District Heating and Cooling Program Policy Analysis

Full Report

Prepared for

Assistant Secretary for
Community Panning and Development
Department of Housing and
Urban Development

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Chapter 1
INTRODUCTION

1.1 PURPOSE

This report has several purposes. Simply put, this is intended to assist the U. S. decision makers in matching the appropriate energy use to the energy need, whereby 18.4 quads of energy now being wasted in the course of producing electricity, disposing of municipal waste, etc., can be captured and used as an important energy source by business, industry and households. Generally, the purpose of the report is to identify, define and evaluate district heating and cooling (DHC) in the United States in order that the Department of Housing and Urban Development, in its community development program, technical assistance and UDAG policies, and other responsible agencies, for their areas of responsibilities, can adopt and implement appropriate federal policy regarding this urban technology. More specifically the purpose of the report is to:

- o identify and describe the impact of district heating and cooling development on energy production and use
- o identify and characterize available federal policy options as they relate to DHC system development
- o identify, quantify and evaluate the impact of these policy alternatives
- o quantify and evaluate appropriate levels of federal interest in district heating and cooling
- o recommend appropriate actions which can and should be taken by HUD and other federal agencies within the context of the policy alternatives.

In order to accomplish the above stated purposes, this report was prepared after months of exhaustive analysis drawing extensively upon the resources of American industry, utilities, system owners and developers, consulting engineers, cities, states, professional organizations, national laboratories,

and federal agencies. The report consists of two volumes --an Executive Summary which focuses on the important findings, conclusions and recommendations; and the full report which represents the most thorough and documented DHC policy evaluation conducted to date.

The report consists of seven chapters.

CHAPTER 1
- Introduction

CHAPTER 2
- District Heating and Cooling Status Trends and Plans: United States and Europe

CHAPTER 3
- Barriers to District Heating and Cooling Development

CHAPTER 4
- Market Potential of District Heating and Cooling

CHAPTER 5
- Federal Policy Options

CHAPTER 6
- Benefits of District Heating and Cooling

CHAPTER 7
- Conclusions and Recommendations

Chapter 1 - the Introduction, identifies, defines and describes district heating and cooling. The introduction presents a concise description of DHC markets suitably served by DHC; the institutional relationships surrounding DHC ownership, development and operation; and the primary characteristics of DHC systems which stimulate interest and motivate communities to develop DHC systems.

Chapter 2 - DHC Status, Trends and Plans, evaluates and documents the condition of DHC today in both the United States and Europe. Chapter 2 also evaluates the impact of DHC development and the results of federal and state initiatives conducted during the last few years.

Barriers confronting district heating and cooling development are identified, analyzed and evaluated in Chapter 3. Barriers discussed in Chapter 3 include market entry barriers, system financing issues, regulatory barriers and uncertainties, and air quality issues.

Chapter 4 - Market Potential of District Heating and Cooling, identifies and quantifies the DHC market and forecasts the level of DHC development which can be anticipated without federal intervention of any kind. This chapter establishes the base case against which options are later tested. Federal policy options are then identified and described in Chapter 5. The subject policy options reflect varying levels of federal encouragement and support for DHC system development.

Chapter 6 - Benefits of DHC, quantifies and evaluates the benefits which can be expected to accrue as a result of any of the considered policy options. This impact evaluation calculates and estimates benefits at the national and local levels.

Finally, Chapter 7, presents the major conclusions drawn as a result of the detailed analysis. Practical recommendations are suggested which will have a substantial impact on DHC system development and the nation's energy supply system; and will leverage substantial private investment with very modest federal support.

1.2 DEFINITION AND DESCRIPTION OF DISTRICT HEATING AND COOLING

In order for the United States to improve its energy systems, adherence to two energy principles or axioms will be required. The first is that we must widely match national/community energy resources with national/community energy needs or service requirements. A quantitative and qualitative understanding of both national and community specific energy resources and service requirements is necessary to fulfill this requirement.

The second principle involves our definition or characterization of energy. Typically, policy makers view energy quantitatively, i.e., kilowatt hours, thousands of cubic feet of natural gas, barrels of oil, cords of

wood or tons of coal. However, energy also has an often ignored qualitative measure. We often disregard energy quality in our systems; e.g., we burn natural gas at around 1100°C and circulate it through a building at 60°C for space heating purposes. That same natural gas could be used to melt glass or make fertilizer. In turn we either ignore or fail to use low quality energy appropriately. Therefore, the second principle simply stated is that nations/communities need to use high quality energy to meet high quality needs and low quality energy to meet low quality needs.

A primary goal of district heating and cooling systems is to increase efficiency in supplying the energy services required by a community in a manner consistent with the two energy planning principles cited above. However, energy conservation must be achieved within the constraints imposed by other equally important considerations. District heating and cooling systems implementation strategies must seek to achieve energy efficiency while maintaining the United States's broad economic, social, and lifestyle objectives. Below are two thoughtful comments from apparently dissimilar positions.

> "If approximately 2/3 of the heat produced by primary fuel in the generation of electricity continues to be wasted, electrification should be strongly discouraged as inherently inefficient; indeed, most average efficiencies have fallen in the past few years. Correcting the scandalous waste of fairly high-temperature heat from power stations, as with the district heating schemes could reduce this objection gradually over the next few decades."*

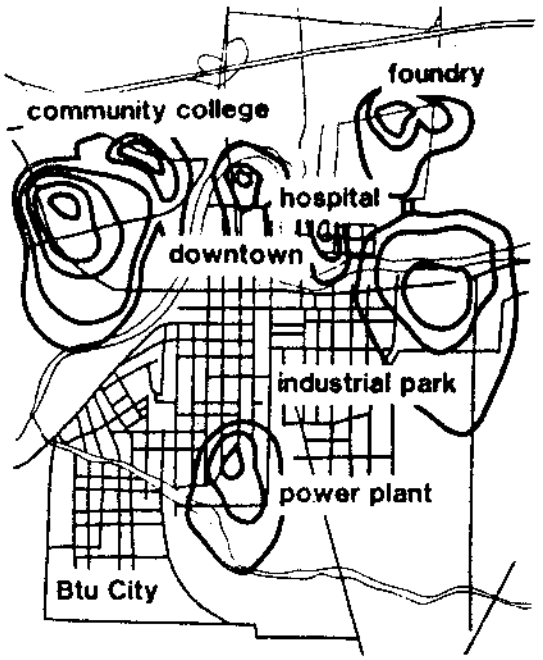
*Lovins, A.F. World Energy Strategies, Ballinger, Cambridge, Mass.

"Thermal pollution", in other words, could be put to good use which would otherwise demand fresh primary energy. Meanwhile, the electric industry, which now uses 1/4 of the U.S. primary energy, plans to use fully 1/2 of this energy in 2000, which would require 2/3 of the total continental runoff as cooling water to take the "waste" heat.

The importance of using 'waste' [power plants, industries, etc.] heat for heating or industrial processes can hardly be over-emphasized. The obstacles are less technical or economic than institutional. To reduce these, it may sometimes be worthwhile to degrade high-temperature heat deliberately in order to insert a stage of buffering between the power station and the users.*

*Kovach, E.G., ed., Technology of Efficient Energy Utilization,

U.S. cities consist of a number of "heat islands" or areas of dense energy utilization. These heat islands are concentrated loads, large production/conversion facilities, or a combination of both. Generally they consist of large buildings such as a community college or hospital; major industries with large process loads such as a foundry or a food processing plant; power stations, collections of buildings such as a central business district or a high density residential/office area, or Department of Defense installations. Many of these heat islands are large loads which have low quality energy service requirements which include space conditioning or low quality process needs such as metal cleaning or food processing. Other heat islands have high quality service requirements such as an electric power



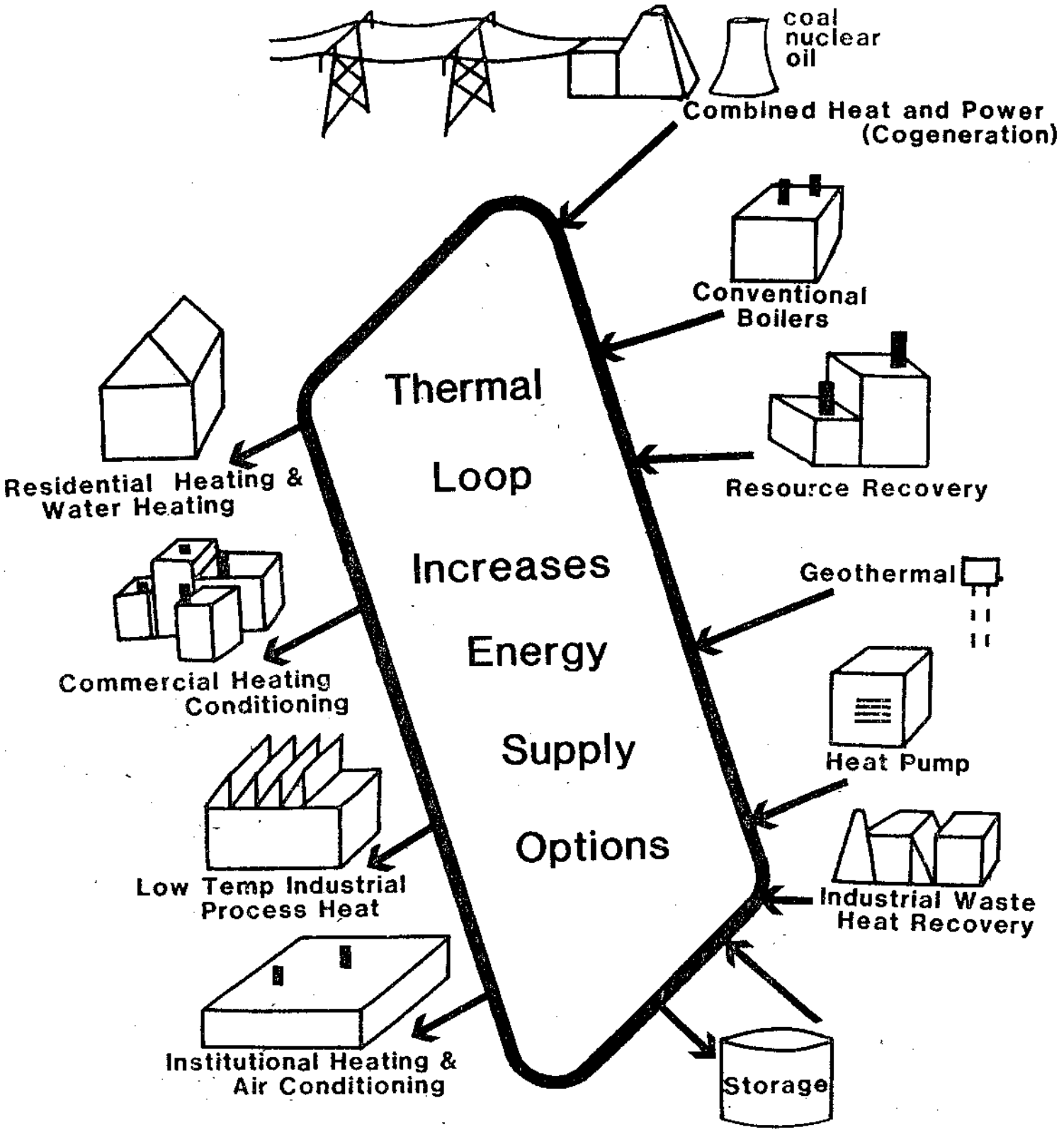
Map 1-1

plant, a foundry, a paper mill, or an aluminum smelter. Typically, all of these loads are met with high quality energy regardless of the service requirement and they reject large amounts of low quality energy into the environment. Condensing electric power stations reject the low quality energy into a regular cooling tower; other users simply reject it into the atmosphere. It is evident that what cities need is a system which allows the power station or the foundry to sell its wasted energy to the hospital, downtown, or the community college within the town.

District heating is the urban energy technology which allows the transport of low quality energy to meet appropriate service requirements. More specifically, District Heating and Cooling Systems are thermal energy networks carrying hot water, steam or chilled water from one or more central production stations to service the energy needs of commercial, residential, institutional and industrial users. The thermal loop allows energy (Btu's), as distinguished from fuels, to be bought and sold within the community. Because the piping network transports energy, virtually any available fuel

source can be incorporated into the district heating and cooling system, including scarce fuels (natural gas or oil), non-scarce fuels (coal, nuclear, urban waste), renewable resources (solar, geothermal, groundwater), or manufactured fuels (industrial waste heat.)

