning, a district heating concept which relies on the development of small "heat islands" which can eventually be linked into a larger system may prove feasible.

NOTES--CHAPTER 2

(1) Department of Energy and Telecommunication, Assessment of District Heating/Cooling Potential in Columbus, Ohio: Final Report (September 1982), p. 44.

(2) Harry and Mogens Larsen A-S, Consulting Engineers, "Feasibility Study," Volume III of a Conceptual Study (August 1984), p. 6.

(3) Ibid., p. 9.

(4) Danish National Building Agency, "How Denmark Saves Energy," (August 1984), p. 3.

(5) I am indebted for the following discussion to Rich Zelinski, Program Director, Public Technology, Inc.; and Allen Kennedy, Manager, Community Systems, USDOE/Argonne, in their report to the Energy Task Force of the Urban Consortium, "District Heating in Denmark: Report of a Study Visit," (December 17, 1985), p. 6 ff. I am also indebted to David Rubin, San Francisco Public Utilities Commission, for his remarks to the Danish Board of District Heating contained in that report.

(6) I am indebted for the following discussion of downtown development trends to William F. Hoyt and Burell T. Charity of the Division of Strategic Planning for their study, "The Importance of Downtown," one of a series on different aspects of Columbus development.

(7) William F. Hoyt and Burell T. Charity, op. cit., p.3.

(8) Urban Land Institute, "Columbus, Ohio: An Evaluation of Downtown Housing and Retail Strategies, Conducted for the City of Columbus and the Columbus Area Chamber of Commerce," A Panel Advisory Service Report (September 8-13, 1985), p. 15.

(9) Division of Strategic Planning, City of Columbus, "Riverfront Strategic Plan" (Draft, 1984), p.1.

(10) Urban Land Institute, op. cit., p. 38.

(11) Op. cit., p. 11.

(12) These figures were obtained from various journal and newspaper articles, but I have relied mainly on Tom Moody and Dana G. Rinehart, "Ohio's Most Populous City Turns Trash to Megawatts," in Ohio Cities and Villages, December 1984.

(13) "Ohio utility rates decline in survey," Columbus Dispatch, January 31, 1986.

(14) "Falling oil prices to spur price competition with gas," Energy User News, Vol. 11, No. 4, January 27, 1986.

Chapter 3. Methodology

INTRODUCTION

In carrying out this study project, our intention was to follow, as closely as possible, the assessment methodology used by the consulting engineers. Our report would then translate the process into layman's language to make this process as transparent as possible for the benefit of planners in other jurisdictions. The report was not conceived as a "do-it-yourself" guide to district heating assessment or as a substitute for analysis which must be done by qualified district heating engineers. Rather, we felt that planners should be able to understand the process used in an engineering analysis and if necessary, to make a "rough cut" estimate of the feasibility of particular technical solutions.

There were several uncertainties regarding the economic viability of a district heating project in downtown Columbus. In particular, the viability of the initial or start-up phases of system development--those generally accepted as the most critical--was uncertain. There were questions about the ability of district heating to compete with the generally modest gas prices available to individual building systems, and whether or not a suitable consumer base could be identified. Could district heating utilize any surplus capacity of large existing boiler installations in order to reduce the disproportionately high capital investments of the initial phases? And did such surpluses exist in downtown Columbus?

From the outset of their investigations, the consultants assumed a need to identify the potential customer base in terms of "heat islands." These are clusters of buildings offering concentrations of good potential for district heating. Possibly, although not necessarily, such concentrations would be found in areas of relatively high thermal load density. Development of heat islands would reduce the initial investments in the distribution mains, typically the largest single investment in a district heating system.

The "heat island" theory was developed in Denmark, and much of the successful development of Danish district heating has been attributed to it. The fundamental question to be addressed here, however, was: Could appropriate heat islands be identified in downtown Columbus of sufficient size to justify investment in district heating infrastructure?

The answer to this question would be based on technical engineering parameters and economic factors. In order to analyze these engineering and economic factors, HML Consulting Engineers basically employed a four-step process which can be outlined as follows:

1) Examination of existing heat source potential in downtown Columbus
2) Identification of consumer market
3) Preliminary system design
4) Analysis of system economics

The immediate challenge for Columbus planners and their consulting engineers was to identify a feasible start-up project in the downtown area. This project would not have to be large-scale and comprehensive in scope. It was thought that the demonstration value of even a small start-up project would be worth the investment. If the objective of a district heating project is to provide low-cost heat, it was also assumed that this heat would be provided either as a by-product of electrical generation (co-generation) or, if co-generation were not possible, from boilers using lowest-cost fuels. In downtown Columbus it was assumed that this would mean either coal or "self-help" gas.

EXAMINATION OF HEAT SOURCE POTENTIAL

In order to achieve the most favorable operating economics, it is important to utilize sources of heat which offer the lowest possible costs. These low costs can be realized in either of two ways: by substitution of low cost fuels for higher cost fuels, and by avoiding capital costs through the use of existing boiler plants.

Existing Boilers

Natural gas is the most commonly used fuel in downtown buildings. At the time of the study, natural gas cost most users approximately $8.50 per MMBTU of useful heat ($5.80/MCF gas input). This compares to a cost of approximately $13.20 per MMBTU for electricity (4.5¢ per KWH) and a cost of approximately $2.75-3.00 per MMBTU for coal ($49.40/ton input). (It should be noted, however, that under FERC Rule 436, natural gas from contract carriage (often called "self-help" gas) may be available to a few of the largest users at a cost of approximately $3.75-4.00 per MMBTU.) These cost differentials obviously favor the use of coal-fired capacity where possible. However, environmental regulations coupled with the larger capital investment requirements of coal-fired plants tend to limit the utilization of coal.

Using information obtained from the Ohio Environmental Protection Agency in a previous district heating study, existing coal-fired heat production facilities near the downtown area were identified. These plants were surveyed to determine if any excess capacity existed for possible use as initial heat sources for start-up projects. On the basis of these surveys, it was determined that one building complex in particular--Grant Hospital--had significant potential as an initial heat source with nearly 43 MMBTU/HR (11 to 12 megawatts thermal) of excess production capacity available, and was located in an area appropriate to a possible start-up project (see Map 2, page 53).

In the course of gathering data in the consumer market identification phase of the study, another potential heat source was discovered - the boiler plant at the Ohio Department of Transportation building. This natural gas fired boiler plant has an excess capacity of approximately 80 MMBTU/HR. This excess capacity is likely to diminish, however, if a new state office tower is connected to the existing plant.

Power Plants

In addition to the investigation of existing boiler capacity, the suitability of two City-owned resources--the trash-burning Municipal Electric Plant and the Old Municipal Light Plant--were evaluated as potential heat sources for a distict heating system. Both of these evaluations were undertaken by engineering consultants, and a detailed description of their methodology is beyond the scope of this study. However, some generalizations about their conclusions can be made.

The Municipal Electric Plant utilizes three conventional three-stage condensing turbines. The engineering consultants estimated that heat could be recovered, at low investment cost, with only a small loss of electrical generation capacity. This would offer a potential for 5 MW thermal, or 17 MMBTU/HR., heating capacity per turbine (a total of 51 MMBTU for all three turbines). However, the Municipal Electric Plant is located nearly four miles south of downtown, and the potential heat sales at this output are unlikely to justify the large capital investment required for the interlinking transmission main.

An even greater thermal potential could be realized, however, by either replacing the existing condensing turbines with back pressure turbines or by modifying the existing turbines to a back pressure design. Through the use of back pressure turbines, approximately 420 MMBTU/HR. of thermal capacity would be available at temperatures very suitable to hot water district heating. This would require considerable capital investment, however, (roughly estimated at a cost of $5 million), and the addition of a cooling tower at the plant to reject heat during the summer months. Additionally, it is estimated that this would reduce the plant's capacity to generate electricity by approximately ten percent.

Because of the level of investment required, however, none of the approaches described above is likely to be undertaken in the near term.

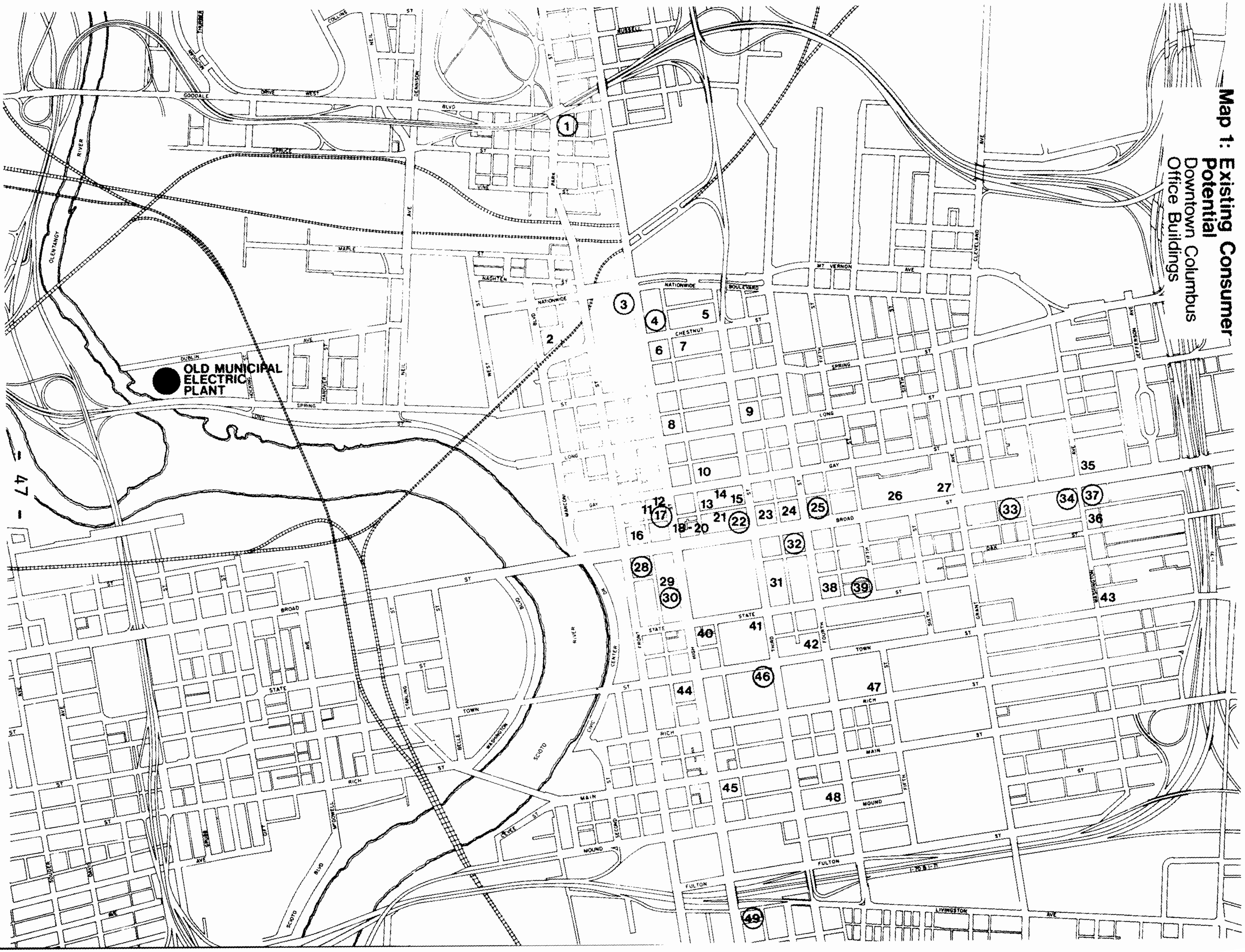
The consulting engineers also evaluated the Old Municipal Light Plant for its potential as a heat source. The Municipal Light Plant was originally comissioned in 1913, and was operated more or less continuously until 1978. The principal reasons for decommissioning the plant were the inability of the plant to meet the emission standards established by the EPA, and the Fuel Use Act, which restricted the continued operation of a natural gas turbine generator.

The central question which the consultants addressed was whether it was possible to refurbish the plant's equipment and bring it back into operation in such a way that it could provide heat to a district heating system. The consultant concluded that the equipment was generally of such an age and state of neglect that it was economically impractical to utilize it. The only possible exception was the gas turbine generator, which could perhaps be refurbished, though at considerable cost (estimated in one study to be as much as $700,000). An accurate assessment of this option was beyond the scope of the present study and would require disassembly of the equipment in order to determine its true condition.