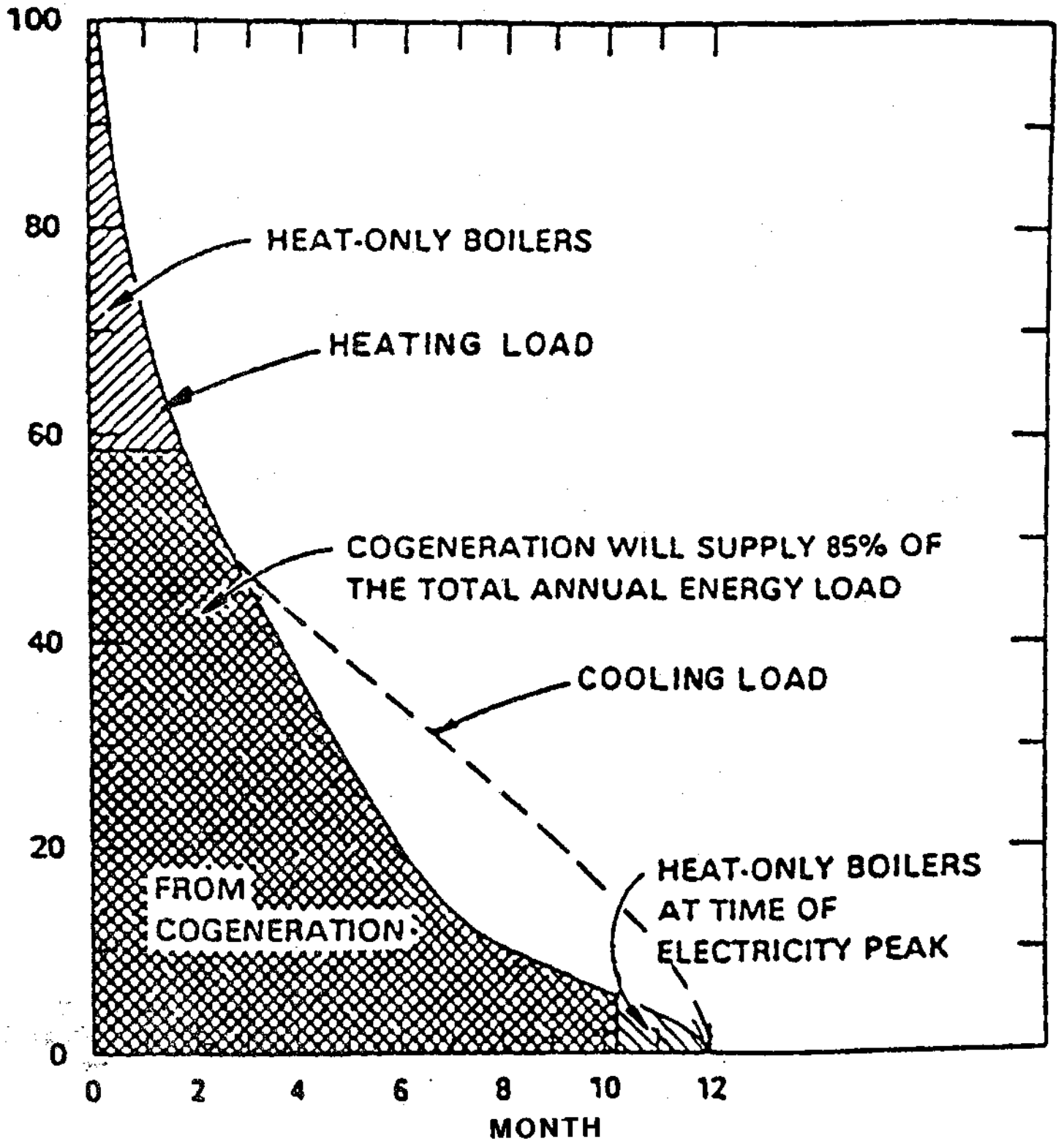
District Energy Systems may be small-scale, such as hopital complexes, educational facilities, shopping centers, and dense residential developments--or large-scale, such as an entire downtown or large sections of a city. Carefully determining specific community characteristics is important in developing a successful system.



DISTRICT ENERGY SYSTEMS

Figure 1-1

Although cogeneration plants are the preferred source of waste heat for large district heating systems, heat-only boilers (with no electric generation) are sometimes used in developing systems. Either stationary or portable hot water boilers are an integral part of many larger systems, where they are used during peak-load conditions or as standby units. These heat-only boilers have the advantage of low initial capital cost, but are not used for normal base-load conditions (Figure below) because of their relatively high operating costs compared to cogeneration plants. Heat-only boiler operating costs can sometimes be reduced by the use of lower cost and lower heat value fuels such as forestry waste (biomass) or by the incineration of solid waste. Other comparatively low-heat value energy sources such as solar, geothermal, and industrial waste heat are suitable for district heating and can be added to the thermal loop to supplement the energy supplied by base-load energy sources.


100
80
60
40
20
0
HEAT-ONLY BOILERS
HEATING LOAD
COGENERATION WILL SUPPLY 85% OF
THE TOTAL ANNUAL ENERGY LOAD
COOLING LOAD
FROM
COGENERATION
HEAT-ONLY BOILERS
AT TIME OF
ELECTRICITY PEAK
0
2
4
6
8
10
12
MONTH

Graph 1-1

Although one of the purposes of this report is to discuss the benefits available from district heating and cooling systems, two technical benefits deserve specific, early identification. DHC systems conserve scarce fuels and help cities use energy more efficiently by:

1. Substituting energy normally wasted or alternative forms of energy for oil and natural gas that are currently used in individual buildings; and

2. Utilizing energy resources more efficiently through the use of cogeneration power plants.

1.3 DISTRICT HEATING AND COOLING MARKETS

The industries, businesses and buildings in a city are the fundamental building blocks or foundation of any district heating and cooling system. Engineers call them loads; economists call them consumers; regulators call them customer classes. Under any title they are the market. Like any business, the DHC system sells a product. Its product or service is electricity and thermal energy. Unless the product sells there will be no system nor will any of the external benefits accrue to the city, state or nation.

The four major market sectors served by a DHC system are commercial, industrial, residential and institutional. Each of the four markets display somewhat different characteristics regarding service requirements, complexity, desired payback rates, general location in the community, environmental imports, innovativeness, financial capability, and age of energy equipment. These varied characteristics are of considerable importance in assembling a market.

Commercial Markets

The commercial market for thermal energy generally consists of high density central business districts (CBD's), large individual structures,

office buildings and shopping centers. Many newer buildings in this market may in fact already have hot and/or chilled water inbuilding systems. Commercial users generally require the shortest paybacks for energy-related investments. Beyond the issue of first cost, potential disruption resulting from construction can often be the most frequent issue raised. Cities in West Germany minimize these concerns by using technical approaches such as tunneling underneath major thoroughfares and plazas to maintain customer traffic.

Industrial Market

Industrial markets require emphasis on reliability and straight forward Btu equivalent comparisons. Since industries can sometimes afford energy system investments with reasonable paybacks, this market segment buys on "fuel price" to a greater degree than other potential users. Reliability of energy supply is also a prime consideration. Many industries have substantial low temperature heat requirements and are therefore likely district energy system customers, included, by example, textiles, rubber and plastics, and food products. Some industries require high quality energy and therefore reject large quantities of waste heat which can be captured and sold to other customers through the thermal loop. Paper and allied products, chemicals, primary metals, and stone, glass, and concrete are examples of industries which can become part of the resource/central plant components of a district energy system.

Residential Market

The residential market consists of multi-family high-rise apartments, attached housing/condominiums, and single family homes. Substantial debate surrounds residential district heating and cooling service. Most of the debate focuses on the specific distribution cost involved. The distribution

cost required to serve single family homes is proportionately greater than that required to serve a paper mill or similar aggregate demand. However, medium and high density residential areas certainly represent economically attractive loads. Like so many other DHC system issues, service of lower density housing requires site specific analysis. Proximity of lower density residential areas to other large customers, the level of system maturity, the price of competing fuels, and the system's concurrent thermal and electrical load curves are among the specific considerations necessary to determine the feasibility of residential hook-ups.

Institutional Markets

Institutional markets include hospitals, schools, colleges, military bases and government buildings. These markets are similar to commercial markets in that the service requirement is primarily space conditioning with little, if any, process applications. Like industrial markets, reliability and the Btu cost equivalent comparison are important issues. Institutional markets often consist of several buildings or facilities under common ownership or control. Most importantly many will have their own central energy system or building-scale hot or chilled water systems.

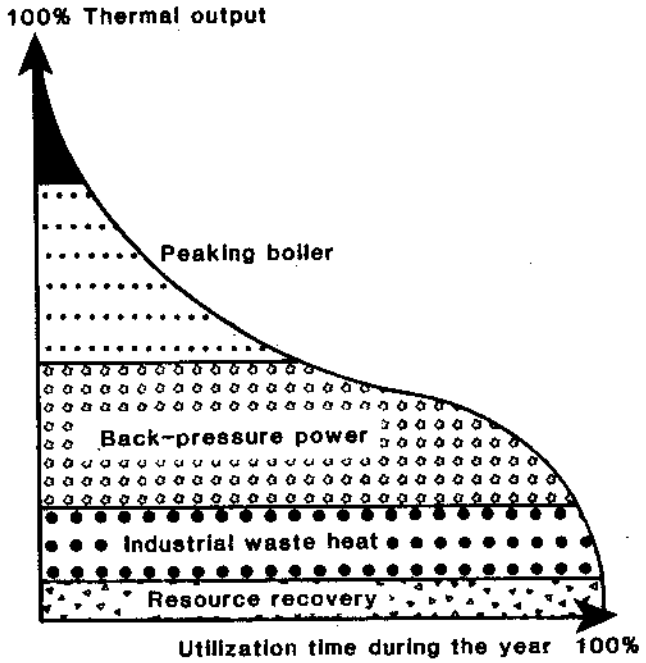
1.4 DISTRICT HEATING AND COOLING SYSTEM COMPONENTS

An opportunity for energy conservation in a DHC network can be created by the integration of technological systems. An integrated technology system is developed by combining the hardware of a city's energy systems into a single, unified system capable of providing one (or more) energy service required by the community. District heating and cooling systems employ various technologies to convert a variety of energy resources into usable forms of energy such as thermal energy and electricity services to a community. Four components or

subsystems are typically required--a resource system(s), a central plant(s) system, a distribution and storage system, and end-use systems. A brief characterization of these system components will assist during any policy discussion.

Resource System

The district heating and cooling resource system deals with the supply of primary fuel or energy. Use of multiple fuel or energy resources is possible and in many cases desirable. In fact, the primary fuel or energy resources may change over time as the system grows and matures or may vary by season and time of day as loads change and the energy streams fluctuate. Selected systems may rely on "scarce fuels" such as oil or natural gas for all or part of their requirements. However, emphasis will generally be placed on the use of abundant or renewable sources of energy such as coal, solid waste or geothermal. The integrated technologies in a DHC system offer considerable potential for substituting abundant or renewable sources of energy for scarce fuels such as gas and oil. Often these substitutes are found within the state. Technological integration makes it economically feasible to employ the conversion processes necessary to convert solid waste or coal into forms of energy usable by the businesses, institutions and residents of a community.



Graph 1-2

DHC and municipal solid waste (MSW) systems are now becoming mutually supportive and economically linked in the U.S. and thus deserve special mention here. Estimates state that 175 million tons of MSW are discarded in the U.S. annually, with ever increasing costs of land filling. MSW plants producing energy are attractive investments and can reduce urban costs in the mid and long-term. There are some refuse-derived fuel (RDF) systems currently operating in the United States. In Nashville, Tennessee, for example, an RDF incinerator supplies all the steam required by a new district heating/cooling system. Another in Akron, Ohio burns RDF in a special boiler to feed steam to a district heating system as well as to a university, hospital and industry.

Resource recovery systems are capable of providing a variety of energy and fuel products. Currently, the most marketable of these products are steam, hot water and electricity. Given the generally (1970 forward) escalating cost of traditional fossil fuels and the unlikelihood of a reversal

in this trend, waste-derived energy may well represent a lower cost energy source over the long run. Thus, the energy produced in solid waste processing and resource recovery facilities can serve as a significant thermal energy source in new DHC systems. The newly constructed 2200 TPD plant in Baltimore, Maryland, owned by Signal RESCO will supply steam to the downtown district heating system, shoot water to a new network in Cherryhill, and produce electricity.

In addition to the energy benefits, a MSW energy plant can have significant impact on the solid waste management of a city. Energy recovery from MSW will substantially reduce the volume of landfilled wastes, thus conserving and extending the life of existing landfills. Furthermore, since plants for district heating systems will tend to be centrally located, the total miles traveled by collection vehicles should be reduced.

The potential U.S. markets for energy from MSW plants can be estimated by considering the size distribution of either individual communities or U.S. Standard Metropolitan Statistical areas (SMSA's). Table 1-1 shows the size distribution of American cities as well as estimated waste generation rates. Table 1-2 shows summary characteristics of SMSA's. Twenty-three cities alone are large enough to support a plant capable of processing more than 1,000 tons per day. Over 800 cities alone could support plants in the 50-500 tons per day capacity range, and an additional 1,200 could support plants with capacities in the 15 to 50 tons per day range. Most importantly, today cities and other adjacent, political jurisdictions are joining together to form authorities which assemble even larger volumes of municipal waste. Consequently the number of feasible MSW systems increases greatly with multi-jurisdiction cooperation.

Table 1-1

U.S. CITY SIZE, POPULATION, AND WASTE PRODUCTION IN 1975

Size Range (thousands)	Number of Cities	Population (million)	Average Population Per City (thousands)	Average Municipal Solid Waste Per City (tons/day)
5 - 10	1,463	10.3	7.1	12
10 - 20	977	13.8	14.1	25
20 - 25	238	5.3	22.0	39
25 - 50	514	17.9	34.9	61
50 - 100	230	16.1	70.0	122
100 - 250	105	14.9	142.0	248
250 - 500	34	11.8	348.0	609
500 - 1,000	17	11.3	664.0	1,160
over 1,000	6	17.8	2,970.0	5,200

Table 1-2

U.S. STANDARD METROPOLITAN STATISTICAL AREAS (SMSAs)
SIZE, POPULATION AND WASTE PRODUCTION IN 1975

SMSA size (thousands)	Number of SMSAs	Population (million)	Average Population Per SMSA (thousands)	Average Municipal Solid Waste Per SMSA (tons/day)
Under 100	27	2.5	92	160
100 - 250	97	16.6	171	300
250 - 500	63	22.7	361	630
500 - 1,000	37	27.1	733	1,280
1,000 - 2,000	20	28.3	1,417	2,480
2,000 - 3,000	8	19.0	2,373	4,150
over 3,000	7	40.0	5,693	9,960

Source: Materials and Energy from Municipal Waste, Congress of the United States Office of Technology Assessment, Washington, D.C., OTA-M-93, July, 1979.

Developing resource recovery systems is neither cheap nor easy. The capital, and the operating and maintenance costs of resource recovery plants are substantial, regardless of scale or technology. Capital costs can be expected in the $50,000 to $75,000 per ton range, with annual operating and maintenance costs ranging from $13 to $20 per ton of waste processed. Nevertheless, such systems can be economically attractive because they earn revenue from two sources: the sale of an energy product and tipping fees paid to deposit waste in the system.