The consultants did note that the plant's <u>site</u> has a number of advantages which would make it an ideal location for a district heating facility (see Map 1, p. 47). The presence of a railroad spur to bring in coal by rail car, existing coal handling facilities, access to cooling water, and proximity to the downtown area are all attributes which could make it an ideal site for a district heating source. And, with the use of modern equipment, including emissions abatement measures, environmental regulations could be met--even for a coal-fired plant.

Map 1: Existing Consumer Potential

Downtown Columbus Office Buildings



IDENTIFICATION OF CONSUMER MARKET

In identifying the potential consumer market for district heating in the downtown area, the consultants focused their attention on some large office buildings in the downtown area and on identifiable future development projects. District heating service is particularly advantageous to the latter because it can eliminate the initial costs of individual boiler plants.

The first step was to identify appropriate buildings. This was done using information from the city's planning department and a market study of office space in the downtown area which had been recently undertaken by a private firm. These reports identified buildings by address, gave the square footage of floor space for each building, and identified the organization responsible for building management in each case. Using the addresses of these buildings, the planning staff was able to access information on boiler plants, which included the type of boiler (whether steam or hot water) and the boiler's fuel input rating. For the purposes of the present exercise it was assumed that the HVAC systems with steam-producing boilers were probably incompatible with hot water district heating due to the prohibitive cost of the HVAC modifications that might be required. Similarly, it was assumed that the HVAC systems with hot water-producing boilers would likely be compatible with hot water district heating. Therefore, the study focused on "compatible" buildings. Based on the input ratings of the boilers, the consultants developed estimates of the buildings' peak and annual loads. Table 4, pp. 49-50, shows the results of this step.

TABLE 4. Examples of Existing Consumer Potential
Downtown Columbus Office Buildings

Building No.	Type of Boiler	Number of Boilers	Rated Input Per Boiler	Total Rated Input
1	GHWB	1	910,000 Btu/hr.	910,000 Btu/hr.
2	N/A	N/A	N/A	N/A
3	EHWB	2	2,040 KW	13,925,000 Btu/hr.
4	GOHWB	2	3,000,000 Btu/hr.	6,000,000 Btu/hr.
5	N/A	N/A	N/A	N/A
6	GSB	1 1)	2,450,000 Btu/hr.	2,450,000 Btu/hr.
7	GSB	5	3,780,000 Btu/hr.	18,900,000 Btu/hr.
8	GSB	1	732,000 Btu/hr.	8,582,000 Btu/hr.
	GSB	1	7,850,000 Btu/hr.	
9	N/A	N/A	N/A	N/A
10	GSB	2	100 HP	6,695,000 Btu/hr.
11	GSB	1	2,793,000 Btu/hr.	2,793,000 Btu/hr.
12	GOSB	2	2,188,000 Btu/hr.	4,376,000 Btu/hr.
13	GSB	2	5,234,000 Btu/hr.	10,468,000 Btu/hr.
14	GSB	1	4,200,000 Btu/hr.	4,200,000 Btu/hr.
15	GSB	1	1,640,000 Btu/hr.	4,140,000 Btu/hr.
	GSB	1	2,500,000 Btu/hr.	
16	GOSB	3	8,400,000 Btu/hr.	29,400,000 Btu/hr.
	GSB	1	4,200,000 Btu/hr.	
17	GOHWB	1	735,000 Btu/hr.	735,000 Btu/hr.
18	GSB	2	4,200,000 Btu/hr.	8,400,000 Btu/hr.
19	GSB	1	4,200,000 Btu/hr.	4,200,000 Btu/hr.
20	N/A	N/A	N/A	N/A
21	GSB	1	3,600,000 Btu/hr.	3,600,000 Btu/hr.
22	GHWB	2	6,312,000 Btu/hr.	12,624,000 Btu/hr.
23	GOSB	2	25,106,000 Btu/hr.	75,318,000 Btu/hr.
	GSB	1	25,106,000 Btu/hr.	
24	GSB	1	3,500,000 Btu/hr.	3,500,000 Btu/hr.
25	EHWB	2	320 KW	2,184,000 Btu/hr.
26	GSB	2	5,231,000 Btu/hr.	10,462,000 Btu/hr.
	ESB	2 2)	630 KW	4,300,000 Btu/hr.
27	GSB	2	1,620,000 Btu/hr.	3,240,000 Btu/hr.
28	GHWB	2	9,800,000 Btu/hr.	19,600,000 Btu/hr.
29	GSB	2	4,165,000 Btu/hr.	8,330,000 Btu/hr.
30	GHWB	2	16,730,000 Btu/hr.	33,460,000 Btu/hr.
31	GOSB	1	4,200,000 Btu/hr.	8,400,000 Btu/hr.
	GSB	1	4,200,000 Btu/hr.	
32	EHWB	2	2,400 KW	18,942,000 Btu/hr.
	ESB	4	187 KW 3)	
33	GHWB	1	3,500,000 Btu/hr.	3,500,000 Btu/hr.
34	GHWB	2	6,277,000 Btu/hr.	33,195,000 Btu/hr.
	EHWB	3	755 KW	
	GSB	1	6,277,000 Btu/hr.	
	ESB	1	195 KW	
	GHWB	1	3,750,000 Btu/hr.	
	EHWB	1	650 KW	

TABLE 4, continued)

Building No.	Type of Boiler	Number of Boilers	Rated Input Per Boiler	Total Rated Input
35	N/A	N/A	N/A	N/A
36	N/A	N/A	N/A	N/A
37	GSB GHWB	1 3	1,050,000 Btu/hr. 800,000 Btu/hr.[4]	3,450,000 Btu/hr.
38	N/A	N/A	N/A	N/A
39	GHWB	1	780,000 Btu/hr.	780,000 Btu/hr.
40	GSB	2	4,200,000 Btu/hr.	8,400,000 Btu/hr.
41	N/A[5]	N/A	N/A	N/A
42	GOSB	2	5,230,000 Btu/hr.	10,460,000 Btu/hr.
43	N/A	N/A	N/A	N/A
44	GSB	1	2,050,000 Btu/hr.	2,050,000 Btu/hr.
45	N/A	N/A	N/A	N/A
46	GHWB	2	4,200,000 Btu/hr.	8,400,000 Btu/hr.
47	N/A	N/A	N/A	N/A
48	N/A	N/A	N/A	N/A
49	GHWB	1	1,750,000 Btu/hr.	1,750,000 Btu/hr.

NOTES:

1 The building has three gas/oil combination steam boilers. Data were available only for the gas-fired steam boiler.

2 These boilers were to have been dismantled by the time this study is published.

3 This number is the average rated input of the four electric steam boilers. The actual inputs are as follows: one at 200 KW, two at 150 KW, and one at 250 KW.

4 This number is the average rated input of the three gas-fired hot water boilers. The actual inputs are as follows: one at 1,050,000 Btu/hr., one at 600,000 Btu/hr., and one at 750,000 Btu/hr.

5 The building is electrically heated and has no boilers.

6 GHWB - Gas Hot Water Boiler
GSB - Gas Steam Boiler
GOHWB - Gas or Oil Fired Hot Water Boiler
GOSB - Gas or Oil Fired Steam Boiler
EHWB - Electric Hot Water Boiler
ESB - Electric Steam Boiler

To estimate the market potential for district heating from future development projects, the consultants referred to records maintained by the city's planning department. These records indicated the probable sizes of the projects in terms of square feet, and the types of uses (e.g., office building, museum, hotel) proposed for these projects. The consultants then used demand estimates for heating and hot water service requirements for each type of use (for example, 46 BTU/HR. per square foot of office space) to calculate peak and annual loads for each project. Table 5 (p. 52) shows the demand estimates that were used, and Map 2 (p. 53) and Table 6, (pg. 54), indicate the site locations and relevant information.

In this way, the locations of potential district heating consumers and their estimated heating demands were identified and displayed.

PRELIMINARY SYSTEM DESIGN

The first step in the preliminary design process was to assess the relationship between the identified heat source and potential district heating consumers. Their locations were plotted and the heating demand estimate for each building was indicated. This map was then inspected to identify clusters of buildings, concentrations of thermal loads, spatial relationships between potential heat sources and heat loads, and any geometrical patterns that might suggest optimal distribution routes.

The results of this process identified several possible "heat islands" in the Columbus downtown area which could be developed in phases. (See Map 3, p. 55.)

TABLE 5.

Maximum Hourly Demand Coefficients (MHDC)

(for heating and hot water service)

Building Use	Coefficient
Offices & Banks	46 Btu/sq. ft./hr.
Retail & Wholesale	46 Btu/sq. ft./hr.
Food Markets	46 Btu/sq. ft./hr.
Restaurants	50 Btu/sq. ft./hr.
Pre-College	41 Btu/sq. ft./hr.
College & Universities	55 Btu/sq. ft./hr.
Hotels & Motels	68 Btu/sq. ft./hr.
Hospitals	71 Btu/sq. ft./hr.
Churches	31 Btu/sq. ft./hr.
Auto Services	21 Btu/sq. ft./hr.
Government	46 Btu/sq. ft./hr.
Miscellaneous	40 Btu/sq. ft./hr.
Warehouses	21 Btu/sq. ft./hr.

From Harry and Mogens Larsen, Feasibility Study, August 1984, Vol. II, pg. 53., Table 27.

Map 2: Potential Consumer Base

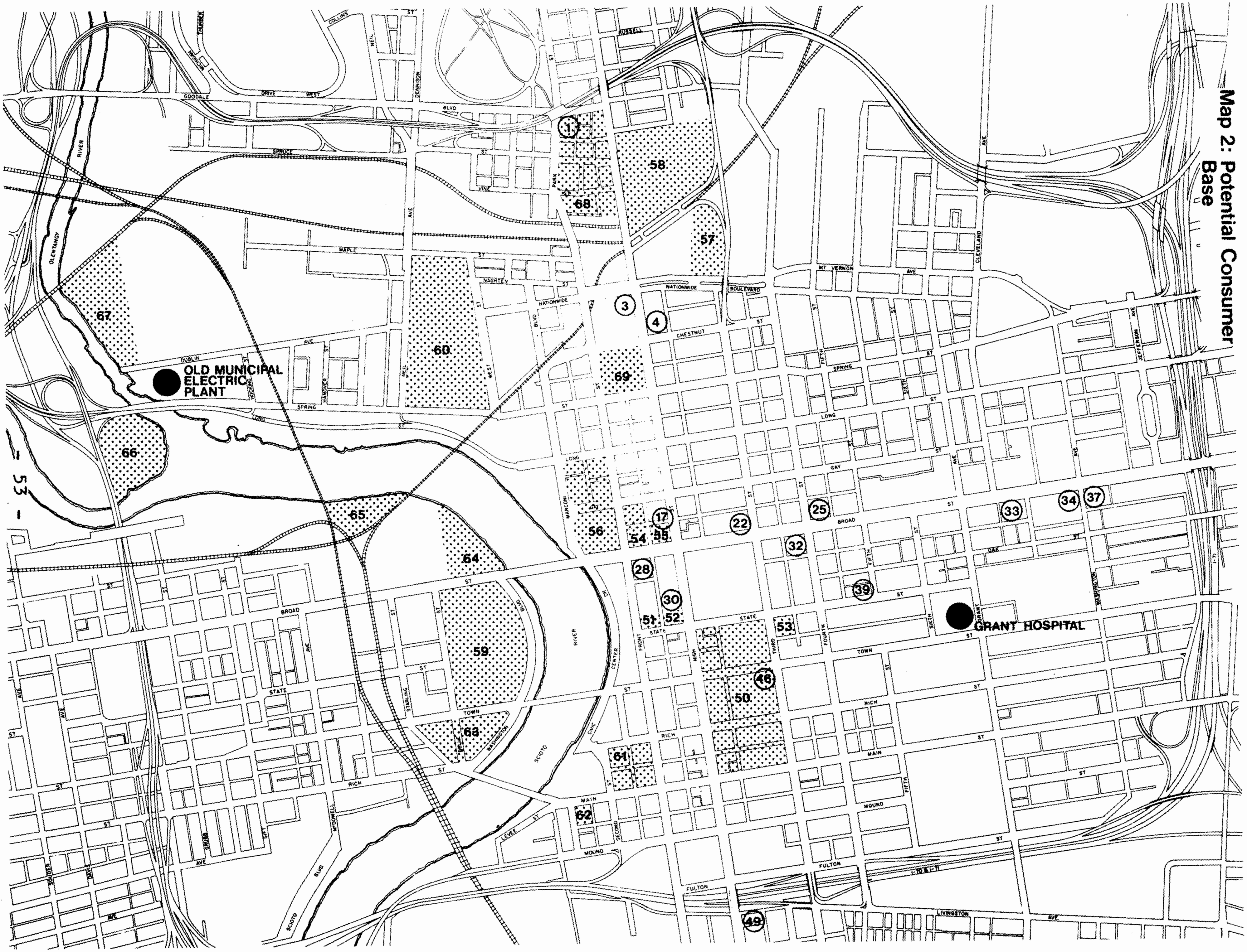


TABLE 6.

Downtown Development: A List of Proposed Projects and Potential Development Sites

Project Number	Project Name	Construction Date	Occupation Date	Design Status	Building Use	Building Size Square Feet	Estimated Peak Load Million Btu/hr.
50	Capitol South	1985	1988	Underway	Commercial Mix	680,000	23.2
51	State Office Tower	1985	1987	Started	Office	560,000	27.8
52	Performing Arts	1985	1987/88	Started	Arts Centre	120,000	5.5
53	Old, Old Post Office Ren.	1985	1986	On Hold	Office/Restaurant	110,000	5.1
54	LeVeque Tower Renovation	1985	1986	Preliminary	Office/Restaurant	400,000	13.5
55	One Columbus Office Building	1985	1987	Under Constr.	Office	450,000	15.8
56	Civic Center Complex	NA	NA	Conceptual	Office	NA	NA
57	Ohio Center Expansion	NA	NA	NA	NA	NA	NA
58	Ohio Center Parking Lot Domed Activity Center	NA	NA	NA	Parking Dome	NA	NA
59	Central High School	NA	NA	NA	NA	240,000	14.6
60	Old Penitentiary	1987	NA	Conceptual	Retail Office Residential	210,000 100,000 510,000	47.9
61	Riverplace Housing Development	On Hold	On Hold	No Activity	Commer./Resid.	96,000	4.4
62	Waterford Housing Development	NA	NA		Commer./Resid.	77,000	NA
63	Health Department Area	By 1992	-	Planning	Residential	NA	NA
64	Veterans Memorial Area	By 1992	-	Planning	Hotel/Restaurant	18,000	.8
65	Rickenbacker Military Museum	1986	1988	Conceptual	Museum	40,000	1.6
66	Confluence Area	1986	1988	Underway	Restaurant	24,500	1.1
67	Olentangy Corridor Area	By 1992	-	Planning	Residential	NA	NA
68	North Market Area	NA	1990	Conceptual	Church	46,000	1.8
69	Nationwide Area	NA	1990	Conceptual	Office	1,200,000	39.8

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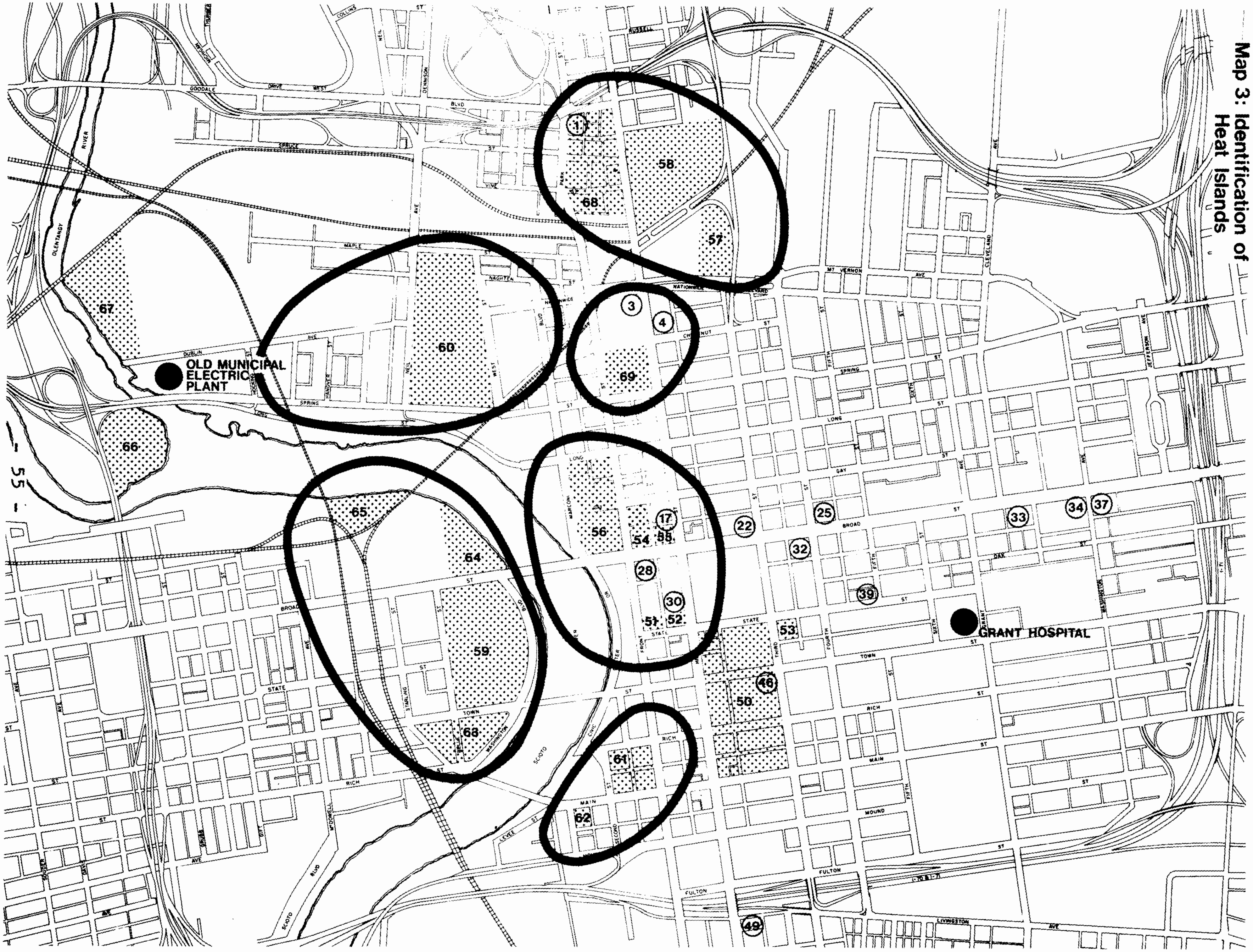


Map 3: Identification of Heat Islands

Once these "heat islands" were identified, the next step was to lay out a provisional distribution network and determine the technical engineering design parameters. To some extent, this process is arbitrary. A number of non-technical considerations, such as development goals and phasing limits must be considered. The process is probably best illustrated by using the Columbus experience as an example.

The largest and most obvious "heat island" is the cluster of eight potential consumers in the central downtown area identified as Phase 1 (note the area within the circle on Map 4, p. 57). There are several good reasons to develop this area first.

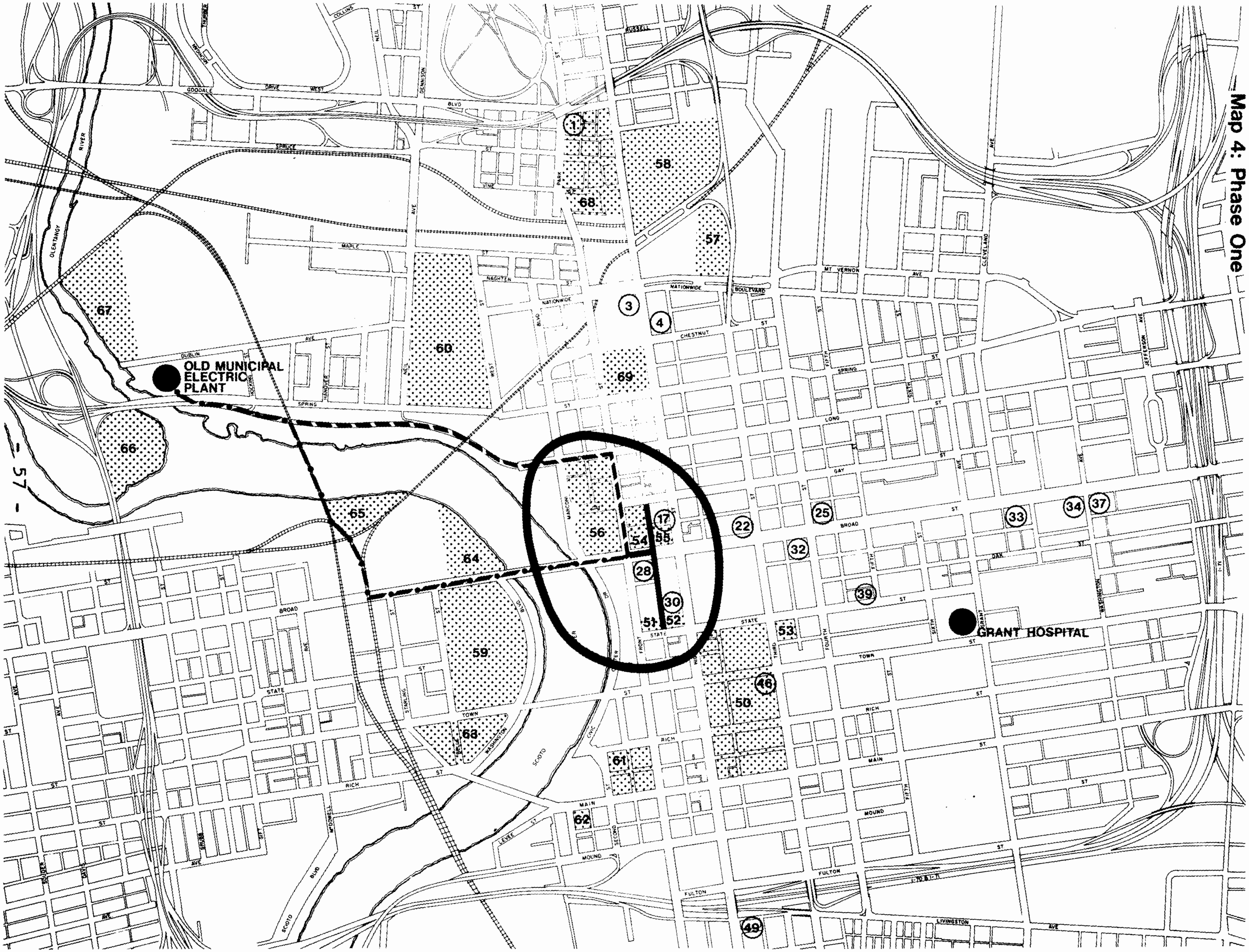
1) The area is centrally located within the overall service area, allowing for easier and more economic expansion of the system to the surrounding "heat islands;"

2) Substantial new construction is proposed for the area (including a new city government office complex) which could take particular advantage of district heating by avoiding the initial costs of boiler plants;

3) The area has the highest "thermal density" in the service area; that is, there is a large amount of heated floorspace within a very compact area.

An existing potential heat source has been identified in the immediate area -- the ODOT building. However, this boiler plant is gas fired, and it is likely to be extremely difficult for wholly gas-fired district heating to compete economically with the larger individual gas-fired units. Price competitiveness of the gas-fired

Map 4: Phase One



source may be improved if either cogeneration (with a good price for electricity sales) is involved, or if a significantly lower gas rate can be negotiated for the district heating plant. Consequently, the consultants evaluated a system based on either a new gas or coal-fired thermal-only boiler plant or a gas-fired cogeneration plant located at the site of the Old Municipal Light Plant.