Geothermal energy--earth heat--is one of our most plentiful resources. Heat from the earth often reaches the surface as a hot spring, a geyser or a fumarole. When water trapped in factured porous rock is heated, a hydrothermal resource is formed. It can be tapped by drilling wells into it. The amount of energy that can be extracted depends on the recharge of water extracted and the size of the heat source. Commercial thermal energy is obtained from many hydrothermal resources today, both for electric power production and for direct heat use. New developments in exploration technology permit developers to identify new earth heat resources and to define their size more accurately. These new exploration techniques led to the discovery of new hydrothermal resources in the Eastern U.S.

KNOWN AND POTENTIAL HYDROTHERMAL RESOURCES

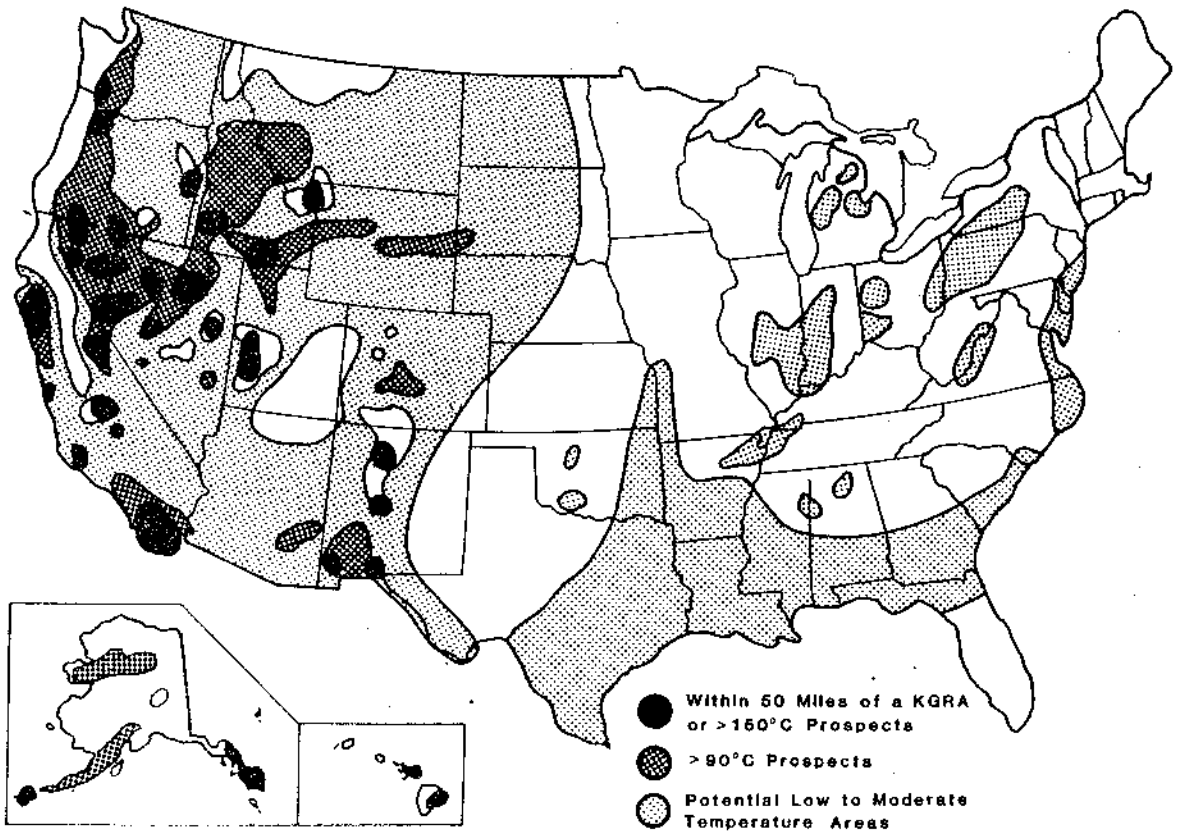


Figure 1-2

Central Plant System

This component converts primary resources into usable forms of energy, i.e., electricity, steam, hot water--that are transported to end-users. Depending on city needs, the central plant system can be one centrally-located plant or several interconnected, strategically placed facilities. Numerous central plant technologies or configurations are available to meet thermal and electrical loads in a specific community. These include coal or MSW fired plants, internal combustion engines, central heat pump systems and heat-only boilers.

HOT WATER DISTRICT HEATING SYSTEM: PRINCIPLE OF OPERATION

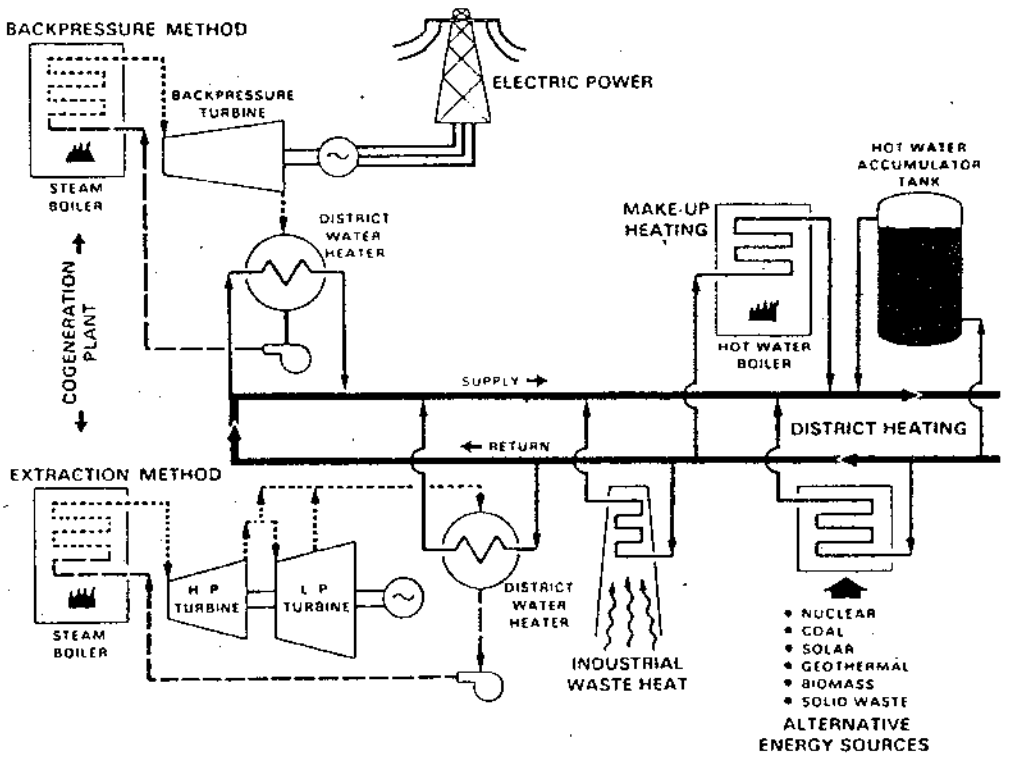
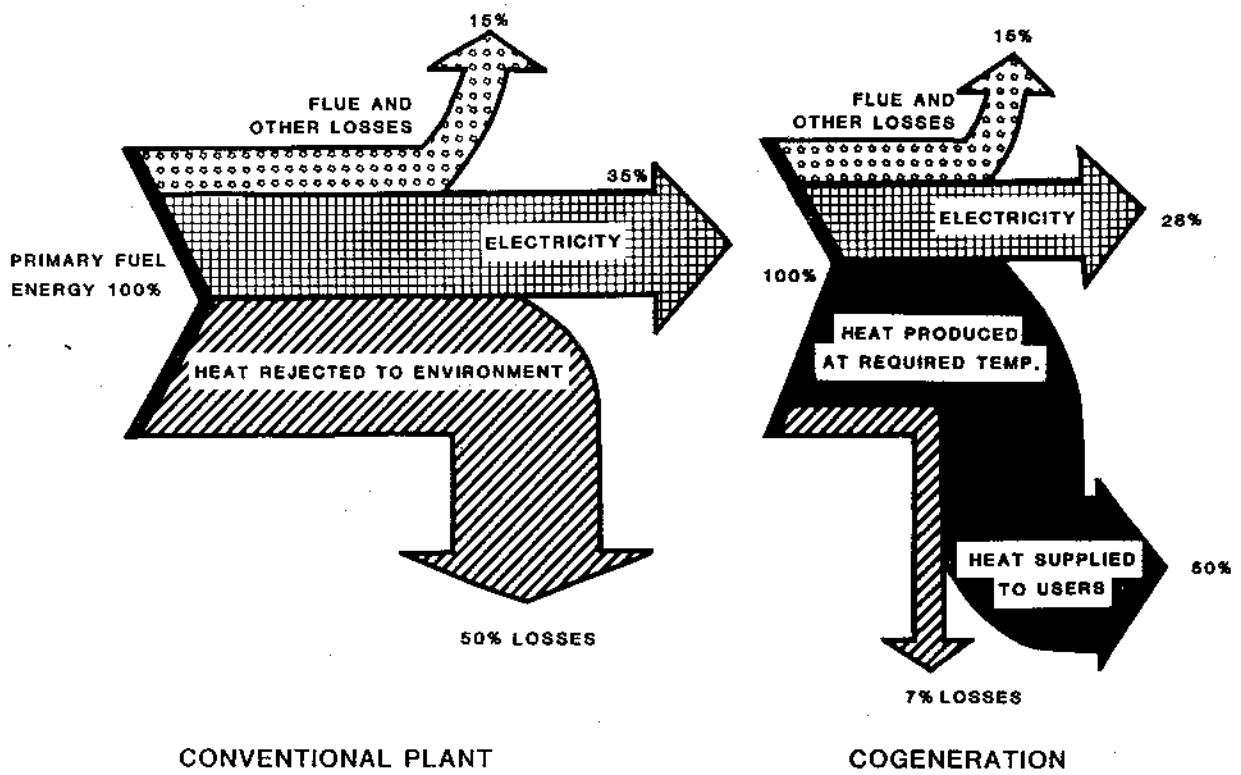


Figure 1-3

An important element in district energy systems planning and economics will be the incorporation of cogeneration or combined heat and power (CHP).

Cogeneration, the simultaneous production of electricity and thermal energy, can be a valuable input to the growing district heating and cooling system. By using the waste energy of electric production, cogeneration squeezes more energy out of each unit of fuel, and can raise the efficiency of central plants from about 30 percent to 80 percent. The increase in overall system efficiency results in accrued benefit to both thermal and electric customers. The cost and benefit allocation between these two types of customers encourages development and allows both to benefit.



POWER PLANT

COGENERATION RETROFIT EFFICIENCY

Figure 1-4

Distribution and Storage System

This component distributes the energy produced in the central plant to end-users in the community through a network of pipes and power lines. The piping network will be designed and constructed to meet the city's specific needs. Distribution systems consist of a pipe loop which carries hot water to and cool water away from the end-user. These pipes can be contained in pipe tunnels, concrete culverts, direct-buried and/or above-ground configurations. Cities with high space cooling requirements and high commercial or office densities may choose to distribute both hot and chilled water depending on the season. Storage capacity may be incorporated into the distribution system if either the electric or thermal energy demand profile of the community does not coincide with the supply profile, i.e., if the community doesn't require simultaneous heating and cooling.

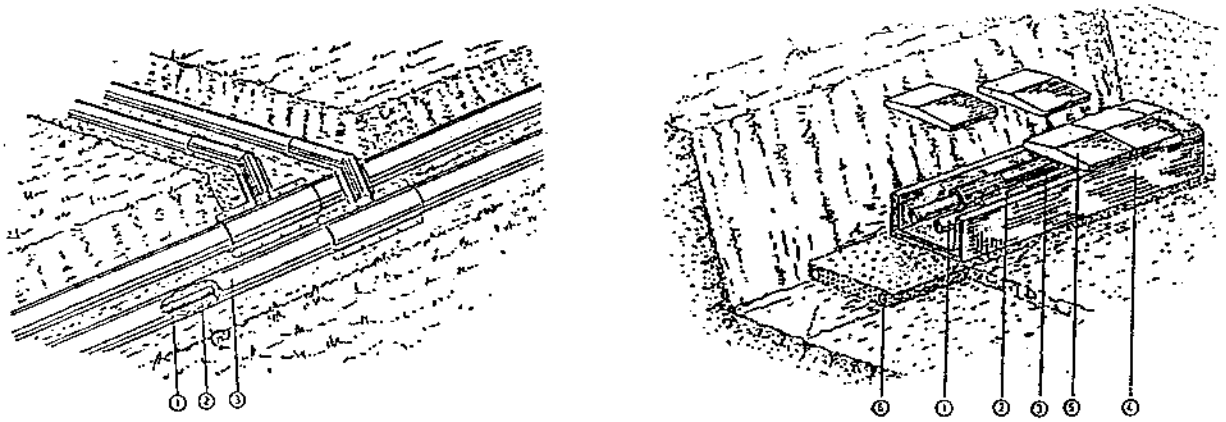
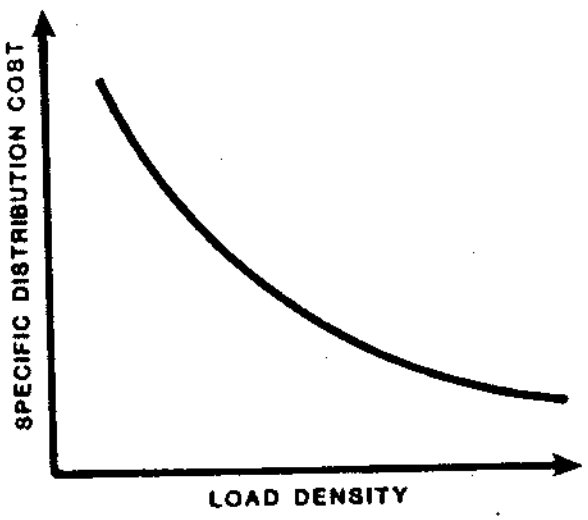


Figure 1-5

Typically, hot water system operating temperatures range from 190°F (when the outside temperature is relatively warm) to 250°F (when the temperature is below zero). Of course, the supply and return temperatures will vary from system to system based upon end-user requirements. With cogeneration, district heating supply temperatures are reduced during the summer months in response to reduced thermal energy demand, and to compensate for the increased electric power demand during this season of the year.