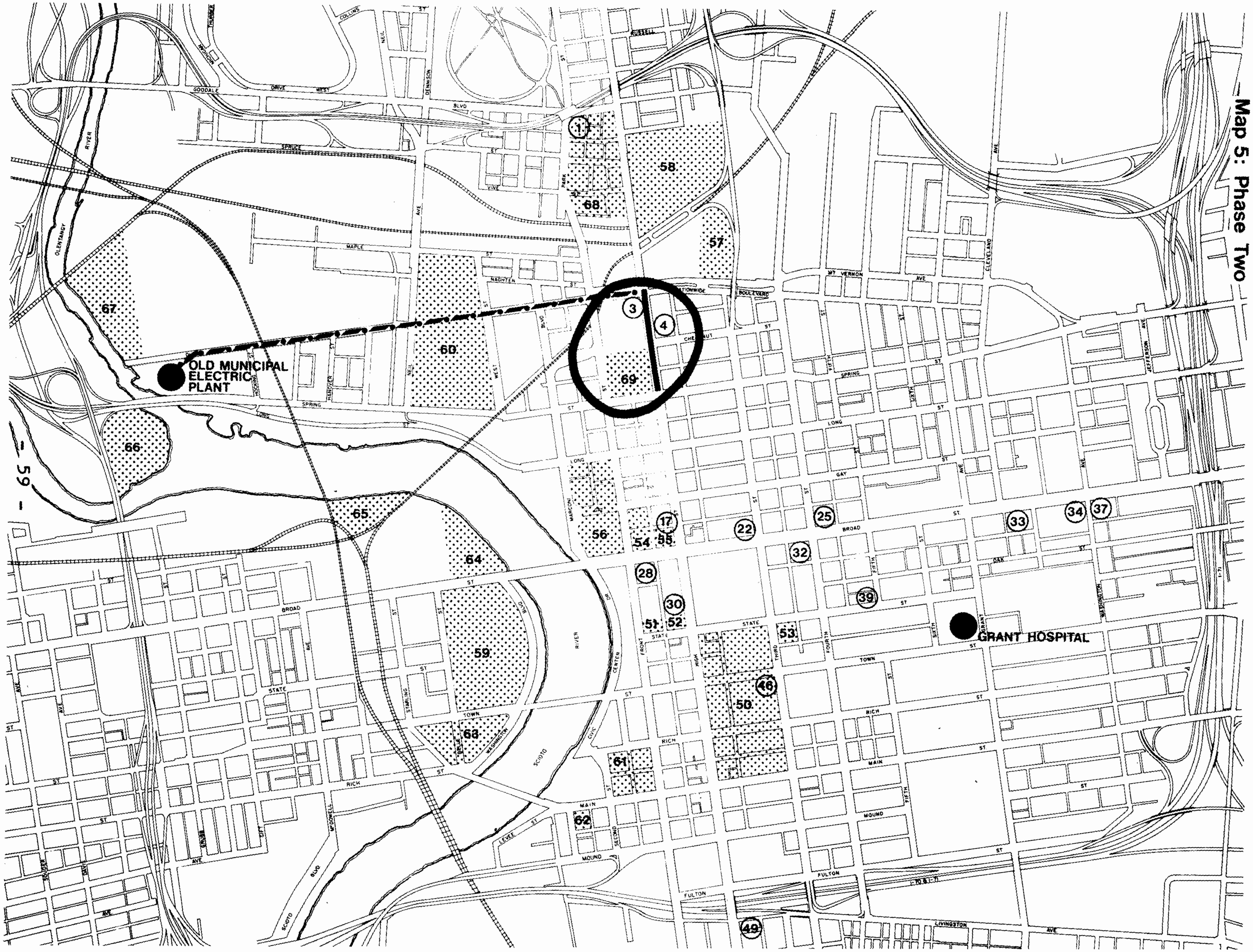
In laying out the pipe network to service this "heat island," the first step is to identify a simple route to connect all of the buildings together. In this case, such a route is fairly simple to determine with one straight run of distribution main (note solid line on Map 4, page 57). The second step, determining the best route for a transmission main to connect this area to the Municipal Light Plant, is not as obvious. One route option is shown by the dashed line on Map 4, page 57. Another is the route chosen by the consultants, shown by the dot and dash line on Map 4. The reason for using this route is that it allows the Phase 4 "heat island" to be serviced from this same transmission main (note Phase 4 area on Map 6, page 61).

The second logical "heat island" for development is in the area of northern downtown labeled Phase Two (see Map 5, page 59). There are several reasons for early development of this area, including:

1) A large existing thermal load;
2) Major new construction scheduled in the area; and
3) An economical interconnection among most of the buildings with one straight run of pipe.

As in Phase One, interconnecting the buildings to be served is a fairly obvious and straightforward process: a short, straight run of pipe is required (note solid line

Map 5: Phase Two



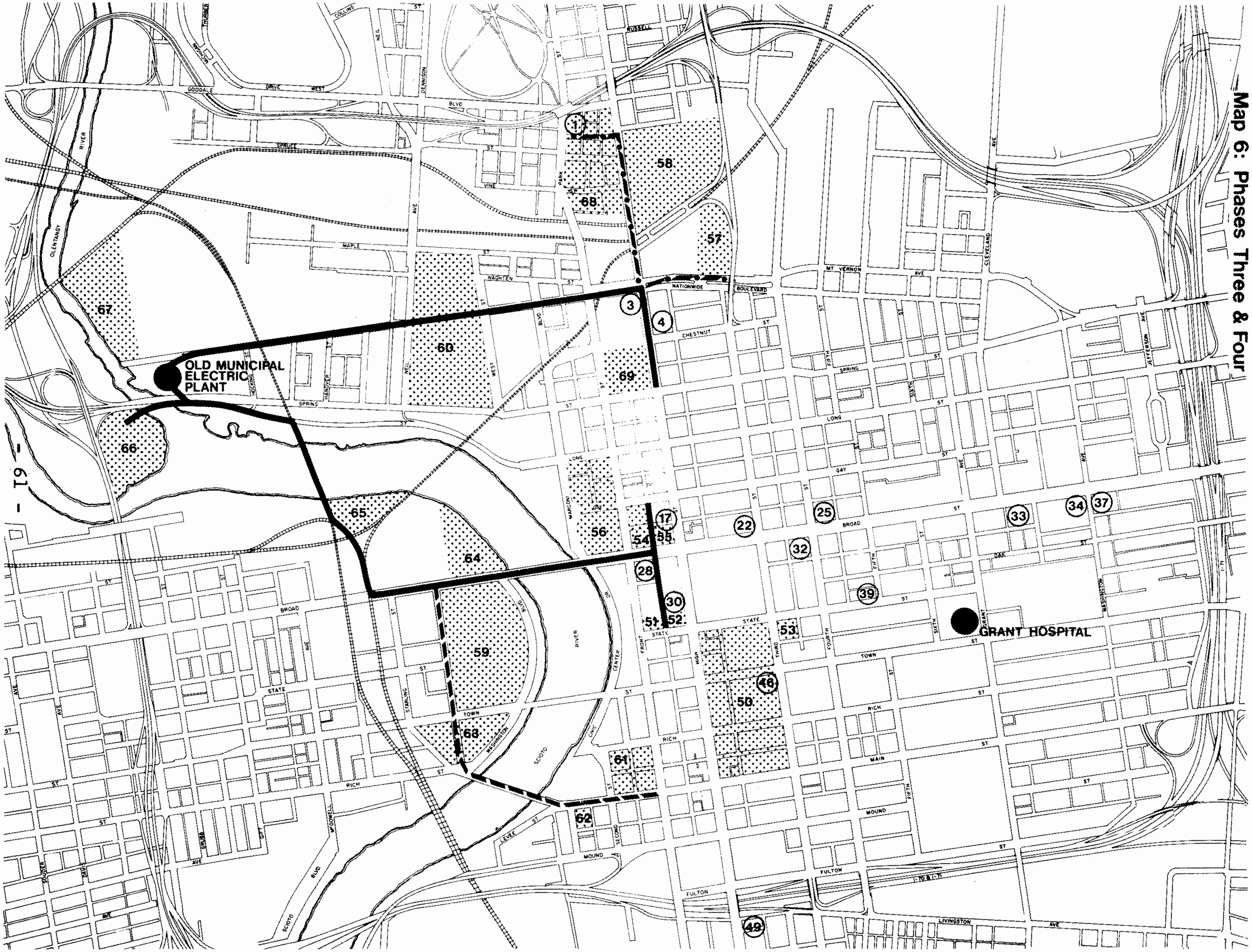
on Map 5, p. 59). Likewise, the route for the transmission main is the obvious straight line from the Phase Two area to the Municipal Light Plant site (as shown by dot and dash line on Map 5, p. 59).

Like the Phase One route, this route also allows a second "heat island" (Phase Three) to be served by this one transmission main. Further, this route helps to achieve one of the major objectives of the district heating project--to stimulate the revitalization of the Phase Three area along the riverfront by making low-cost energy available to development projects. The redevelopment project planned for the old Ohio Penitentiary Site would serve as the anchor customer for the third phase.

The next stage of development would be to expand service in the Phase Four area (see Map 6, p. 61). The route chosen by the consulting engineers is a fairly "common sense" choice, given the existence of the Phase One transmission main and the location of the customer base to be served. (The customer base in this area includes the Central High School site, the Health Department site, the Waterford housing development project, and the Riverplace housing development--the latter a public housing project.)

The final phase identified by the consultants, Phase Five, is an extension northward of the Phase Two pipe network. This expansion would be based on the construction of a multi-purpose activity center or stadium at some time in the near future (See Map 6, p. 61). The route chosen for the transmission mains is the simplest and least-cost choice.

Map 6: Phases Three & Four



Following completion of the first five phases, the network layout would appear as in Map 6. While this is the final expansion phase assumed by the consultants, further expansion of the system would be desirable.

The last step in the preliminary design is to determine the required size of the pipes in the system. This is necessary in order to estimate capital costs in the preliminary economic analysis of the system. The process requires estimating the peak thermal loads served by each branch of the system, estimating how many gallons per minute of hot water flow are collectively required to supply the required heat demand, and then estimating the sizes of pipe required to accommodate those levels of water flow. Then capital costs for the complete distribution system can be calculated by summing the costs for all pipes in various sizes and lengths.

ECONOMIC ANALYSIS

Introduction

Following the costing-out of the project system, it is usual to conduct an economic analysis in four steps, as follows:

(1) End-user cost comparisons;
(2) Life-cycle cost comparisons;
(3) Project liquidity analysis
(4) Sensitivity analysis

If Step 1 indicates that district heating is unlikely to be able to compete with the conventional systems of the individual buildings, it is probably not necessary to conduct further analyses. All four steps were applied to the Columbus Study with encouraging results for district heating.

Due to the high degree of uncertainty in the project area about the construction dates of new developments either proposed or planned, the economic analysis of a district heating system was limited to the most economically critical phase of system development, i.e. the initial phase. This was considered to be a "worst case" basis for assessment, for it would include overinvestment in plant and system capacities (for future expansion phases). Project economics would therefore benefit from the better revenue-to-investment ratio of subsequent phases.

Project Options and Characteristics

Three basic project options were considered, each serving the same customer potential--with a connected heat load value of approximately 102 million BTU's per hour (MMBH) compared with an ultimate connection load value of approximately 252 MMBH. All three options made use of existing site and building facilities. One option included renovation of an existing gas turbine unit for cogeneration purposes (i.e. electricity and heat production), while the other two were "heat-only" facilities.

Capital Requirements. The estimated capital requirements of the three project options are shown in Table 7, p. 64. They equate to approximately $47,000 per MMBTU/H of connected load for the cogeneration project, while the two "heat-only" estimates work out to roughly $46,000 and $39,000 respectively for the coal-fired and gas-fired projects.

TABLE 7.

Estimated Capital Investments--Riverfront District Heating Scenarios

Project Scenario	All-Gas Co-generation	Coal Heat-Only Gas Back-Up	Gas Heat-Only, Oil Back-Up
(1) Gas Turbine Renovation	$ 700,000	$ --	$ --
(2) Back-Up/ Peaking Boilers	450,000	850,000	630,000
(3) Building Modifications	200,000	150,000	80,000
(4) Ancillary District Heating Equipment	1,000,000	1,000,000	1,000,000
(5) Distribution Mains System	1,210,000	1,210,000	1,210,000
(6) Consumer Substations	300,000	300,000	300,000
(7) Contingencies	380,000	370,000	310,000
(8) Fees and Expenses	560,000	550,000	470,000
ESTIMATED PHASE ONE TOTALS =	$ 4,800,000	$ 4,700,000	$ 4,000,000

Annual Costs. The annual costs of the three projects were calculated on the basis of the estimated capital requirements and a number of production factors, costs, and prices, including those for fuel and power, maintenance and staffing, production and distribution efficiencies, inflation, and interest rates.

These costs were divided by the estimated heat sales to customers to provide a cost per unit of heat for district heating in its first year, approximately as follows:

Project 1: Gas Cogeneration...........$ 7.75
Project 2: Coal-Fired Heat Only.......$ 8.65
Project 3: Gas-Fired Heat Only........$ 8.61

End-User Cost Comparisons

The cost of owning and operating an individual gas-fired boiler system represents the "base case" against which each district heating scenario must be compared in order to determine economic viability. Often in project analyses, only fuel costs are accounted for in comparing individual system costs with district heating costs. In such incomplete analyses, the costs of maintenance, repair, labor, cleaning and replacement, electricity for burners, chemicals for boiler water treatment, insurance premiums, and so forth are ignored.

Even worse in such analyses, when unit costs for individual boilers are used, they are often given as a cost per unit of fuel input--without regard to boiler efficiences. Even where boiler efficiencies are taken into account, there is a tendency to use the rated efficiency (i.e. at maximum output) instead of the actually much lower annual efficiency--a result of the fluctuating loads on the boiler plant throughout the year.

In the Columbus assessment, in order to fairly account for the capital costs of individual systems, a figure of $10,000 per MMBTU/H of plant capacity was included as part of the "base case". This was required by the development nature of the Phase One project options--that is, to account for the individual plant capacity that would have to be built if district heating did not exist. With a district heating hook-up during construction, however, a developer can achieve an additional savings or "avoided cost" of the amount that would have been spent on the installation.

The "base case" estimates for individual boiler systems used in comparison with district heating were as follows:

Capital Cost (in $ Millions)	1.02
Fuel Costs ($/MMBTU)	5.63
Operations & Maintenance Costs ($Million/Year)	.40
Boiler Production Efficiency (%)	75
Distribution Efficiency (%)	100
Annual Inflation, general (%)	5
Annual Inflation, gas fuel (%)	3
Capital Recovery Interest Rate (%)	11
Number of Years to Recover Capital	20

It should also be pointed out that an individual-system boiler efficiency of <u>75 percent</u> over the year was allowed--far higher than the average 50 to 65 percent used by existing district heating utilities throughout the U.S. This was done in order to accomodate an objection made by the representative of Columbia Gas to the assumed higher efficiency of district heating plants. The consultant included the 75 percent efficiency for individual building systems in comparison with district heating systems as follows:

Efficiency of:	Plant	x	Mains	=	System
Gas Cogeneration	76%		93%		73.0%
Coal, Heat Only	80%		93%		74.4%
Gas, Heat Only	85%		93%		79.0%

The average gas-fired individual system in the Columbus assessment was, on the basis of the above, calculated to have a cost of approximately $10.00 ($9.99) per MMBTU of useful heat.

On the basis of this analysis, a straight cost-only comparison of district heating against individual systems indicated the following:

	Cost/MMBTU	Savings
Individual Systems	$ 9.99	--
Project 1--Cogeneration	$ 7.75	22.5%
Project 2--Coal Heat Only	$ 8.65	13.5%
Project 3--Gas Heat Only	$ 8.61	14.0%

On the basis of these favorable results further analysis was warranted.

Life-Cycle Cost Comparisons

Several methods can be used for life-cycle cost analyses, including Net Present Value (NPV), Internal Rate of Return (IRR), and Savings to Investment Ratio (SIR). The latter is easy to understand and simpler to compute, but both the NPV and IRR methods have their advantages.

The NPV method is useful when it is necessary to choose between competing projects, but the "values" arrived at do not convey information that is easily understood in terms of return on investment--which is often a high priority consideration.

The IRR method, on the other hand, is more widely accepted by potential investors, especially as the results are easily compared to the returns on other types of investment. Mainly for this reason, the IRR method is most broadly used, and "economic viability" is usually judged on the basis of a required rate of return on investment. If the IRR is equal to or greater than the required rate of return, the system is considered financially attractive and therefore "economically viable." If the IRR is less than that required, the economics of the system are unlikely to attract investment.

The required rate of return can either be established, in cases where the investors and their terms of investment are known, or estimated, where they are unknown. Serious investors are likely to consider investing at the moment in for-profit operated systems where the IRR is in excess of 20 percent. Non-profit operated systems, on the other hand, might accomodate a lower IRR, possibly on the order of 12 to 15 percent. Obviously, these required rates of return are a matter for objective assessment on a case-by-case basis.

Again in order to accomodate the suggestions of the District Heating Task Force, the consultants used a price inflation rate of 3 percent per annum for gas, which they also chose to use for coal and oil. The choice of 5 percent as the general inflation rate (at 2 percent above fuel inflation) provided a less-than-favorable scenario for district heating in long-term comparisons with individual boiler systems.

The life-cycle cost analysis was calculated over a 20-year period. The consultants accepted that the current fuel price trend was downward, and that a leveling-off could be expected for a year or so. Columbia Gas of Ohio had forecast a leveling-off until 1990, when annual increases were again anticipated.

The required rate of return was set to 20 percent and the interest rate on borrowed capital was taken as being 11 percent.

The internal rates of return (IRR's) for the three district heating options were calculated at 22.9 percent for the gas cogeneration option, 24.0 percent for the coal heat-only option, and 24.5 percent for the gas heat-only project. (See Table 8, p. 74). Each project option thus meets the 20 percent rate of return criteria.

First-year all-inclusive unit costs for heat, calculated according to the life-cycle method, rendered the following:

	Heat Cost/MMBTU
Individual Systems (Reference Case)	$10.58
Project 1: Gas Cogeneration	$ 8.62
Project 2: Coal-Fired Heat Only	$ 8.82
Project 3: Gas-Fired Heat Only	$ 8.70

These results indicated that all three district heating options were economically viable and attractive investments. The analysis also indicated that even under a relatively unfavorable scenario, district heating could offer substantial savings to consumers in their annual heating bills, and could therefore be considered marketable.

Project Liquidity Analysis

The third step in economic analysis of the Columbus example required an calculation of the payback period, or the time over which cumulative savings or revenues offset the initial investment. The choice of an acceptable payback period defines a developer's or investor's willingness to trade off current risks and short-term losses for longer-term rewards.

Analysis of project liquidity is often addressed using either the Simple Payback (SP) or the Discounted Cash Flow (DCF) methods. The Simple Payback method is calculated on the basis of nondiscounted cash flows, that is, by actually ignoring the diminished value of money over time. In reality, an investor wishes to maximize returns in the earlier years of the project. The SP method also ignores the value of cash flows following the point at which payback is reached. The Discounted Cash Flow (DCF) method attempts to compensate for the first problem by discounting future cash flows. However, the DCF method also ignores the value of cash flows beyond the payback period. Therefore a project costing $1000 and which returns $200 per year for five years would have the same payback period as a project costing $1000 which returns $200 a year for ten years.

Of the two methods, the Simple Payback is simpler to calculate, but the Discounted Cash Flow method is more generally accepted. However, it is evident that a choice of projects based solely on the payback period will be flawed. End-user costs must be considered, as well as the rate of return to investors. Any project assessment must likewise be subjected to a variety of tests on the sensitivity of its various assumptions or estimates.

Sensitivity Analysis

Sensitivity analysis is a series of assessments, in "what-if" scenarios, to test the effects of changes made in underlying variables and assumptions. For example, the investor may want to test changes in future cost escalation rates for fuel or power, or test the effects of higher interest rates or capital expenditures. In doing such testing, it is important to maintain these "what-if" variables within realistic limits.

The economic viability of district heating systems is generally accepted as being mainly sensitive to the following three factors:

(a) the competitive fuel price level for individual systems;

(b) the costs of capital in the form of capital requirement levels and interest rates; and

(c) the magnitude of annual revenue from heat (and power) sales in terms of both annual heat requirements and marketable prices.

Competitive Fuel Prices. Ideally, district heating should seek to use either "waste" or surplus heat at low cost, in order to compensate for the relatively heavy cost of capital invested. Even with this heavy up-front capital investment, a district heating system should still be able to compete with the best of the individual systems. However, even where such least-cost sources are unavailable, district heating systems of any reasonable size should be able to purchase fuel at more advantageous prices than most individual systems. The question becomes, can the difference between the fuel prices to individual consumers and the district heating entity compensate for the heavier system investment costs on the district heating side?

In the Columbus assessment, "waste" heat was available in only one project scenario, i.e. the cogeneration project. The other two projects relied upon lower fuel prices available to the district heat producer. All three projects remained, however, competitive with individual systems using general service rate gas.

Sensitivity analysis showed that if the rate of inflation of gas prices were to exceed the general inflation rate by up to 5 percent, the internal rates of return for the gas-fired alternatives came down by a maximum of 3 percent. However, the IRR for the coal-fired project would improve by up to 9 percent. Even in the least advantageous fuel cost scenarios, then, district heating systems retained their marketability.

If "self-help" gas became available to many individual boiler owners, the economic picture would change substantially. "Self-help" gas is contract gas which can be purchased directly by the consumer from a producer or broker at a lower price than prevailing tariffs. In the mid-Ohio area, self-help gas is currently priced at $3.08 per MCF, against which district heating could not offer a more attractive alternative. However, due to the conditions of supply required by the gas company, self-help gas services can be offered to only a very few of the largest consumer properties in the Columbus downtown. These few buildings are the most difficult to attract to district heating in any event, since they are currently able to purchase gas at more favorable prices and to operate their own systems more efficiently than the average building owner or manager.

A further disadvantage of self-help gas contracts for the typical downtown consumer is that such services are only available on a one-year contract basis. If consumer property owners consider the longer-term savings potential of a district heating service contract over a 20-year period, district heating might prove more competitive with the self-help gas alternative.

It is also possible that a district heating producer could take advantage of lower self-help gas prices unavailable to the average consumer. In such a case, district heating could economically use self-help gas not only as a peaking but also as a baseload fuel, effectively competing with gas prices available to the commercial or residential-rate customer.

Costs of Capital. In the project analysis model used by the consultants, the interest rate on capital was assumed to be 11 percent in all cases. The costs of boiler equipment, pipes, fittings and so on were estimated according to standard industry practice, consultant experience, and locally-available cost figures. However, sensitivity testing was carried out on each scenario to show the impact of capital cost overruns or underestimates. The model was fairly sensitive to capital cost estimates. Each scenario showed a drop in IRR of about 1 percent for each 1 percent increase in capital costs.

Magnitude of Revenues. The magnitude of revenues obtainable from the sale of district heat is dependent both on price and on the quantity of heat sold. Obviously, given the large front-end capital investment in

TABLE 8.

Sensitivity Analysis on Phase One District Heating Alternatives

Variables	Gas-Fired Cogeneration	Coal-Fired Thermal Only	Gas-Fired Thermal Only
Capital Costs ($Million)	4.80	4.70	4.00
Base Load Fuel Costs ($/MMBTU)	4.39	1.93	2.99
Peak Load Fuel Costs ($/MMBTU)	4.39	5.35	5.63
O & M Costs ($Million/Year)	.35	.30	.20
Electric Power Costs ($/KWH)	.03	.02	.02
Other Costs ($Million/Year)	.20	.20	.20
Production (Boiler) Efficiency (%)	76	80	85
Distribution Efficiency (%)	93	93	93
Inflation, General (%)	5	5	5
Inflation, Gas Fuel (%)	3	3	3
Maximum Load Conditions (MMBTU/Hr.)	102.3	102.3	102.3
Duration, Max. Load (Hrs.)	1880	1880	1880
Capital Recovery Interest Rate (%)	11	11	11
Power Sales Price ($/KWH)	.033	--	--
Consumer Cost ($/MMBTU of Useful Heat)	7.75	8.65	8.61
Consumer Savings, Annual (%)	22.5	13.5	14.0
BASE CASE IRR	22.9	24.0	24.5
Increase Capital Costs 25% (IRR)	17.0	18.2	18.4
Increase Capital Costs 50%	13.2	14.7	14.6
Decrease Load Duration to 1500 Hours	16.7	18.4	19.5
...and Increase Cap. Costs 25%	11.7	13.6	14.4
...or Increase Capital Costs 50%	--	10.7	11.1
Decrease Average Annual Efficiency of Individual Boilers to 65% and Increase Gas Inflation (*)	31.4	29.4	35.0
...and Increase Cap. Costs 25%	24.2	22.2	27.1
...or Increase Cap. Costs 25% and Decrease Load Duration to 1500 Hours	18.5	16.9	22.1
Decrease Electric Power Sales Price to $.025	17.4	--	--
Decrease Electric Power Sales Price to $.019	13.0	--	--

*Annual gas inflation over the 20-year period increases to 5%; general inflation remains 3%

the system, the economic viability of the system will increase if the system use is maximized. The "maximum load duration" estimate is used in preliminary feasibility assessments to represent the efficient use of the district heating infrastructure. The estimated maximum load duration of 1880 hours, or "equivalent maximum load hours" represents the number of hours the system would be working if it were at full load. In reality, the system will be in use more than 1880 hours throughout the year, but usually only at a fraction of the designed load capacity.