The design of DHC piping must account for several factors which influence the overall utility of the system. In general, a high design temperature for the hot water supply reduces the required water flow rate and pipe dimensions for a given return water temperature, and also provides a potential advantage for consumers with existing low-pressure steam heating systems. A low design temperature, on the other hand, enables the cogeneration plant to generate more electricity for a given heat supply, reduces the design pressure required for the system, and allows less expensive piping and insulation to be used.



Graph 1-3

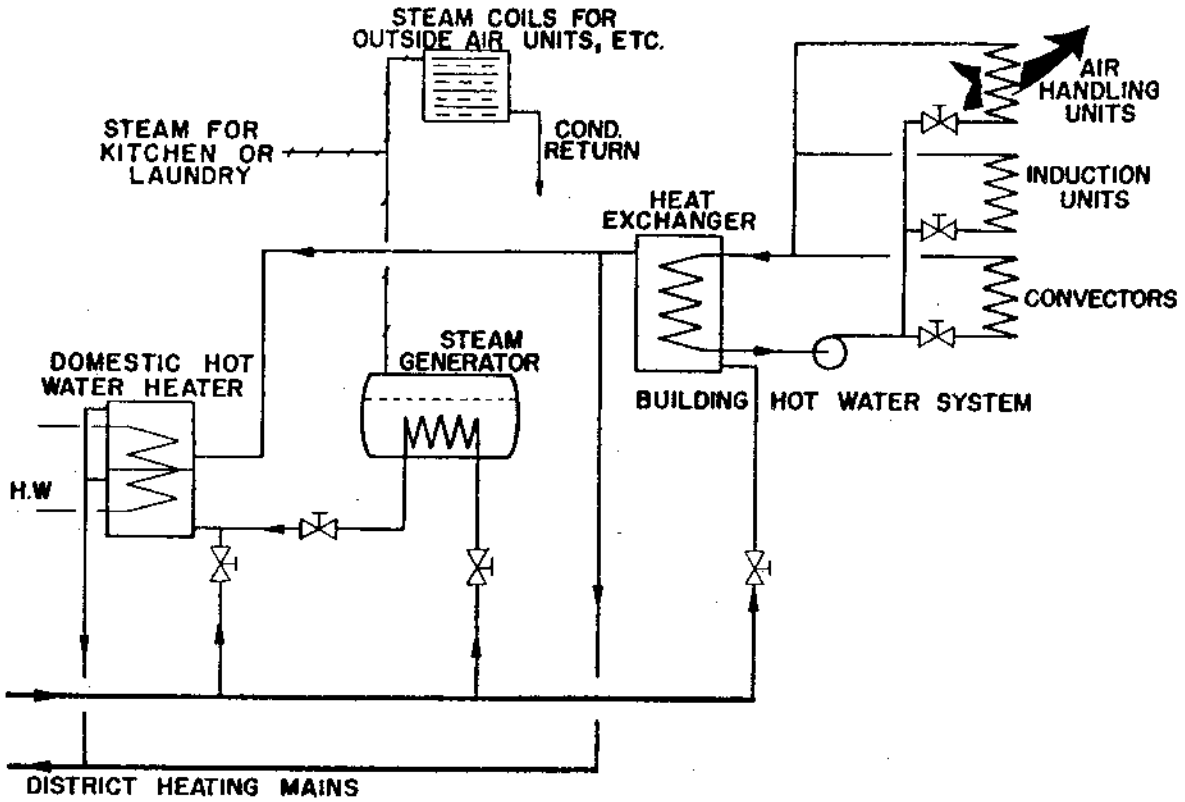
Distribution system economics are important in determining service areas of new and expanding DHC systems. The relationship between load density and piping cost influences the selection of particular heat islands within a community in order that a profitable energy system can be developed.

End-Use System

The final component of a DHC system is the end-use system. The end-users of energy, whether a residential community, commercial buildings, an industrial park, or a combination of these, must be considered in the design, construction, financing and rate making of the system. The system owner/-developer will place emphasis on providing utility services at rates that are economically attractive to consumers, and "price-stable"; i.e., consumers can expect that their energy expenditures will represent a relatively constant share of their total budget.

The attractiveness of district energy systems to the end-user is based on the following system attributes:

- Increased efficiency through economies of scale and use of combined heat and power production equipment.
- Lower installed cost for large groups of commercial, office, residential, and institutional buildings.
- Lower cost fuel use such as coal or heavy fuel.
- Building space savings realized due to decreased needs for boilers and associated equipment in individual buildings.
- Reduced maintenance costs resulting from centralized equipment and a trained system maintenance staff.
- Reduced environmental effects resulting from shifting emissions to controlled point sources.



LARGE COMMERCIAL OR INSTITUTIONAL BUILDING PIPING SCHEMATIC

Figure 1-7

1.5 DHC SYSTEM OWNERSHIP

There are three basic ownership arrangements: all private, all public, and combination of private-public ownership. Within these three basic arrangements there are numerous variations that will be decided on locally. The final arrangements will be based on each city's or utility's needs, financial capability, and legal and regulatory limitations.

Although single owner situations will occur, it is likely that many ownership arrangements will involve some sort of partnership between local governments and companies with each owning or financing parts of the system. Joint ownership will often be considered given the capital intensity of DHC systems, the anticipated high rates associated with private borrowing, and the

complexities inherent in community retrofit. Ownership configuration of a particular district energy system may change over time as the system grows and heat islands are connected. The following matrix presents the local system components and the more common system owners.

OWNERSHIP ALTERNATIVES

	Utilities	Cities	Entrepreneurs	Special Districts	Community Corporations	Building Owners
Production Facilities						
Distribution Systems						
End-User Equipment						

Figure 1-8

Since each potential component owner has different goals and is motivated by different rewards, each will treat system component ownership differently based on individual purposes, goals and priorities, and motivations.

1.6 FORCES MOTIVATING DISTRICT HEATING AND COOLING DEVELOPMENT

Throughout the United States there are dozens of companies, entrepreneurs, institutions, regulatory agencies, governments, industries, and interests groups that are interested in the wide-spread application of district heating and cooling. The number and characteristics of DHC beneficiaries vary from community to community depending upon various system configurations utilized on a site-specific basis. As there are multiple beneficiaries of accelerated implementation of DHC, there are also numerous motivating or driving forces underlying DHC efforts.

The implicit motivating force is of course, financial gain. Just as all corporations' implicit goal is to optimize profit, so do all DHC interest groups anticipate financial gain. The implicit financial gain motive affects entrepreneurs, utilities, customers, industry, suppliers, fuel companies, special interest groups, and local, state and federal governments. Characterizing DHC motivation as strictly financial gain would be as overly simplistic as identifying profit to be the sole goal of a farmer or as characterizing IBM's only goal to be quarterly dividend payments.

Depending upon the specific mission and perspective, there are nearly infinite permutations available to identify, organize and discuss the forces driving DHC development. Many of these forces are not independent of one another, thus further complicating their consideration, organization and discussion. Seven primary forces motivating DHC development have been identified for purposes of evaluating DHC status and trends in the United States--evaluating and testing the results of program efforts to date--and for considering future policy direction. These forces are:

- energy efficiency
- energy prices
- indigenous resources
- entrepreneural opportunity
- environmental quality
- security
- cities and states

A brief discussion of these DHC forces follows. The evaluation presented in the following chapters and evaluates DHC efforts accordingly.

Energy Efficiency

Fuels are consumed in the United States through combustion processes with varying efficiencies. For instance, a typical forced air gas furnace operates

with an annual cycle efficiency of between 60 and 70 percent while a coal-fired boiler may operate with an annual cylce efficiency of approximately 75 to 80 percent.

The electric generation component of the energy economy accounts for a substantial portion of U.S. energy consumption. In 1984 it is estimated that U.S. electric generation will require primary fuel input of 26.2 quads in order to deliver 7.8 quads of useful electricity. This results in a 30 percent fuel use efficiency.

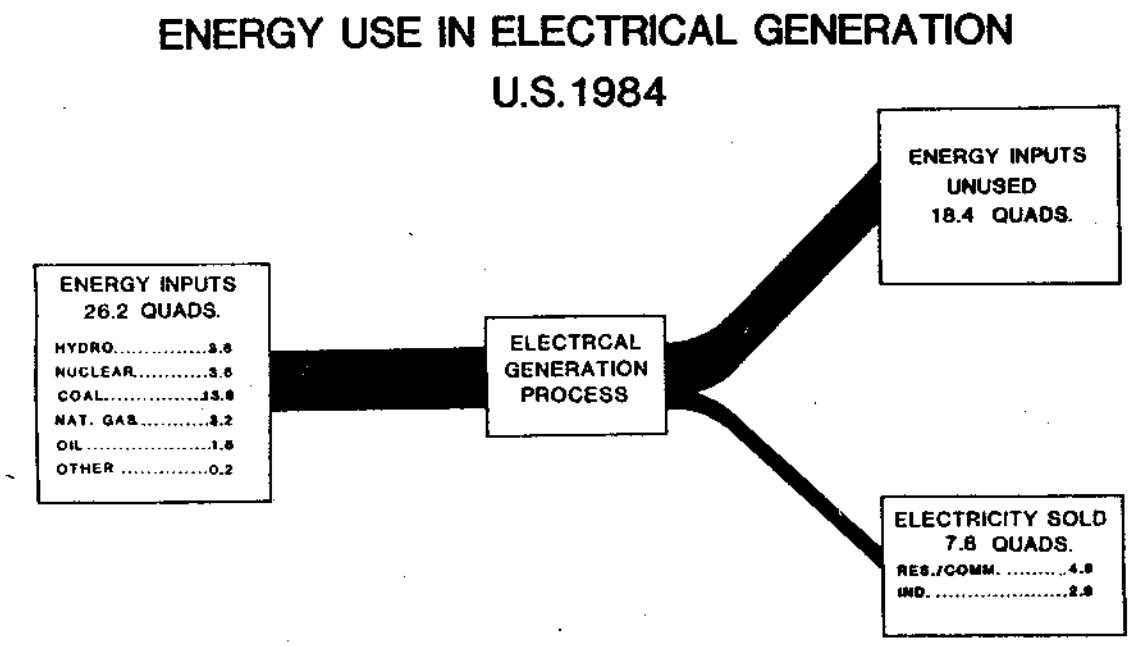


Figure 1-9

Current forecasts indicate that without unrealistic technological breakthroughs such as photo voltaic cells or without the large-scale implementation of cogeneration the near exclusive reliance on condensing generation will change significantly in the future.

Table 1-3

	PRIMARY FUEL INPUT (QUADS)	ELECTRIC SOLD (QUADS)	EFFICIENCY	ENERGY WASTED
1984	26.2	7.8	30%	70%
2010	50.3	15.2	30%	70%

To date, most cogeneration development has focused on the industrial sector by encouraging the use of combined heat and power in such industries as pulp and paper and petrochemical. These cogeneration applications rely upon one thermal customer that may consume the electricity on-site or alternatively sell the electricity to the grid. The cogeneration industry forecast estimates that the U.S. will have approximately 16 million KW of industrial cogeneration capacity in place by the end of 1984. The cogeneration industry expects that this capacity could climb to approximately 39 million KW by the year 2000. Under this scenario cogeneration will account for an extremely small fraction of the U.S. electrical requirement in 1984 and an even smaller fraction in the future.

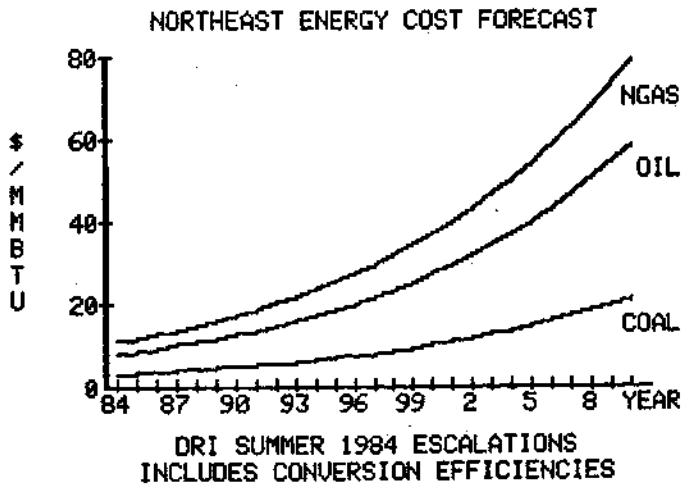
The major barrier facing cogeneration is the availablity of thermal markets. Cogeneration projects implemented to date and those anticipated in the near term, are single customer systems where an individual or specific customer, such as a pulp and paper mill, has a high process heat load, i.e., energy required for industrial use. For combined heat and power to contribute substantially to the U.S. electric demand, larger stations connected to DHC systems must be implemented.

Energy Prices

Substantial discussion and debate surrounds the future of energy supplies. Following the 1970 period of shortages and precipitous price increases, the U.S. did implement significant energy conservation measures. By far the largest portion of this energy conservation savings was captured in the industrial

sector. Many analysts conclude that the "easy" conservation measures were captured during the late 1970's and early 1980's in the industrial sector and anticipate marginally lower conservation savings in the future.

Energy forecasts developed in the mid 1970's predicted rather precipitous price increases compounding well into the future. Forecasts today call for continued energy conservation, international stablity, and adequate oil supplies. These forecasts predict modest increases in energy prices. However, even these modest price forecasts concern consumers. This concern is sharply focused as cities, states, entrepreneurs and energy consumers evaluate their energy price future under gas or oil scenarios verses solid fuels. Accordingly, DHC can help stabilize heating and cooling costs for residential consumers, businesses, and industries by insulating them from the uncertainties of increasing fuel prices.


NORTHEAST ENERGY COST FORECAST
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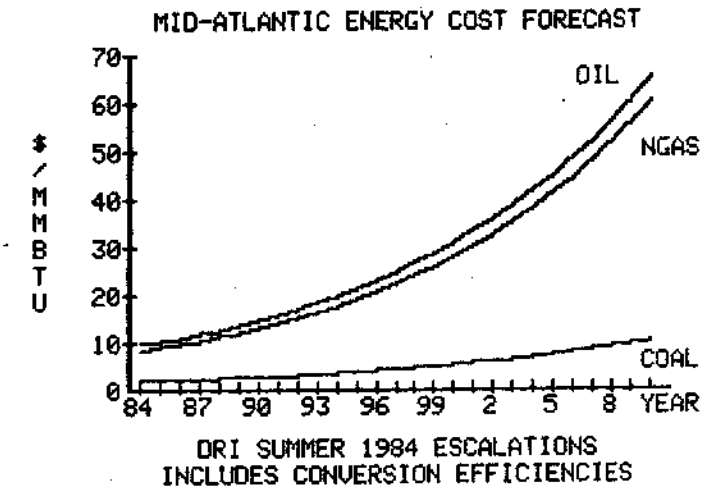
MID-ATLANTIC ENERGY COST FORECAST
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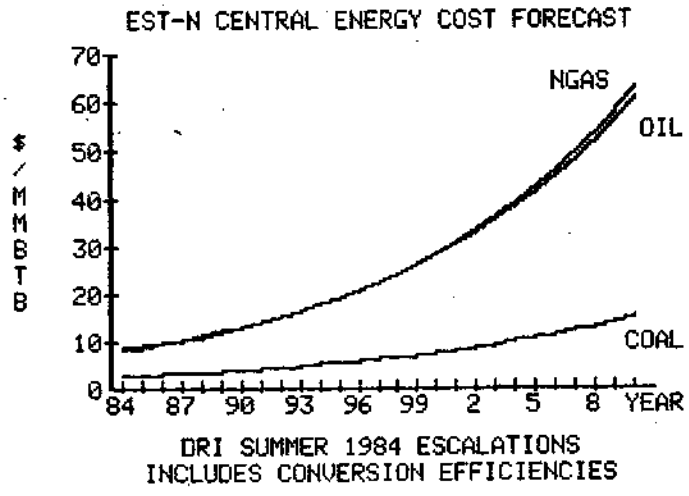
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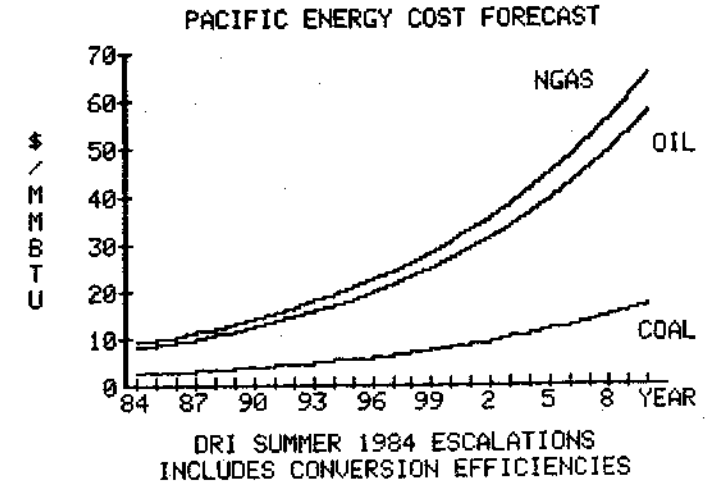
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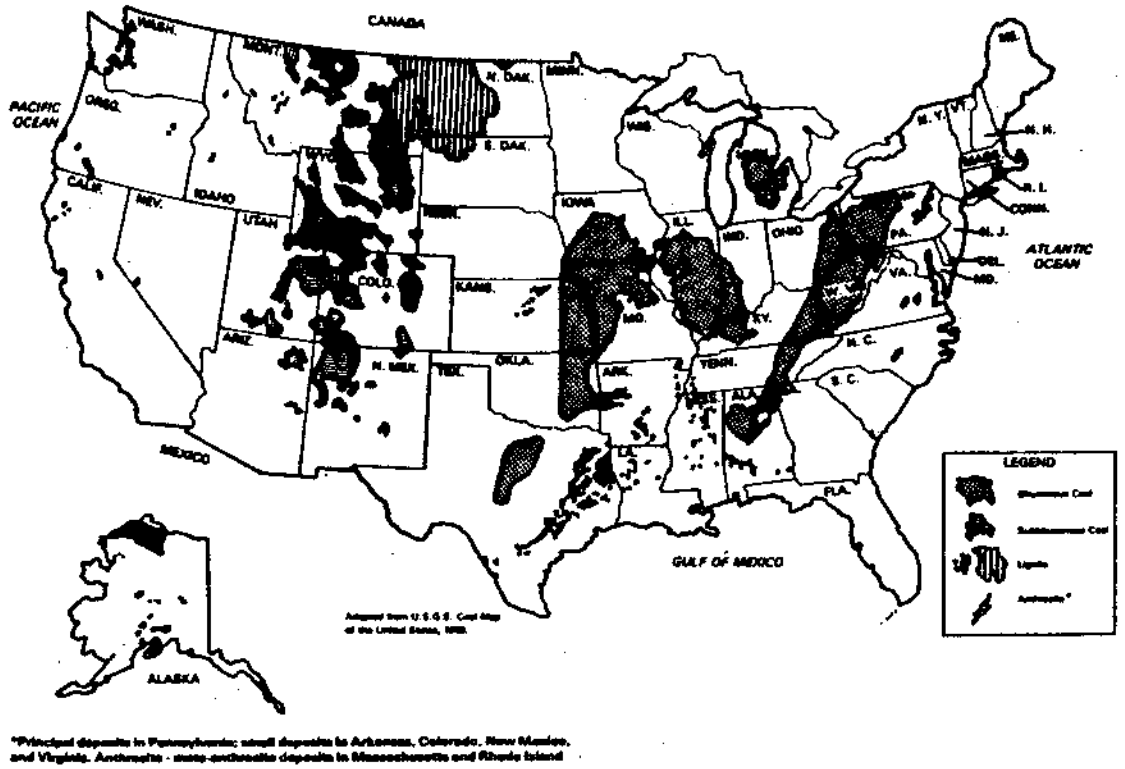
DRI SUMMER 1984 ESCALATIONS
INCLUDES CONVERSION EFFICIENCIES

Graph 1-4

Indigenous Resources

The thermal loop diagram (section 1.2, page 1-6) illustrates DHC's inherent fuel or energy source flexibility. All parties interested in multi-sectoral DHC development recognize that the installation of a thermal distribution network will provide urban areas the ability to burn oil and natural gas, and non-scarce, solid fuels in an environmentally sound manner. DHC system developers recognize the advantage of utilizing fuels which are available in the United States and more specifically in their states or regions. Further, and most importantly, the thermal distribution network will allow energy as opposed to fuels, to be bought and sold as a commodity in the community. State and local proponents of DHC view its implementation as, an important step towards the retention of funds and the improvment of the area's "net balance of trade". Consequently, state and local DHC proponents invariably look toward the future reliance upon locally indigenous resources. Energy sources of recently initiated DHC systems (operational, under construction, or final design/packaging) include:

- coal
- municipal solid waste
- natural gas
- wood
- straw
- geothermal



COALFIELDS OF THE UNITED STATES

SOURCE: U.S.D.O.E. "Coal Data: A Reference" July, 1980; DOE/EIA-0064(80)

Map 1-2

Entrepreneural Opportunity

Current DHC developments utilize a variety of ownership schemes depending upon the project specific characteristics. Ownership schemes employed today include :

- utilities (investor and municipal)
- non utility corporations
- authorities
- cooperatives
- joint ventures

Ownership schemes vary depending upon the regulatory environment, specific project components, benefit cost allocation requirements, local leadership, and community interests.

DHC development during the 1970's and early 1980's identified the opportunity for private investment in the entire system, e.g., Trenton New, Jersey; or in various systems components such as the energy generating station in Baltimore, Maryland.

The adoption of DHC in communities nationwide presents new opportunities for private enterprise and creates opportunities for business to capture markets and utilities to retain urban energy markets by increasing efficiency (and thereby reducing energy cost increases). District heating and cooling permits expansion and diversification of utility markets in several ways. Energy prices have affected the demand for utility services. As conservation has become a reality, many electric utilities have curtailed expansion plans, and existing plant capacity is often under-utilized in many service areas. Using electrical generation plants for cogeneration district heating and cooling will help to improve plant efficiency.

District heating and cooling systems can be designed around existing heating and cooling equipment. Therefore, they can provide markets for energy conversion equipment of all types, waste and heat recovery systems, and specilized equipment such as heat pumps and heat exchangers. They would also provide huge markets for the steel piping, insulation, and plastics industries.

Environmental Quality

DHC systems permit the maintenance of environmental quality where otherwise might be difficult to do so. The several environmental advantages of DHC include higher total energy output per unit of emissions; the replacement of multiple, point source individual boilers with central generating facilities which are equipped with modern emission control equipment; and substantially reduced thermal pollution of service water.

Utilities switching from oil to coal will find state-of-the-art emission control systems to be significantly more cost effective as the cost is spread to thermal customers as well as electric customers. In addition the use of urban waste as a fuel source for DHC systems reduces the problems associated with urban land fill operations.

Security--National and Local

National, state and city leaders all have an interest or stake in energy availability. Analysis and evaluation of previous "energy crises" clearly indicate that the U.S. experienced interruptions of fuel supplies or fuel shortages as opposed to energy shortages. Problems arising during these shortages were related to the supply allocation, and distribution of liquid and gaseous fuels, not energy. During these periods the massive coal reserves of the United States stood in stark contrast to gas lines, natural gas connection moratoriums, and other serious disruptions.

DHC's inherent fuel flexibility coupled with the availability of coal, urban waste and wood represents an important motivation for DHC system developers, energy consumers, industrial interests, and government officials. DHC related reductions in scarce fuel consumption translates directly into reduction of U.S. reliance on foreign imports and the strategic vulnerability associated with this continuing dependence. Reducing oil imports also brings balance of trade advantages to the U.S.

As the U.S. moves toward greater use of non-scarce, domestically available, solid fuels and waste heat, states and urban centers also profit from the reduced dependence upon uncertain or undependable sources. DHC offers cities the ability to insure industry and business reliable energy supplies at stable prices.

Private and public customers receiving district heating and cooling service will legitimately anticipate dependable energy service from the DHC system and avoid unexpected, destabilizing business interruption.

State and City Incentives

States and Cities accrue benefits from the development of district heating and cooling systems including enhanced industrial and urban development potential, increased job opportunities, energy price stability, and maintenance of environmental quality. District heating and cooling systems can aid industrial growth and business expansion in both older established areas and new growth areas. DHC can be an important element in a community's economic revitalization strategy. Coupled with overall redevelopment plans, the DHC system will serve to attract an array of new business into the city. by providing a magnet to retain local firms and attract new business by reducing energy cost increases.

Encouragement of the adoption of DHC in commercial and industrial areas of U.S. cities and towns will have significant economic benefits. The presence of the DHC system in a central business district or industrial area makes the area more attractive to potential investors and helps stabilize, if not revitalize, many older, delcining areas. These areas will eventually depend less on financial support and may once again become self-sustaining, thereby relieving the need for state, local and federal remedial action to address issues arising from the loss of urban economic vitality.

DHC is expected to create many private sector jobs in the very areas where they are most needed. These jobs include skilled, semi-skilled and general labor which will be availiable on a continuing basis over many years thus further reducing the need for federal job programs.

Chapter 2
DHC STATUS, TRENDS AND PLANS: EUROPE AND THE U.S.

2.1 AN OVERVIEW

2.1.1 General Status

The general purpose of Chapter 2 is to evaluate DHC's status, trends and plans both in the United States and Europe. More specifically, the purpose is to establish a base line for policy consideration and evaluation.

This presentation was organized to:

- determine where DHC has been
- determine where DHC is going
- compare DHC in the United States with other western industrialized nations
- evaluate current DHC projects, programs and plans

The diverse nature of district heating and cooling along with the inherent difficulties of multi-country comparisons requires several qualifications and a couple of ground rules. First, consistent, uniform quantification of DHC among the various countries is difficult because of disagreement over the definition of DHC and what is to be included in data keeping. Second, information and data keeping practices vary among the countries. Third, to date, no serious attempt has been made in the United States to establish a DHC definition for data collection purposes or to accurately assemble data regarding DHC systems regardless of the exact definition. Finally, units of measure used to quantify DHC vary from country to country. In the United States district heating statistics are generally maintained and presented in pounds (thousands of pounds of steam), MMbtu's (millions of British Thermal Units), or tons (air-conditioning or chilling tons). Europeans generally, quantify district heating in MWth (Mega Watt hours -Thermal). Fuel consumption and scarce fuel savings are typically expressed in terms of quads (quadrillion Btu's) or barrells of oil in the United States. International comparisons are often

translated into and expressed in terms of Mtoe (Million tons of oil equivalent). The following analysis makes no attempt to adjust for the various units of measure.

The following discussion draws upon information and data from many sources both in the United States and Europe but one important publication deserves special recognition DISTRICT HEATING AND COMBINED HEAT AND POWER SYSTEMS; A TECHNOLOGY REVIEW is by far the most thorough, comprehensive and international assessment conducted to date. DISTRICT HEATING was prepared and published by the International Energy Agency (IEA) in 1983. IEA is an autonomous body established in 1974 within the framework of the Organization for Economic Co-operation and Development (OECD). IEA carries out a comprehensive program of energy cooperation among 21 of the OECD member countries. The U.S. Department of Energy is an active IEA participant and assisted in the preparation of DISTRICT HEATING. Both the international and U.S. analysis presented below draws heavily upon this important publication; however, it should be noted that the U.S. DHC data given in DISTRICT HEATING is probably the most incomplete of all countries presented. (Through no fault of IEA.)