The economic analysis model is highly sensitive to the assumption used for maximum load duration. As shown in Table 8 (p. 74), a decline in the maximum load duration from 1880 to 1500 (a 20% decline) results in a decline in IRR of 27, 23, and 20 percent respectively in the project scenarios. The estimated load duration figure of 1880 was confirmed by the consultants in on-site consumer surveys in the downtown area.

Table 8 displays the project variables for each of the three scenarios, followed by a select number of sensitivity tests which result in changes in the internal rates of return. In general, the estimates for the project variables (capital costs, load duration, inflation and so forth) are on the conservative side. In some cases, the consultants have used numbers with which they disagreed, merely to accomodate objections on the part of District Heating Task Force members.

Sensitivity Test Results. Tests were carried out on project variables thought to be most important. The effect of higher capital costs on the IRR's is clearly negative, as is the decrease in heat sales (maximum load duration) from 1880 to 1500 hours. In all three scenarios, the separate impact of these changes brings the

IRR's below 20 percent. However, a less pessimistic view of the individual boiler "base case" against which district heating alternatives are compared has a strongly favorable impact on project economics. As shown in Table 8, changing the assumed efficiency of individual boilers to a more realistic 65 percent in annual terms, together with the assumption of modest gas price inflation over the 20 year period brings the IRR's up to 30 percent or better.

Naturally any combination of these effects, both positive and negative in impact, can be considered according to their degree of likelihood. One other possible negative impact had to be considered. That was the effect of a lower price for electricity sales in the cogeneration scenario. Decreasing the expected electricity sales price to $ .025 cents from $ .033 per KWH has a negative effect on revenues and therefore on the IRR's. In general, however, it can be stated that the sensitivity exercise shows that the IRR's are pushed below 20 percent only under the most extreme negative assumptions. It must also be kept in mind that the three project scenarios only focus on the initial phase of riverfront district heating development, considered in itself to be a "worst case" for project assessment.

SUMMARY

This chapter has outlined a four-stage process by which consultants and staff identified a potential district heating source, assessed the consumer market, completed a preliminary system design, and analyzed the economic viability of three different project scenarios. Although the economic analysis of the project alternatives would appear to favor district heating development in the north riverbend area, in fact the scenarios outlined in this report are unlikely to proceed further in their present forms. The major barriers to district heating are the uncertainties and investment risks inherent in the development of the riverfront area. These are mainly problems of timing and scale of development, and the likelihood of further changes in the sequence and pattern of new construction in the project area.

Questions remained at the end of this project assessment. These include whether the Old Municipal Light Plant site and facilities would continue to remain available for future district heating plant and equipment, and whether alternative district heating development sites based on the short-term potential of connecting existing downtown properties might not prove more attractive investments. Nevertheless, the economic analysis indicates that district heating, if properly developed, can be a strong contender for heat sales in the future downtown market.

Chapter 4. Strategies and Decisions

INTRODUCTION

As described in Chapter 3, work done by the City of Columbus and HML Consulting Engineers in 1985 and 1986 indicates that potential heat islands do exist in downtown Columbus. Such islands have been identified not only along the riverfront but also in the northern and eastern sections of the downtown, as shown in Map 3. At least as of mid-1986, it appeared that district heating made available to customers in these heat islands could be provided at a rate competitive with natural gas. Similarly, it is reasonable to suppose that other viable heat islands exist elsewhere in Columbus in other project scenarios.

Establishing the technical and economic feasibility of a district heating project or projects, however, is only the first step of a long process toward actual construction of a system based on long-term user contracts. It is the purpose of this chapter to outline that process and to indicate the decisions that will have to be made as well as possible strategies to follow in successfully implementing a multi-user district heating system in Columbus. Of special interest are the decisions that must be made by the City government regarding its own role in developing, financing, and participating in such systems.

STRATEGIES/SCENARIOS IN DISTRICT HEATING DEVELOPMENT

There are several possible combinations of ownership, financing, and marketing that could bring about successful district heating development in Columbus. For reasons outlined in Chapter Two, however, it is likely that district heating development in Columbus will follow an overall strategy that can best be described as incremental and "opportunistic," as opposed to large-scale and comprehensive. Following the Danish approach of starting small, establishing heat-island start-up projects, and interconnecting these for inclusion in larger systems, it is probable that Columbus district heating will begin with:

(1) A district heating link between the trash-burning Municipal Electric Plant and a few County and State-owned facilities nearby. This system could be sized in order to allow for the possible connection of greenhouses or other commercial/institutional developments near the Power Plant.

(2) An initial small-scale downtown system, perhaps centered on an existing boiler plant, which would minimize organizational effort by connecting a small number of users possessing a substantial combined heat load.

Such an initial strategy of development in Columbus appears not only logical but also necessary in order to establish the viability of district heating and to begin to develop the Municipal Electric Plant as a source of thermal as well as electrical energy.

Given such an overall strategy of district heating development, there are several possible scenarios by which an initial project or projects might come into being. These scenarios are identified by the type of ownership being considered. The selection of ownership option, in turn, determines the type of financing which can be obtained and the share of risk that must be assumed by the participants. In reality, there are several combinations of ownership/management options that might work. For example, a municipally-owned system could be managed and operated by a profit-making corporation with contract incentives to hold down prices, enhance sales, and expand service areas. However, for the purposes of a potential Columbus project, there are are three basic ownership options: for-profit, non-profit, and municipal.

For-profit

The for-profit corporation has the obvious advantage of being able to attract capital investment as well as management skills through the profit incentive. If there are tax benefits to be gained from the investment in facilities and equipment, these benefits can be shared with investors. However, at the time of writing it is by no means clear that such tax benefits for district heating investments will be a part of new tax legislation in Washington.

The profit incentive also helps ensure that the district heating system is operated efficiently. The expectation of future profits also provides an incentive to expand the system.

Perhaps the most important benefit of the for-profit option to Columbus, however, is the assumption of risk and provision of capital by private investors. For reasons discussed earlier in Chapter 2, it is considered unlikely that the City itself will want to assume further risk or to undertake further indebtedness for large-scale energy production or distribution. However, an estimated return on investment of 20-25 percent is possible in Columbus, which should be sufficient to attract private investment.

In a for-profit district heating system, however, there is an inherent conflict between providing cost savings to consumers and profits to investors; the difference between the cost of producing and distributing district heat and the cost of heat from conventional systems must be divided between savings to consumers and profits to investors. Thus, the greater the profit shares taken, the less are the savings that are passed on to consumers, and vice-versa. As the price of conventional fuels declines, savings are less. This means that profit shares are also constrained. In a competitive market of falling conventional fuel prices, as in Columbus, a district heating system which depends on profit levels to generate investment may operate at a disadvantage.

A for-profit system may also be subject to rate regulation. It is not clear in Columbus whether a district heating system operating solely on the basis of contracts with customers would be subject to rate regulation. It is certainly in the interest of potential district heating/cooling developers to avoid rate regulation where possible. As stated by Larry Christensen in a study performed for HML Consulting Engineers,

> In competing for scarce investment dollars, any potential DHC system in Columbus will be at some disadvantage to other potential systems unless the owner or the nature of a Columbus DHC system is such that it will not be subject to rate base regulation by PUCO.[1]

From the City's point of view, there is a further possible disadvantage to a for-profit district heating system, in the form of the City's relative inability to influence decisions on rates (or contracts), on marketing, and on service area coverage. This lack of City influence is compounded by the fact that any franchise approval by the City (giving the district heating corporation an exclusive right to operate within the jurisdiction) would be subject to voter approval. Since none of the parties involved wishes to undergo the additional risk and expense involved in such a process, it is unlikely that a prospective district heating development corporation would ask the City for such a franchise right. In this situation, a corporation would simply organize, declare its intention to do business, and begin signing contracts with customers. Without a franchise grant, however, the City is unable to require compliance from the district heating corporation regarding long-term development plans, rates or tariffs, or corporate structure. In sum, the City would lack effective leverage over the system.

There are, however, other possible sources of City influence over the shape and extent of district heating development. The City is a major potential consumer, as well as a potential supplier of thermal energy. Contractual arrangements with the district heating corporation could supply the City with a certain amount of leverage. The City has another source of leverage in that it has been asked by the partners in an incipient venture to commission a private district heating development corporation, to develop the basis for the creation of a district heating service corporation. It is proposed that the private development corporation would itself commission and fund the engineering and other services necessary to bring district heating to a fully designed and "bankable" stage. City participation in this venture may provide a source of leverage--allowing the City a voice in determining the ultimate organization, service coverage, rates, and financial arrangements of a district heating corporation.

One of the major disadvantages of the for-profit arrangement is the possible difficulty in retaining the consumer confidence which is typically a feature of cooperative or not-for-profit corporations. Could the for-profit corporation inspire similar consumer confidence through such innovative mechanisms as representation on the corporate board, or even through a form of profit-sharing with consumers?

Non-profit

The not-for-profit organization likewise offers certain advantages both to users and to the City. In Columbus, it appears that such an organization would be exempt from rate regulation; although this advantage may also be obtained by a for-profit organization which sells heat exclusively by contract. A non-profit organization would also be exempt from federal income taxes.

Perhaps the main advantages of the not-for-profit district heating corporation are economical and political. The non-profit corporation still depends on revenues to retire debt and to maintain the system. However, the lack of profit shares means that more of the system savings can be passed on to consumers or used for system expansion and improvements. In a system located in a highly competitive market, this feature may be critical to the success of the system. Politically, the not-for-profit feature of the system may be a valuable asset in helping to attract consumer confidence.

In Columbus, a potential disadvantage of the not-for-profit district heating organization, in comparison with a for-profit entity, is the former's limited ability to attract private financing. It has already been pointed out that in Columbus, where substantial public investment is unlikely, a future district heating system must depend heavily on private financing. The lack of profit potential, however, precludes private equity investment in the system. This, in turn, makes such a corporation a much less attractive candidate for bond financing. Consequently, a non-profit corporation without any institutional backing will likely face significantly higher financing costs. In addition, the not-for-profit corporation must be able to give investors some assurance of "deep pocket" backing. Without direct municipal involvement, or without other sources of equity financing, such assurances cannot be provided.

A non-profit corporation may be organized as a cooperative. This would allow users greater control and may help obtain community support. In Denmark, about 86 percent of the 350 district heating systems are cooperatively owned and managed. However, the cooperative organization often requires substantial commitments of time and effort from the participants who must administer the system. And, while common in Denmark, this type of organization is not so common in the American business community. A lack of consumer familiarity adds to the perception of risk associated with this form of organization.

Similar questions about the effectiveness of City leverage can be raised about the non-profit as about the for-profit entity. The City could obtain desired leverage through board membership, or alternatively through some form of loan to the district heating corporation. As in the for-profit arrangement, the City is likely to be both a major user and producer of district heating, and in connection with a cooperative company would be able to take a leading role in the system.

In the previously cited study by attorney Larry Christensen, the author states that the role of the City of Columbus is likely to be significant whether the system is a for-profit or not-for-profit corporation.

> ...The active support of the mayor and the city council is essential to development of district heating and cooling in Columbus. For the next several years, there will likely be no new significant construction of new DHC systems in the United States without such support from public officials.[2]

Municipal

There are certain advantages to municipal ownership of district heating. These advantages include better control over policy and regulatory matters, exemption from rate regulation, exemption from federal income tax, and a better ability to coordinate developmental objectives. A municipal government, depending on its credit rating, may have better access to lower-cost financing than private organizations.