The energy characteristics, resources and consumption vary among the countries of Scandanavia, Europe and the United States. Traditionally, Scandanavian countries, e.g. Denmark, Sweden and Finland are oil dependent while Germany utilizes domestically available coal to a larger extent. Tables 2-1 and 2-2 summarize the primary energy supply characteristics of many IEA countries.

Table 2-1

PRIMARY ENERGY SUPPLY (Mtoe) - (1981)[1]

	OIL	GAS	SOLID FUELS	HYDROELECTRICITY, NUCLEAR AND OTHER	TOTAL	ELECTRICITY PRODUCTION (TWH)
Austria	11.2	4.2	4.9	7.2	27.5	42.9
Belgium	18.4	8.4	11.1	3.4	41.3	50.8
Denmark	10.7	0	7.0	0	17.7	19.8
Finland	10.7	0.6	2.3	10.9	24.5	39.1
Germany	113.1	41.7	88.9	17.7	261.1	368.8
Ireland	4.9	1.2	2.1	0.3	8.5	10.9
Netherlands	24.3	29.5	5.1	0.8	59.7	64.1
Norway	8.0	0.8	1.4	13.9	24.1	92.8
Sweden	20.6	0	5.3	22.9	48.8	102.7
United Kingdom	70.8	41.6	69.5	10.9	192.8	277.7
United States	744.1	484.2	359.8	143.1	1,767.2	2,472.7

1. Excludes stock changes

Sources: Energy Policies and Programmes of IEA Countries - 1982 Review, OECD Paris, 1983; Energy Review 2, 1982, Energy Department, Helsinki 1982

Table 2-2

ENERGY SOURCES FOR THE RESIDENTIAL AND COMMERCIAL SECTORS (1981)

	FUEL MIX (%)					
	OIL	SOLID FUELS	GAS	ELECTRICITY	OTHER	TOTAL
Austria	37	24	13	22	4	100
Belgium	49	8	30	13	0	100
Denmark	67	5	1	17	10	100
Finland[1]	50	29	1	20	0	100
Germany	51	7	20	18	4	100
Ireland	32	50	2	16	0	100
Netherlands	11	1	76	12	0	100
Norway	30	8	0	62	0	100
Sweden	58	5	1	27	9	100
United Kingdom	18	14	46	22	0	100
United States	29	1	44	26	0	100

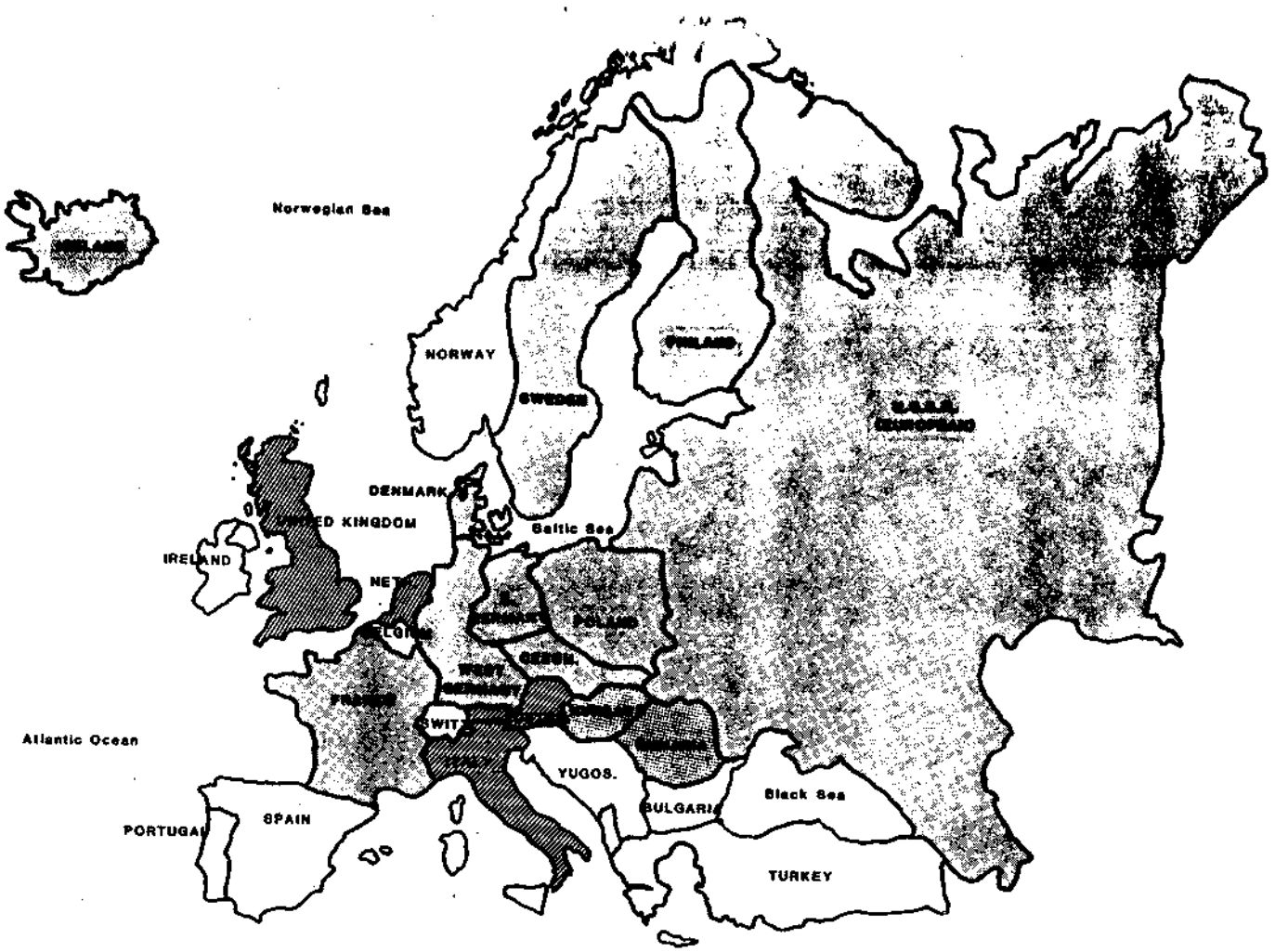
1. 1980

Source: Energy Policies and Programmes of IEA Countries - 1982 Review, Paris 1983; OECD Energy Balances, Paris 1982.

As indicated above, the IEA district heating analysis conducted in 1983 represents the most thorough and comprehensive comparative analysis of DHC conducted to date in the United States and Europe. Consequently, the following summary discussion has been excerpted directly from DISTRICT HEATING AND COMBINED HEAT AND POWER; A TECHNOLOGY REVIEW.

U.S. observers and decisions makers should excerise certain caution regarding the comparative statistics of installed DHC and combined heat and power as presented in the following tables. The reader will note that only the statistics presented for Norway and the U.S. are estimates. Norway, with limited installed capacity has little reason to closely monitor DHC CHP development. The United States, on the other hand, estimates substantial DHC development yet little documentation for this exists. The 40,000 MWth figure represents the best estimate assembled from various sources. The 40,000 MWth estimate is as good as any number currently available and is certainly as accurate as 38,000 or 42,000 MWth. A complete discussion of the current U.S. DHC status is presented in a following section of this report.

> Market penetration [of DHC] in relation to total space heating needs is very high (up to 42%) in some countries, particularly Denmark, Finland and Sweden. In absolute terms, the greatest impact of district heating has been in the larger countries, Germany and the United States. Consumer attitudes are generally favorable in these countries, with the exception of the United States, where consumer attitudes are more neutral. Heat prices are generally competitive with alternative heating options for existing systems, except for some steam district heating systems in the United States.
>
> In countries, such as Austria and the Netherlands, the impact of district heating has been moderate. In other countries, including Belgium, Ireland, Norway and the United Kingdom, the impact of the technology has been small.



DISTRICT HEATING IN EUROPE

Countries with wide-spread DH&C service

Countries with moderate DH&C service

Countries with limited DH&C service

Map 2-1

Total installed heat production capacity for district heating in the IEA region (including Finland) is estimated to be 122,000 MWth (Table 2-3), mostly concentrated in Denmark, Finland, Germany, Sweden and the United States. Installed capacity in Europe is 82,000 MWth, together with 40,000 MWth in the United States. Combined production linked to district heating systems is very prevalent in Europe and accounts for 36% of installed heat capacity. In the United States, the extent of combined production linked to district heating is negligible.

The total annual primary energy input for combined production is about 10 Mtoe (million tons of oil equivalent), over half (56%) of which is coal. Oil accounts for 20% and gas (at 19%) and others (at 5%) account for the remainder. In the case of heating-only plants, total annual primary energy inputs are approximately 15.3 Mtoe, consisting of oil (55%), natural gas and coal (each at 20%), and others (5%).

The extent to which district heating is based on combined production is negligible in the United States, moderate in Sweden, and high in all other countries considered. In the case of Sweden this is caused by under-utilization of existing capacity, due to electricity generating over-capacity, and the low price of electricity [large percentage hydroelectric] which render combined production based on oil uneconomic for electricity generation. For the United States the regulatory climate as well as the main type of consumer (university and defense establishments, without major power needs) have deterred the development of combined systems.

Table 2-3

IMPACT OF DISTRICT HEATING AND
COMBINED HEAT AND POWER SYSTEMS (1981)

	Installed Capacity			
	District Heating			
Country	Heating-only (MWth)	Combined Production (MWth)	Total (MWth)	Industrial Combined Production (MWe)
Austria	2,100	900	3,000	-
Belgium	741	193	934	-
Denmark	12,000	1,800	13,800	-
Finland	5,163	3,964	9,127	5,485
Germany	9,950	21,050	31,000	8,600
Netherlands	991	556	1,547	1,400
Norway	50[1]	50[1]	100	-
Ireland	-	-	-	50
Sweden	12,800	4,000	16,800	1,200
United Kingdom	5,707	93	5,800	2,500
United States	40,000[1]	-	40,000	14,900
Total	89,502	32,606	122,108	34,135

1. Estimate

As shown in Table 2-4 the existing installed capacity of district heating and combined heat and power systems (excluding industrial-on-site-combined production systems) result in significant energy savings, of 5.2 Mtoe of primary energy annually for the countries concerned. This represents 0.2% of total primary energy supply, or import savings of about US$1bn annually.

A comparison of Tables 2-3 and 2-4 indicates the relatively large contribution towards energy savings accounted for by combined production, compared to installed heating-only capacity, even allowing for the many heating-only plants which are used only for peaking and reserve purposes.

Clearly the energy saved in each country depends on the magnitude of installed capacity as well as on the relative share of capacity accounted for by combined production systems. In absolute terms, the savings are larger for Germany and the United States. In the case of Germany, the svaings are attributed mainly to the high proportion of district heat supply accounted for by combined production. For the United States, with negligible combined production capacity, the savings are attributed to the combination of the large heating-only capacity and the efficiency gains of centralized heating-only installations, compared to individual furnaces. In percentage terms, the greater impact is in Denmark and Finland. Significantly these are also the countries in which, together with Germany, amajor part of district heat supply is generated from combined production.

Table 2-4

ESTIMATED ANNUAL ENERGY SAVINGS FOR EXISTING DISTRICT HEATING AND COMBINED HEAT AND POWER CAPACITY[1] (1981)

Country	From Combined Production	From Heating-Only	Total	Total Primary Energy Supply (Mtoe)	Total Energy Savings as a Share of Primary Energy Supply (%)
Austria	0.10	0.05	0.15	26.3	0.6
Belgium	0.02	0.02	0.04	43.6	0.1
Denmark	0.43	0.38	0.81	17.3	4.7
Finland	0.34	0.09	0.43	25.1	1.7
Germany	1.62	0.17	1.79	262.9	0.7
Netherlands	0.43	-	0.43	61.9	0.7
Norway	-	0.005	0.005	24.2	0.02
Sweden	0.08	0.35	0.43	50.2	0.9
United Kingdom	-	0.14	0.14	194.5	0.07
United States	-	0.99	0.99	1,768.2	0.06
Total	3.02	2.05	5.21	2,474.2	0.2

1. Excludes industrial combined production capacity.

The impact of oil-substitution is shown in Table 2-5. The Table provides an assessment of the extent to which existing district heating and combined heat and power plants have displaced oil for heating purposes in the countries concerned. Due to the lack of information of fuel mixes etc., industrial combined production systems are excluded. Oil-substitution, in the context of district heating, is attributed to heat production from heating-only or combined production plants based on fuel sources other than oil (coal, natural gas, peat, wood waste etc.); the efficiency gains of centralized heating-only or combined production plants based on oil-firing, compared to individual oil-fired units; and heat recovered from industry, waste incineration, or other low-grade sources which would otherwise have been produced by individual oil-fired heating units.

Table 2-5

ESTIMATED ANNUAL OIL-SUBSTITUTION IMPACT OF EXISTING DISTRICT HEATING AND COMBINED HEAT AND POWER CAPACITY (1981)[1]

Country	Impact of Oil Substitution (Mtoe)	Share of Total Primary Energy Supply (%)
Austria	0.29	1.1
Belgium	0.11	0.3
Denmark	1.53	8.8
Finland	1.13	4.5
Germany	5.38	2.0
Netherlands	0.30	0.5
Norway	0.01	0.05
Sweden	0.89	1.8
United Kingdom	1.06	0.5
United States	4.81	0.3
Total	15.56	0.6

1. Excludes industrial combined capacity.

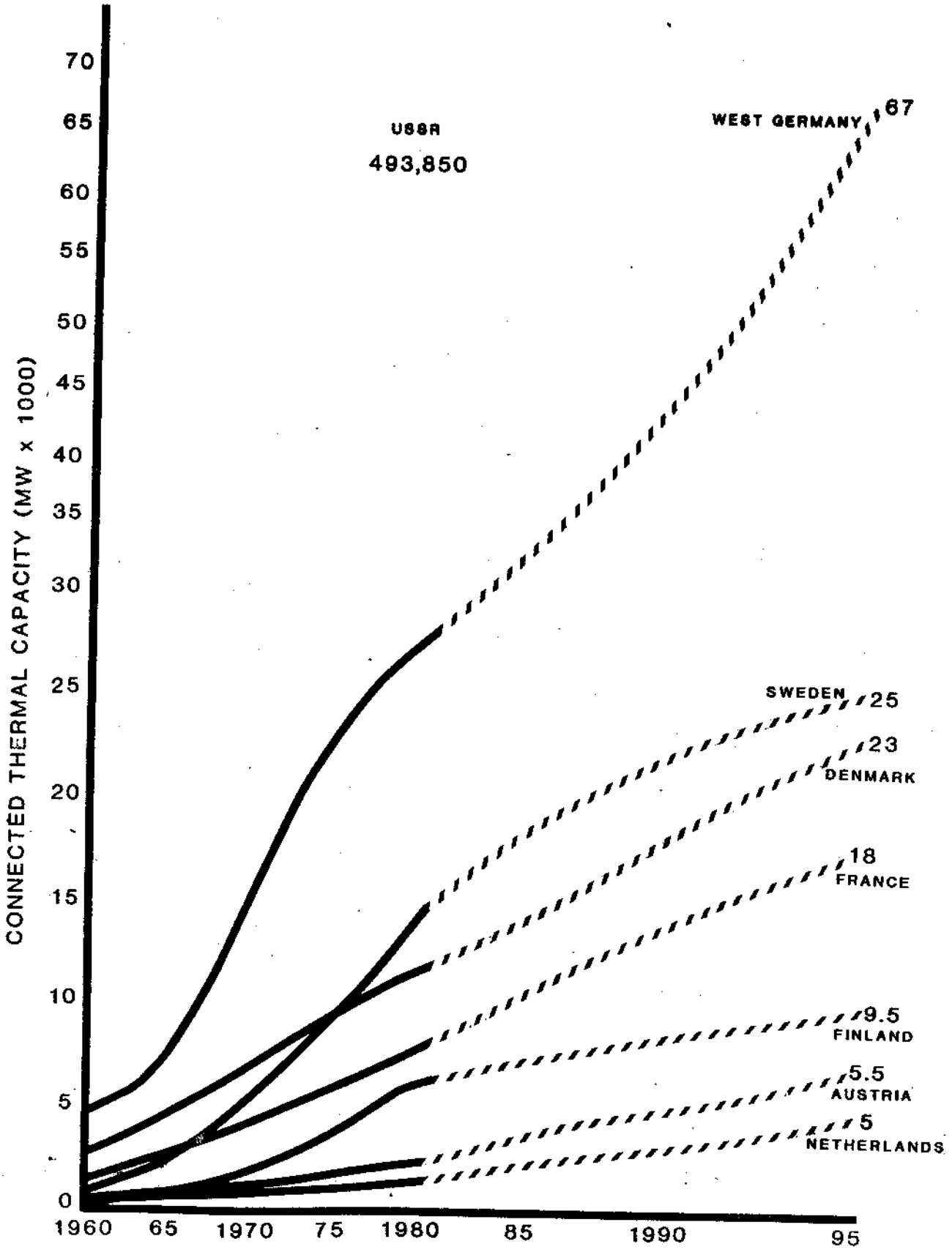
The oil-substitution impact, at 15.6 Mtoe of primary energy annually, is much greater than the effect of energy conservation alone, particularly for those countries with large combined production capacities based on coal (Denmark, Finland and Germany), or heating-only plants based on coal (Denmark and the United Kingdom), as well as those with extensive use of natural gas for either heating-only plants or combined produciton units (Austria, Germany, Netherlands and the United States).

2.1.2 European Country Illustrations: Status and Plans

Previous discussion clearly illustrates the modest penetration of district heating and cooling in the United States compared to Europe in general. Although, the European DHC overview is interesting and documents the extensive nature of DHC development, it begs the question--How are European countries proceeding with DHC development and what do they intend to do in the 1980's and 90's?

The following discussion briefly summarizes DHC status, trends and plans of several European countries. It is not an exhaustive analysis of each country. The reader is encouraged to review two recently published reports which deal extensively with district heating and cooling in Europe. First, THE ROLE OF DISTRICT HEATING AND COOLING IN THE UNITED STATES, prepared during 1984 and published in January, 1985, by the National Academy of Science, National Research Council. The second, which is quoted extensively below, is the previously sited work by the International Energy Agency, DISTRICT HEATING AND COMBINED HEAT AND POWER SYSTEMS A TECHNOLOGY REVIEW, 1983.

As might be expected, European countries have ambitious plans for DHC development well into the 1990's. On the basis of available information, projected DHC installed capacity is expected to increase from 82,000 MWth in 1981 to over 170,000 MWth by the early 1990's. This represents a 109 percent increase. The projection does not include industrial combined heat and power (cogeneration) production capacity which is expected to double during the same period. The following tables and graphs document and summarize European DHC plans into the 1990's.



Existing and Proposed DHC Installed Capacity

Graph 2-1

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Table 2-6

IMPACT OF DISTRICT HEAT AND COMBINED HEAT AND POWER SYSTEMS - II (1981)

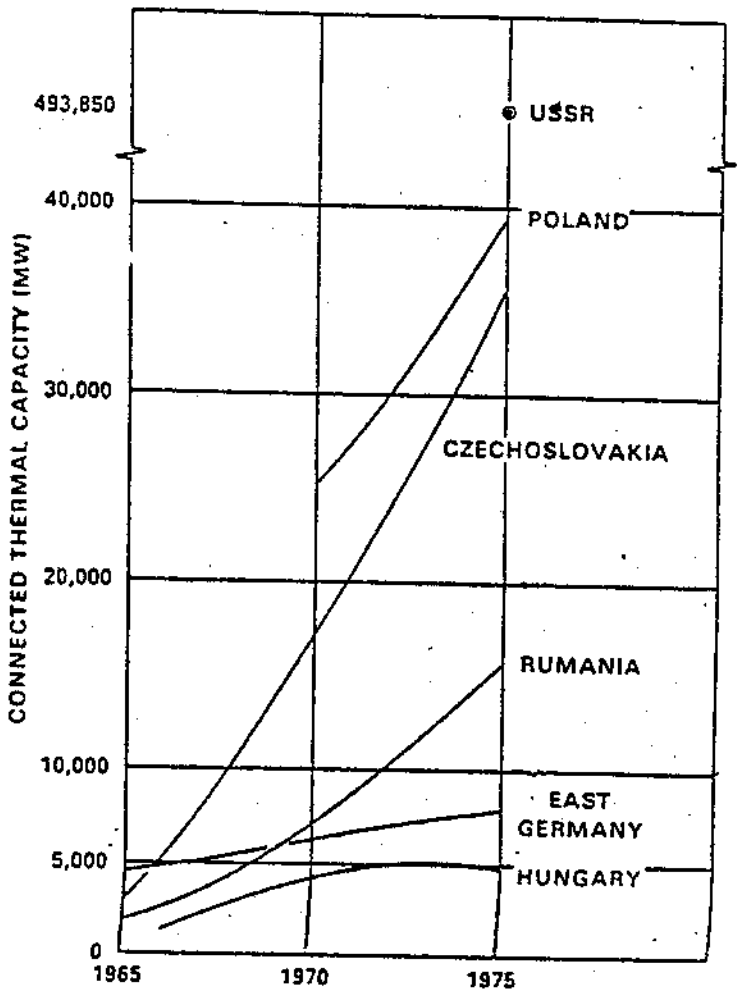
COUNTRY	EXISTING PENETRATION	PROJECTIONS FOR EARLY 1990'S: INSTALLED CAPACITY OF DISTRICT HEATING (MWth)	CONNECTED LOAD (MWth)	INDUSTRIAL COMBINED CAPACITY (MWe)
Austria	-4% of low-temperature end-use energy needs	5,500	-	-
Belgium	-0.4% of useful energy demand for residential space and water heat	1,059	3,530	-
Denmark	-42% of final energy consumption for the residential and commercial sectors -40% of space heating needs in the residential and commercial sector -30% of single-family dwellings -50% of multi-family dwellings -0.76 million dwellings	23,000[1]	-	-
Finland	-8% of total primary energy -23% of space heating needs in the residential and commercial sectors and 38% in the industrial sector	-	9,500	5,500
Germany	-4-5% of residential and commercial energy demand -1.5m apartments -1.7m non-residential buildings -16% of space heating needs in large cities (population above 100,000) -2% of space heating -2% of space heating needs in medium-sized cities (population 10,000-100,000) -7% of low-temperature heat demand	-	67.000[3]	16,000
Ireland	-	-	-	100-150
Netherlands	-	5,000	-	2,500
Norway	-	100	-	-
Sweden	-27% of space and water heating demand -47% of multi-family dwellings -3% of single-family dwellings -16% (by volume) of public and commercial buildings	-	25,000	1,200
United Kingdom	-1-2% of space heating demand	23,000[2]	-	2,000-3,000
United States	-1.5% of total primary energy -4% of space and water heating demand	130,000-200,000[2]	-	33,000

1. Including 1,800 MWe of combined production capacity;
2. Long-term technical potential only; this is not a market projection;
3. Mid-point of estimated range, 56,000-78,000 MWth

Documenting Eastern European district heating development and program plans is extremely difficult due to the lack of data and information. The Soviet Union is, by far, the current world leader in the use of district heating with almost 500,000 MW of installed capacity, 70 times that of the United States. Other European countries having extensively developed DHC networks include: Poland, Czechoslovakia, Romania, East Germany and Hungary.

Graph 2-2

DEVELOPMENT OF DISTRICT HEATING IN EASTERN EUROPE

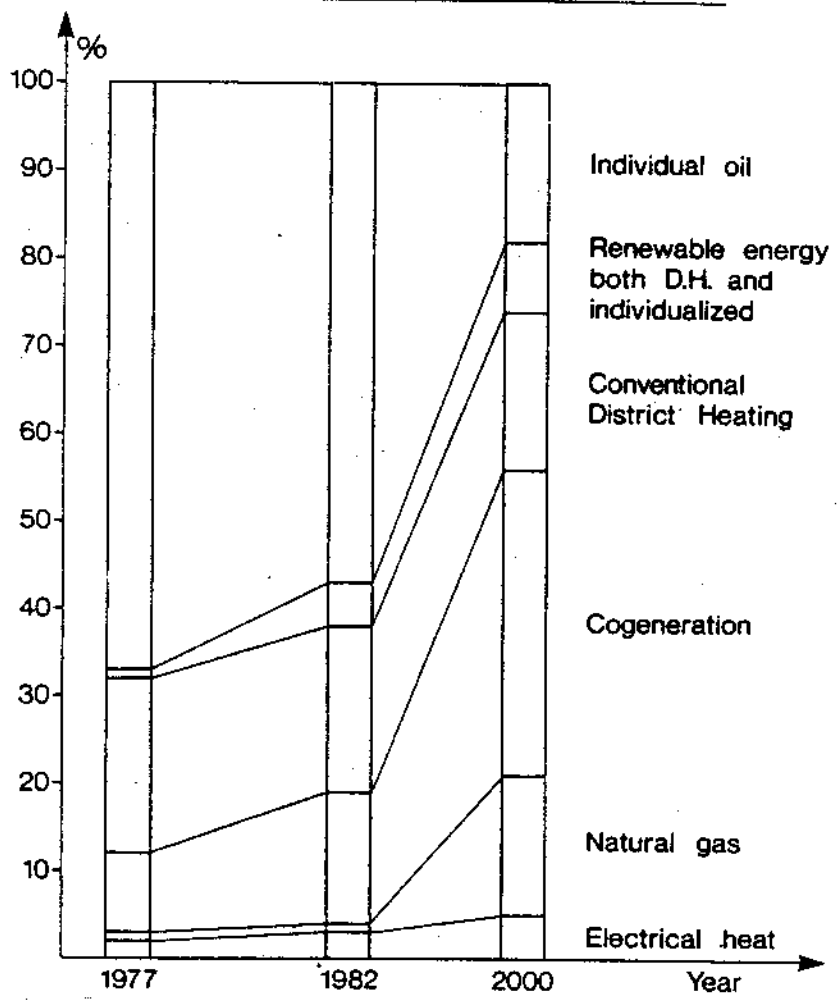


Denmark

Both district heating supply and combined heat and power production have had a major impact in Denmark. District heating accounts for approximately 42% of energy needs in the residential and commercial sectors. Total installed heat capacity is 12,600 MWth, plus approximately 1,800 MWth of combined production capacity. Heat supply from the latter represents 45% of total heat production. Heating-only capacity is by and large fuelled by oil, coal and wood, while combined production units are fuelled mainly (over 90%) by coal. Heat recovery from waste incineration and from industry accounts for 6%-7% of total production.

Graph 2-3

DISTRIBUTION OF HEAT CONSUMPTION



Planned distribution of district heating in Denmark in the year 2000 (Bernsen, 1984)

The scope for further utilization of waste heat recovery from industry is limited by the structure of Danish industry itself, which tends to be less energy-intensive than in other countries, and hence there are few large energy consumers in industry which would have waste heat available to feed into a district heating grid. The scope for the expansion of heat recovery from waste incineration is also limited, but will, nevertheless, increase as opposition to tipping increases.

Most heat production units and distribution systems are developed, financed, owned and operated by municipal utilities or local co-operative organizations. Combined production facilities are, however, owned and operated by the regional electricity utilities. Heat prices in Denmark are extremely competitive, especially when based on combined production systems. In addition, connection costs for the consumer are comparatively low and never exceed the cost of the nearest competing heating option.

The levels of direct Government assistance for district heating and combined heat and power systems have been declining in recent times and were phased out at the end of 1981. Furthermore, the consumer is encouraged through standards, rules and regulations, rather than by direct assistance.

Denmark is highly dependent on energy imports, mainly oil and coal. The availability of Danish off-shore oil and gas will have a significant impact from the middle of this decade. The former is already being produced in small quantities, while the latter will be available from 1984. A major natural gas grid has been constructed across the southern portions of the country to ensure rapid up-take of the available gas supply. In addition, natural gas from the European gas grid has become available during 1983 and a number of district heating schemes are being converted to gas-firing.