However, due to reasons outlined fully in Chapter Two, the municipal ownership option is unlikely to materialize in Columbus district heating. Columbus is a growing community with many capital improvement needs competing against each other for priority. Decision-makers are justifiably cautious about assuming the risks and responsibilities for any losses which might be incurred by such an enterprise, and would be unwilling to subsidize district heating operations, should this prove necessary in the short term. Given these circumstances, municipal ownership does not represent a viable option for Columbus.

DECISIONS

Given these various scenarios of district heating development, the City is presented with a set of choices that must be made. In fact, these choices are being presented in a clear and urgent fashion, since local developers have now come to the City expressing an interest in private development of a district heating system and requesting the participation of the City in initiating development services.

Within a short period of time, decisions on the following issues will have to be made by the Mayor and his administration in cooperation with City Council:

Sale of Thermal Energy from Municipal Electric Plant

The City's consultants have already drafted an agreement with the Franklin County commissioners which would allow for the sale of heat from the Municipal Electric Plant to the County Workhouse in its vicinity. The proposal received from private developers would provide private financing for this project. It also proposes a heat purchase agreement with the City for heat from the power plant.

The City now must decide if it wants to enter into an agreement with a development or service corporation and if so, under what terms. The current proposal focuses on heat recovery in small quantities from secondary steam. However, the district heating developer is interested in the project not just from the short-term viewpoint of supplying the County Workhouse, but also in the longer-term prospects of attempting to develop the immense thermal potential of the power plant as a whole. In this the City would certainly share the developer's interest.

Ultimately, however, full use of the thermal potential of the Municipal Electric Plant depends either on the addition of back pressure turbines or on adaptation of the existing turbines to back-pressure units. Both solutions are costly. Even with an acceptable return on investment through heat sales, the level of City interest in future expansion based on the project proposals may be constrained by the financial commitment necessary to retrofit City-owned plant and equipment.

Originally, it was thought that heat-pump technology could be used to extract heat from the cooling water waste stream at the plant, but the cost of heat pump equipment for the initial project at the County Workhouse appeared prohibitive. Use of such equipment as a partial source for waste-heat recovery in a larger district heating system, however, might yet prove viable.

The Public Role in District Heating Development

For reasons previously outlined, the City of Columbus is unlikely to own or operate a district heating utility. As explained earlier, the City is also unlikely to be asked to grant an exclusive franchise to a district heating enterprise--an issue which would have to be decided by the voters. This would seem to limit the range of options available by which the City could exert some leverage over the organizational form, rates, and service coverage of district heating in Columbus. But there are a number of other forms of participation in a district heating venture which are open to the City. Among these are:

Municipal Thermal Production. The City has one operating thermal source in the form of the Municipal Electric Plant, and a potential source in the form of the old Light Plant. The City can obtain revenues from sales of thermal energy to a district heating corporation. However, in the case of the old Light Plant, significant investment would be required in order to refurbish existing equipment.

Co-operative Membership. If a district heating/ cooling entity is set up as a user cooperative or related enterprise, the City could represent its own interests as a member of the board.

Quasi-Public Agency. A district heating authority could be set up as an autonomous agency with a governing board appointed by local governments.

Not-for-profit Corporation. A non-profit entity may be established to own and operate a district heating system. The governing board may be self-perpetuating, consist of representatives of various segments of the community (residential, small commercial, etc.), or be elected in some way by consumers. An example of this type of organization is the Saint Paul District Heating Development Corporation.[4]

For-profit Corporation. A district heating entity may be organized in Columbus as a for-profit enterprise. It is possible in this case, though not likely, that the City could be asked to grant a franchise permitting exclusive development. (It should be pointed out, however, that no Columbus utility company currently operates under any such franchise agreement.) A franchise would allow the City to require certain conditions to be met. If not, the City's influence could still be made effective if the City were asked to provide assistance to the service corporation in the form of loans or other economic development assistance.

Regardless of which forms of organization may ultimately be chosen to develop district heating, the City is likely to retain a large role in district heating development. In part, this is due to its potential role as a producer and consumer of district heating. But more importantly, an influential City role is desirable because district heating ought to be an integral part of any development strategy, particularly in the downtown/riverfront area. In Columbus, as in most American cities, tremendous economic and demographic forces are at work, which over time have tended to move centers of population and employment further toward the periphery of the urbanized area. In order to counter these decentralizing tendencies, and to market downtown development as an alternative, strong attractions will be needed. District heating is one of the elements that can help the downtown area compete with suburban areas for jobs, development, and housing. The City of Columbus will have to play a positive role in linking district heating with its other development goals if district heating is to be fully exploited as a development tool.

Any discussion of the City's potential role in district heating development, especially as part of a not-for-profit enterprise, raises the important issue of City liability for any losses incurred by the enterprise. This is an especially important issue in Columbus with its recent experience of the trash-burning Municipal Electric Plant. It is therefore important that any proposal which would include the City as a participant must include ways of limiting the City's liability in the project. This is likely to be essential in gaining public approval and political support.

Public Investment in District Heating

If district heating is to take root in Columbus, its most likely form will be as an autonomous, private-sector entity. This raises the question of whether the City is prepared to invest financially in order to help initiate a privately-held district heating enterprise. The City is restricted by charter from making any grant of public monies (from its own revenues) to a privately-held, for-profit enterprise. However, there are a number of ways in which the City might be asked to participate in helping to organize and finance a district heating corporation.

Loan or grant. Under the auspices of economic development activity, the City could be asked to provide a loan or grant to a district heating development or service corporation. In years past, such assistance might have been provided out of UDAG (Urban Development Action Grant) or CDBG (Community Development Block Grant) funds available to the City from federal sources. This year, such sources will be greatly reduced if not non-existent. However, it is still possible that some portion of funding could be provided from CDBG sources, if the City decides that it should become a lender.

Sale or Lease of Assets. In addition to the trash-burning Municipal Electric Plant, the City owns other assets that (1) it wants to dispose of and (2) that would have a potential value to a district heating corporation. The major asset in this category is the old Municipal Light Plant in the riverfront development area. Studies performed for the City by HML Consulting Engineers indicate that the old plant may have some potential value as a thermal or cogenerating facility. Certainly the site itself, given its excellent location within the riverfront development area, would prove valuable to a district heating development corporation. The City may be able to recover some of the value of the site through sale or lease of those facilities. The City may also be able to use the old Municipal Light Plant, as well as the potential for district heating connections to its own downtown office buildings, as bargaining chips in negotiating the form and direction of district heating development.

Contracting. The City government may be asked to contract with developers and/or engineers for services necessary to further development of district heating in Columbus. A proposal has been received by the City for a joint public/private initiative to develop a district heating service enterprise. If this or a similar proposal were accepted by the City, the City could contract with a development team which would include project developers, engineers, attorneys, and financial consultants. This development team would then be responsible for putting together a marketable district heating project in the downtown/riverfront area. Such a project might or might not include phased development of the thermal potential of the trash-burning Municipal Electric Plant. The City would retain, as contractor for development services, a share of influence in developing and selecting alternatives.

STEPS TOWARD IMPLEMENTATION

Given the above scenarios, it is apparent that a number of organizational and financing options remain open for the City, depending on the degree of involvement and risk that the City is willing to incur in district heating development. At this point (mid-1986) the City has gone about as far as it can go in determining the costs and benefits of potential district heating development--without yet making the decision to accept those risks and proceed with a commitment. It is clear that in order for district heating to develop beyond the "preliminary feasibility study" stage, substantial private sector involvement will be necessary--primarily to carry forward the additional engineering, financial, organizational, legal, and marketing work necessary to assemble a "bankable" project. The private sector has shown an interest in district heating development, based on groundwork laid by previous studies funded by the Danish government as well as by the U.S. Departments of Energy and Housing and Urban Development. Private engineering and development companies have offered to carry forward the additional groundwork necessary, taking risks in the expectation of future profit. However, the private sector also wants to see evidence of City commitment to development of a district heating enterprise, under the assumption that a public/private partnership of some kind will be necessary for both short and long-range district heating development. Such a partnership makes good sense. The City not only owns two of the largest potential thermal sources in the form of the old and new electric plants, but is also vitally interested in the form and direction of downtown development.

There is precedent in the experience of other U.S. cities for local government involvement in district heating development projects. Without exception, in cities where modern district heating systems have been developed, local government initiative and leadership are regarded as crucial to success.

An opportunity now exists to bring these interests together in a cooperative effort beneficial to both public and private sectors. This is an area of endeavor (sometimes referred to as "privatization") which, although much discussed in Columbus and strongly advocated by the Federal government, remains for the most part unbroken ground. In reality, the question is not whether functions that have been or would be performed by the public sector can be turned over to the private sector, with no cost or risk to the public sector. Rather, the question is whether public and private sectors can successfully join together in a form of partnership that brings benefits to both, and in which each can agree on the degree of risk, cost, and profit that must be shared.

In this effort, the City of Columbus has approached the limits of its own resources in encouraging and coordinating further district heating development. Making extensive use of available Federal grants and benefiting from additional feasibility studies funded by the Danish Ministry of Energy, the City of Columbus has attempted to fill a pathfinder role in pointing out opportunities for district heating investment. The City has so far been cautious about its own commitment to district heating investment while supporting and demonstrating opportunities for private development. In late 1985, a joint venture of developers and engineers announced its intention of forming a District Heating Development Corporation--conditional upon the City's commitment to contract with the Development Corporation for services to create, over a one-year period, a District Heating Service Corporation. The City, in response, has had to reassess the costs and benefits of a commitment to district heating development.

If the City decides to contract with a development team responsible for organizing, designing, and marketing a district heating system, the City must determine what its own future influence should be in determining the organization, purposes, and service coverage of a district heating enterprise. A potential City role is of course dependent on a number of criteria--the economic and financial viability of a proposed system; the potential market for City thermal production; anticipated market demand for district heating; and expected benefits to downtown development and redevelopment activities.

If a district heating service enterprise can be created which meets these criteria, and if the private sector shows a willingness to invest in a proposed system, the City should strongly consider a positive role in the enterprise. City participation could be important not only to assimilate district heating into the rapidly changing layout of downtown development, but also to help assure that the project attracts the support of private sector investors and major consumers.

SUMMARY

This chapter has outlined several ownership options for district heating development and has reviewed important decisions that must be made by the City of Columbus regarding municipal sale of thermal energy, the public role in district heating development, and potential public investment. These choices must be dealt with in timely fashion by the public sector if the City is going to maintain the current level of interest by the private sector in district heating development. Over the next twelve months, if district heating as a joint public/private venture is to become a reality, the City should take steps to protect and promote its own interests in a future district heating enterprise. Any proposed contract with a development corporation should help to define those interests and should make clear the criteria by which the City will make its decisions regarding future involvement.

NOTES -- CHAPTER FOUR

(1) Larry E. Christensen, "District Heating and Cooling: The Institutional Parameters for Columbus, Ohio," in Harry and Mogens Larsen A-S, Consulting Engineers, *Framework for District Heating*, Volume II of a Conceptual Study (Aug. 1984), p. 239 ff.

(2) *Ibid*.

Chapter 5. Recommendations and Suggestions for Application

RECOMMENDATIONS

District heating may not be for every community. Nevertheless, modern district heating technology can be adapted to a wide variety of urban and institutional settings. It is difficult to determine a common set of political, economic, and institutional preconditions that would indicate the relative potential for district heating in every community. Obviously, these preconditions vary across national boundaries, as between Denmark and the United States, just as they vary among states or local jurisdictions. The State of Minnesota has attempted in a district heating planning guidebook to develop a checklist of community features that would allow a rule-of-thumb assessment of local district heating potential (see Appendix). Such a tool may be useful to those communities beginning to consider multi-user district heating systems in their own development plans.

Nearly all consultants and practitioners in the field of district heating agree, however, that strong political support underpins the success of most district heating systems. Without such support, even if all other indicators are positive, district heating cannot be expected to succeed. If there is any other single factor that would determine the success of district heating in a particular community, it would be that of economic feasibility. The economics of district heating are heavily dependent on the relative prices of heating with competitive fuels compared to the delivered price of district heat when capital, fuel, and operating costs are considered. In Denmark, it is apparent that district heating has achieved a strongly competitive position. In the United States, the economic justification for district heating may require a somewhat longer-term view on the part of consumers. In Columbus, as in other parts of the Midwest, natural gas is the current leading choice for boiler fuel. The moderate price of gas in the short term poses a clear challenge for district heating entrepreneurs. District heating prices will have to remain at least competitive with natural gas while demonstrating other long-term advantages over conventional systems such as reduced maintenance, better efficiency, and capital equipment savings.

Local government administrators who are interested in the potential for district heating in their own communities would be well advised to review several case histories of district heating development under a number of different ownership, financing, and technical scenarios. Among those cities that, for various reasons, have been of interest to Columbus in the course of our study are Youngstown, Trenton, Baltimore, and St. Paul. Although the St. Paul district heating system was initially much more ambitious than the Columbus project, St. Paul's emphasis on a new hot water system making use of older boilers in power plants near the downtown made the St. Paul project appear exceptionally applicable to Columbus. Trenton was interesting because its system is operated by a for-profit corporation, as is the district heating system in Youngstown. Baltimore, like Columbus, had one of the original twenty-eight feasibility studies funded by HUD in 1981, and subsequently developed a first-phase system using recaptured heat from a solid waste incinerator. A good non-technical summary of issues in district heating and cooling development, as well as useful case histories of other U.S. cities' experiences, can be found in District Heating and Cooling in the United States: Prospects and Issues (Committee on District Heating and Cooling, National Research Council, Washington: National Academy Press, 1985).

Columbus has obviously benefited from the special interest shown in local district heating potential by the Danish Ministry of Energy. Since December 1982, when the Danish government signed an agreement with the City of Columbus, Columbus has worked closely with a Danish engineering firm, Harry and Mogens Larsen Consulting Engineers. HML Consulting Engineers brought to the Columbus project a great deal of experience in modern hot water district heating systems. Their experience in the Columbus project has brought about a synthesis of Danish district heating philosophy and methodology with the special opportunities, constraints and conditions to be found in Columbus. This should ultimately prove beneficial to the project. One lesson learned from this experience is that in choosing consultants, it is important to select a firm with direct experience in the type of system which is desired. Another important attribute of any engineering firm is the creativity and flexibility which allows it to adapt proven concepts to local conditions. Otherwise, inappropriate "off the shelf" designs may be recommended.

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The first question posed at the beginning of this study was whether district heating concepts developed effectively in Denmark could be successfully applied to one or more projects in the Columbus environment. The answer to this question is undoubtedly yes, even though Columbus shows obvious differences from the Danish environment where these concepts originally developed and flourished. Differences also exist between Columbus and other U.S. cities where district heating has been shown to work. In summarizing the several assessments done in Columbus to this point, one might say that a potential market for district heating exists but has not yet been fully developed. Given the highly competitive market based on inexpensive natural gas in Columbus, it may well be said that if such district heating concepts can be demonstrated to work here, they can work nearly anywhere in the U.S. under similar conditions. Such a demonstration was, in fact, the reason Columbus was chosen as the location of the 1983-84 study sponsored by the Danish Ministry of Energy.

A second question to be answered was whether district heating could be used to support urban development and redevelopment in an environment where development is occurring at a rapid pace but without reference to an overall growth plan. Based on work in Columbus to date, the answer is probably yes--but the evidence is inconclusive. District heating would seem to offer greater opportunities to a city in which the timing and scale of development is at least known with some certainty, and where a consensus exists that public/private investment in infrastructure can and should be used to attract development to particular areas. In Columbus such a consensus--focused on the downtown--has yet to take shape.

A final question to be answered was whether or not, in the current political and fiscal environment, district heating could develop in Columbus without substantial public investment. There is no answer at present. District heating has attracted the attention of one group of private entrepreneurs, but this group requires some initial City financial commitment to the next stage of development. The territory of public/private partnerships is largely unbroken ground in Columbus, particularly in regard to utility-type projects such as district heating/cooling. The partnership agreement being proposed by Danish developers is seen as a temporary one--that is, City involvement would only cover about 20% of the additional developmental costs, and would not extend into actual financing, construction, or operations. Nevertheless, even a limited partnership would seem to offer significant advantages to the City in terms of sharing risks and leveraging investment, while promoting public benefits in the form of thermal energy sales and of development incentives for the downtown/riverfront area.

SUGGESTIONS FOR APPLICATION

The following lessons from the still unfinished Columbus experience seem most relevant to other jurisdictions:

Planning and Development Issues

(1) Timing is a critical issue in linking district heating with development or redevelopment projects. The attraction and advantages of district heating to a property developer are optimized if connection to a district heating system can be made during the property's construction stage, when added savings can be obtained by

avoiding the cost of in-house boilers and equipment. However, a district heating system cannot be designed only on the basis of capturing new or proposed developments. A substantial existing heat load is usually necessary in order to facilitate planning and sizing a system.

(2) Use of the "heat island" approach to identify possible start-up and expansion areas appears to facilitate planning and development along the best possible economic lines. District heating systems designed to serve redevelopment areas, however, should be located so that existing customers can provide anchor loads for the initial phases of system development. In this way, it is possible to reduce the economic sensitivity of the system to possible delays or other changes in construction plans for targeted development properties.

(3) The Danish concept of "start small, but think big" may be applicable to district heating scenarios in the United States--especially to those situations in which the timing and scale of development or redevelopment efforts may be uncertain.

(4) Some form of centralized growth planning is certainly helpful, if not absolutely essential, to integration of district heating with development/ redevelopment efforts. Such planning facilitates more accurate assessments of system growth potential and phasing limits as well as assessments of costs and revenues. Oversizing and overinvestment, which are major problems during the early development phases, can thereby be controlled.

(5) Marketing is an essential factor in the creation and development of any successful district heating

system. Marketing is an ongoing process, starting with the initial customer contacts to establish interest and obtain data during the pre-feasibility study. Thereafter, marketing is a valuable educational tool for the district heating developer--informing the customer of advantages; demonstrating comparative costs and savings; and bringing the customer to the point of commitment. After a system is in place, an on-going marketing/survey effort can be used as part of the process of responding to consumer needs, with the objective of improving system operations and economics. The continuing process of educating decision-makers, prospective investors, and the media is also part of a sound marketing strategy.

Economic Issues

(6) In order to achieve the most favorable operating economics with district heating, it is important to utilize sources of heat which offer the lowest possible costs. This can be achieved by substitution of lower-cost fuels (especially in the form of waste heat) for higher-cost fuels, and/or by avoiding capital costs through the use of existing boiler plants.

(7) Preliminary economic analysis of a proposed district heating system should indicate whether the system can deliver heat to potential customers at a unit cost less than the unit costs of heat from conventional systems. If so, further analysis of life cycle economics, of project liquidity, and of the sensitivity of underlying variables and assumptions should be carried out.

(8) District heating must at least be able to compete with conventional heating systems and fuels on the basis of end-user costs. These should be the overall

costs to the consumer--either the total annual cost or the total cost per unit of heat used in a year. Comparisons should not be made between single cost components such as fuel or capital investment. Cost comparisons should never compare unlike items. For example, a common fallacy is to compare a district heating consumer price per unit of heat with the price of a conventional fuel input such as gas. The costs of both district heating and individual systems should include all costs affected by a changeover to district heating, including such items as debt financing, boiler maintenance, pumping costs, insurance premiums, and so forth.

(9) In the United States, economic justification for district heating may require a long-term view of costs and benefits on the part of building owners, managers, and developers. This is especially true when the current price of competitive fuels is relatively moderate. In the short run, district heating rates will have to remain at least competitive with the price of heat from conventional sources while demonstrating other long-term advantages such as reduced maintenance, better efficiency, and capital equipment savings.

Ownership Issues

(10) The for-profit corporation has several advantages among ownership options. Among these are:

-- attraction of private equity investment

-- incentives for efficient operation

-- assumption of risk by private investors

However, a highly competitive heating fuel market may make it difficult for a for-profit district heating corporation to provide attractive savings to consumers while at the same time generating an adequate return to investors.

(11) The not-for-profit corporation has certain economic and political advantages. A greater share of the savings generated by the system can be passed on to consumers or used for system expansion or improvements. Furthermore, the not-for-profit feature may be a valuable asset in helping to attract and retain consumer confidence. The local government may also be able to exert more leverage over a not-for-profit district heating development corporation, depending on the degree of involvement the local government is willing to assume.

(12) Regardless of whether a privately-developed district heating corporation is set up on a profit or not-for-profit basis, the local government should still retain considerable interest in the organizational form and geographical coverage of a district heating system. Various degrees of public-sector leverage can be obtained through

-- loans or grants to the district heating corporation;

-- sale or lease of local government assets, including thermal production from municipal facilities;

-- organizational representation on the board of a district heating corporation or cooperative;

-- grant of an operating franchise;

-- grant of permits for excavation, construction, etc.

Political Issues

(13) Without top-level political support, it becomes very difficult for district heating projects to succeed--even if the local government is only a limited partner in a district heating development venture.

(14) Before becoming involved in actual district heating development, a local government administration should first decide what role it is prepared to play in stimulating, supporting, and promoting such development, whether spearheaded by the public or private sector.

1.4 Independent Assessment Questionnaire

Now that you are familiar with the major considerations for the district heating components, you can complete the Independent Assessment Questionnaire.

This questionnaire can be used in the community, without professional assistance, to determine if local conditions favor a district heating system. This is a good first step to complete before spending a lot of time and money for further planning and development.

A broad cross section of community leaders and citizens, including leaders from municipal, community, financial, and business interests, should complete this questionnaire jointly.

After completing the questionnaire, total the yes and no responses. If there are ten or more positive responses, the community is justified in proceeding with development. If there are fewer positive responses, district heating development is less promising and perhaps should not be pursued. (This is, however, a subjective response and perhaps the interest and discussion generated may be of greater value than the numerical response.)

	More Favorable	Less Favorable
Does your community have one or more large users of thermal energy for space heating, water heating or processing?	Yes ☐	No ☐
Is there major new construction or development planned or underway in your community?	Yes ☐	No ☐
Is there an electrical generating plant in or near your community that offers the opportunity for cogeneration of electrical energy and thermal energy?	Yes ☐	No ☐
Are there existing or planned heat sources in or near your community that may be possible sources of district heating thermal energy?	Yes ☐	No ☐

	More Favorable	Less Favorable
Do any existing or planned local heat sources have excess or potential excess capacity to dedicate to local district heating thermal energy production?	Yes ☐	No ☐
Are most of the major potential customers and large thermal energy users located close together?	Yes ☐	No ☐
Is there a single or small group of thermal energy users that comprise a significant proportion of the community's total thermal energy load?	Yes ☐	No ☐
Is the primary heat source located within one mile of the major concentrations of potential customers?	Yes ☐	No ☐
Are there any significant physical or geographical barriers that divide or present difficulties in serving the entire potential heat load?	No ☐	Yes ☐
Are there any thermal energy users that are planning to replace and/or upgrade their internal heating systems in the near future?	Yes ☐	No ☐
Is there an existing deteriorating district heating system in the community that may be abandoned?	Yes ☐	No ☐
Are community officials and other influential local people interested in district heating? Do they support it?	Yes ☐	No ☐
Does a possible district heating system permit the substitution of a significantly lower cost for higher priced, currently used fuels?	Yes ☐	No ☐
Do major thermal energy users in the community know about district heating and understand its comparative advantages?	Yes ☐	No ☐
Does the community have an existing district heating company or utility?	Yes ☐	No ☐

	More Favorable	Less Favorable
Does the community operate a municipal energy utility system?	Yes ☐	No ☐
Is there private developer interest in district heating development?	Yes ☐	No ☐
Is the community free of other major capital investment projects that might limit the capital availability for district heating development?	Yes ☐	No ☐
Is the municipal government readily able to raise the capital necessary for district heating development either through its bonding capability or its tax base?	Yes ☐	No ☐
Does the community have an economically viable and technically feasible alternative energy source?	Yes ☐	No ☐

	More Favorable	Less Favorable
Total Number of Responses	________	________

REPORT AND INFORMATION SOURCES

Additional copies of this report, "Modular District Heating Planning as a Development Tool," are available from:

Publications and Distribution
Public Technology, Inc.
1301 Pennsylvania Ave., NW
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For additional information on the methodology, data, or conclusions presented in this report, please contact:

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