Following the oil crisis of 1973/74 and the discovery of off-shore gas, the concept of heat planning was introduced by the Government. The resulting Heat Supply Act mandated the preparation of heat plans at local level, with the objectives of promoting the most economic use of energy for heating buildings and to reduce dependence on oil. Under the Act, each municipality is obliged to prepare a heat plan for the area, which would have to be approved by the Government. The plan would allocate heat supply systems, (district heat or gas distribution systems) on a local and regional level.

From the heat suppliers perspective, a cost-competitive product is often available, based on coal or waste heat. The incentive to switch to natural gas must, therefore, be mostly economic. Thus, the pricing of natural gas will play a major role in determining the extent of a switch to natural gas.

The Government has amended the Heat Supply Act to ensure that the price of natural gas does not exceed the price of gas-oil or fuel-oil (on a heat equivalent basis), for which the gas substitutes.

The high level of penetration of district heating supply systems in Denmark can be attributed to a number of factors. These include the long history of the co-operative movement and community involvement at local levels in Denmark; the history of municipal involvement in energy (mainly electricity) production and distribution, including the planning, financing and implementation phases; a high level of consumer acceptance; active political support during the planning phases of district heating development; the use of direct-feed hot water distribution systems, which resulted in lower heat production and distribution costs and lower consumer connection costs; and the implementation of coal-fired combined production systems which has resulted in significantly lower heat production costs.

Total installed heat capacity is likely to increase to 23,000 MWth by 1990. Due to current electricity over-capacity, combined production capacity will only increase marginally from current levels.

The main uncertainty facing the future development of district heating in Denmark is the impact of the availability of Danish North Sea natural gas from 1984. The Heat Supply Act is designed to assist the local planning of energy supply, and provide guidelines on how the implementation of natural gas and district heatng will take place. The natural gas will be used to substitute for oil in heating-only plants. thereby achieving the objectives of increased use of indigenous resources and oil substitution. The price of natural gas will be the main determinant of the extent to which this would occur, but will not exceed the price of the oil for which it substitutes.

Finland

Both district heating and combined heat and power make a significant contribution to Finland's energy supply situation. District heat, whether produced by heating-only or combined heat and power, accounts for approximately one-third of space heating needs.

The total connected district heating load is 7,376 MWth, and total installed heating capacity is 9,127 MWth. Heating-only plants account for 57% (5,163 MWth) of installed capacity, of which 40% are permanent units and 17% are transportable units. Combined production plants account for the remaining 43% of heat capacity (3,964 MWth). Heat is virtually always provided by municipal utilities and municipal companies with only small quantities being provided by

industry and from waste incineration. At the same time, however, combined heat and power production by Finnish industry is very widespread, and amounts to 5,485 MWe of back-pressure plant, mostly in the pulp and paper sector of industry. Total heat output for district heating purposes is 14,000 GWh, more than half of which is produced from combined production plants. The main fuel inputs are oil (44%, mainly used in heating-only and some combined plants) and coal (36%, mainly used in combined production units). The share of oil is being reduced rapidly.

Almost all district heating systems, including the heat production units are planned, financed, constructed and operated by municipal utilities. The role of the main power companies is limited in most cases to interconnection with the municipal utilities for electricity supply. In some cases, the main power companies have become involved in heat and power production.

Government policy places a strong emphasis on district heating, particularly those systems based on combined heat and power.

Because there is no legislation to mandate connection to a system the heat price must be competitive. Generally, the heat price is related directly to the oil price, so as to be competitive. Electricity is competitive for single-family homes. No restrictions are placed on the use of electricity for heating purposes, although if demand surged, the grid would need to be strengthened.

Heat prices, which are very attractive compared to alternative options have been one of the main factors in the success of district heating in Finland. In addition, the widespread use of combined production plant using coal has played a big part in preventing heat prices from increasing rapidly. The successful and widespread use of back-pressure combined production units by industry has also contributed to the successful use of these systems by the municipal utilities.

The Finnish Government has also played a part in ensuring the widespread use of district heating by the implementation of policies, backed-up with appropriate financial and legislative support, to achieve this. Furthermore, this has been achieved without the need to mandate district heating supply for individual consumers.

The total connected load is projected to reach 9,500 MWth in 1990. Coal is forecast to account for over half of fuel inputs, mainly to be used in combined production plant.

Germany

In absolute terms, district heating has had a significant impact in Germany, particularly based on combined heat and power systems. At the end of 1981 total installed heat capacity was 31,000 MWth, including combined heat and power capacity of 21,050 MWth. The latter accounts for three-quarters of total heat output. The contributions from waste incineration and industry waste heat recovery are small. Industrial combined heat and power capacity stands at 8,600 MWe. A large share of the connected heat load is located in five of the major cities: Berlin, Essen, Hamburg, Mannheim and Munich, and the greatest market penetration is, as expected, in these and other cities with high heat-load densities.

In the case of combined production facilities coal is the major fuel (52% of inputs); followed by natural gas (28%); oil and refuse make up the remainder, at 15% and 5% respectively. For heating-only boiler plants, natural gas and oil are the main fuel sources (40% and 30% respectively), with coal (15%), refuse incineration (9%), and others (6%) accounting for the remainder.

Some 76% of district heating systems are owned and operated by municipal utilities, a further 12% are privately-operated, and the remaining 12% are subject to mixed ownership.

Hot water is the predominant heat distribution medium for German district heating systems, although a number of steam networks operate in some of the older systems. Supply temperatures from below 100°C up to 150°C are in common use. Few systems use heat exchangers to interface the consumer with the distribution systems and most systems are based on a direct feed system. In many cases heat is metered, while in others volume flow only is measured and thermostatic control devices are fitted to radiators to ensure low return temperatures.

Heat prices are by and large competitive and connection charges for a new consumer are never greater than the cost of installing a competing system.

While oil is the single largest source of primary energy in Germany, accounting for 43% of total supply, solid fuels (mostly indigenous coal and lignite) and imported natural gas, also account for significant market shares, 34% and 16% respectively. Nuclear and other sources account for the remaining 7%. Solid fuels, as well as, nuclear power account between them for 80% of inputs to electricity generation.

Consistent with the objectives of energy conservation, oil substitution and the development of indigenous resources, the

German Government places a major emphasis on the further development of district heating, based primarily on small- and medium-sized, coal-fired combined heat and power systems, especially using fluidized bed combustion systems. This is to be achieved by means of a US $472 million funding programme, to be provided jointly by the Federal Government and the Länder, to assist heating utilities. Assistance is provided for new coal-fired facilities, conversion of existing systems to coal-firing, refuse incineration with waste heat recovery, waste heat recovery from industrial concerns and the installation of large heat pumps. Total assistance, which can include the cost of transmission and distribution systems, must not exceed 35% of the investment cost. Prior to the initiation of the present support programme, a total of US $800 million had been expended for the same purposes in recent years.

In recent years a number of small, combined heat and power systems, usually fired by oil or gas, have been successfully developed at twenty-eight locations throughout Germany. Total heat capacity is 49 MWth and a further increase in capacity of 36 MWth has been ordered, or is under construction. While a number of difficulties have been experienced, the penetration of such systems is likely to increase.

The successful development of district heating, especially those systems based on combined heat and power production, can be attributed to a number of factors. The main factor has been the existence of a large heat source, adjacent to a large, high-density heat load. Thus, most developments have involved the conversion of existing power stations or the construction of new ones close to cities. For the new, very large stations, situated at some distance from the heat demand centres, the transmission of heat over long distances may not be economically viable. A further factor is that the heating stations situated close to the demand centres are by and large operated by municipal utilities or similar organizations which have had a long history of involvement in local energy matters. The large remote stations are operated in the main by the large regional utilities or by the coal producers and the interest of these bodies in combined production has been limited, although the utilities have underlined their willingness to co-operate in such ventures.

Another factor which has facilitated the development of district heating in Germany has been the relatively smooth administrative machinery which links the Federal, regional and local Governments. This has meant community involvement at local level as well as the development of local planning, which is consistent with regional and national plans and objectives.

Total connected load is expected to increase by 80% to about 67,000 MWth by 1990.

Sweden

District heating accounts for 27% of space heating needs in Sweden. Heat supply from group or block centrals (each heating a small number of buildings) has been estimated to account for approximately 25% more. Thus, district heating, in its broadest context, accounts for about half of space heating needs in Sweden. The total connected district heating load (excluding the group or block centrals) is 15,300 MWth, and delivered heat is 26,900 GWh. Total heating capacity is 16,800 MWth, including 4,000 MWth capacity from combined facilities. Penetration of district heating is greatest for multi-family dwellings (47%) and the inclusion of group heating schemes would increase penetration considerably. Penetration is also high (16% of available volume) in the commercial and public sectors; again penetration would be increased by the inclusion of group schemes. In the single-family dwellings and industrial market sectors district heating has made only a small impact, primarily because of cost factors.

Virtually all group or block central heating schemes are based on oil. Most district heating systems are also based on oil-fired heat production units and oil accounts for 90% of fuel inputs. The remainder consists of almost equal contributions from industrial waste heat, refuse incineration and a combination of coal, wood and electricity.

Combined heat and power capacity currently stands at 2,000 MWe and is mostly oil-fired. Because of the existing (and future prospects of) electrical over-capacity, there are no plans for significant expansion, until perhaps the 1990's when the phasing out of the existing nuclear capacity is to begin.

Installed capacity of combined heat and power capacity in industry currently stands at 1,200 MWe and is mainly in the pulp and paper sector of industry, which has access to plentiful and low-cost fuels. The prospects for further expansion is limited as a result to specific favourable locations. In addition, due to the isolation of these plants from population centres, few are linked to district heating grids.

The dominant features of the Swedish energy structure include extensive over-capacity in electricity generation, as well as low-cost electricity (US$ 0.02-US$ 0.05 per KWh) which results from extensive hydroelectric resources and a large nuclear capacity. In the short-term, as the remainder of Sweden's 12 nuclear power plants come on-line the contribution of nuclear (now accounting for 35% of output) will increase further.

Electricity prices in Sweden are relatively low and are competitive with alternative heating options, including district heating. Resulting from Government policy, district heating is, however, favoured for high density areas and district heat is, as a result, competitive in this market.

In Sweden electricity and district heating are seen to be complementary rather than competitive. The former is seen to be suitable for low-density areas, including single-family houses, and the latter for high-density areas. In addition, the municipalities are responsible for heat supply and distribution and can designate in their plans certain areas to be supplied by district heating systems. At the same time the use of electric resistance heating is restricted for new single-family dwellings. Most electric heating is undertaken with indirect systems, e.g., electric boilers coupled with an existing oil-or solid fuel-fired furnace or a heat pump.

The overall rationale is to ensure flexibility in heating in the long-run as nuclear power is phased out. Individual indirect heating systems could be changed over to district heating from coal-fired heating stations and eventually linked to large coal-fired combined heat and power stations.

While the preparation of local energy plans is mandated for all municipalities, the quality of these plans varies widely. In addition, the use of local indigenous resources such as peat, wood chips etc., in these plans may not be optimal from the national perspective. At the same time the local municipalities may also be reluctant to develop solid fuel systems, particularly based on coal.

The implementation of the municipal energy plans is not compulsory but the Government has, nevertheless, stated its intention to enforce these plans particularly in the large cities of Göteborg, Mälmo and Stockholm.

A number of electric boilers have been introduced for district heating for use in periods of low demand when electricity is at its cheapest. This enables the closing-down of oil-fired plants during these periods. This option could still be attractive, compared with coal-fired units, due to the poor part-load performance of the latter.

A number of large-scale heat pumps, taking advantage of low electricity prices, have been installed over the last few years to produce hot water for district heating. Capacity of about 1,000 MWth is under construction or at an advanced design stage. Because most of these demonstrations have been in operation for only a short period of time it is too early to say how effective they are. Nevertheless, the cost of heat produced appears to be competitive. The heat sources include sewage water as well as waste heat.

Discussions are taking place on the possibility of building a large, 600 MWe, coal-fired combined heat and power plant for the Stockholm area. A large heat pump station (150 MWth) based on sewage and/or waste water is also under consideration.

The very high level of penetration of district heating can be attributed to a number of factors, including the very early involvement of municipal groups and communities in energy production and distribution (electricity and town gas); the high level of community co-operation; active Government support and encouragement; the widespread recognition of the need to conserve energy and to increase fuel flexibility; the agreement between the District Heating Association and the building owners that heat prices would not exceed those of individual oil furnaces; a recognition that the ambient air quality could be improved by installing district heating plants to replace individual oil furnaces; and a high level of consumer acceptance.

Some of the current combined production capacity is coal-fired, as a result of the retrofitting of older condensing-plant. Because electricity prices are low, due to the high contribution of hydroelectric and nuclear power plants, there is little incentive for municipalities to engage in costly retrofits or the construction of new combined capacity. For the same reason, industrial combined capacity is small and is confined mainly to those industries with access to low-cost and abundant fuels such as in the pulp and paper industries.

In order to encourage the implementation of its plans the Government offers financial inducements to developers to construct district heating systems, to retrofit or convert existing systems, and to install new technology options such as electric boilers and large heat pumps. Inducements are also available for the consumer to connect to a district heating system.

It has been shown that for single-family dwellings in Sweden, the most cost-competitive heating option is the electric boiler, followed closely by the electric heat pump (soil-source) combined with an oil-fired unit for peaking purposes and a coal-fired, heating-only district heating or group central system. Oil-fired district heating is the least attractive option for this market sector.

In the case of multi-family dwellings the clear economic winner is a coal-fired district heating system, and the nearest competing option is a large electric heat pump combined with an oil furnace for peaking purposes. As in the case of single-family dwellings, the least attractive option is an oil-based district heating system.

Over the next decade or so the connected district heating load is expected to rise to 25,000 MWth. A total of 6,500 MWth of existing heating capacity and 1,000 MWth of combined capacity are to be converted to fuels other than oil; 3,000 MWth to coal, 1,500 MWth to peat and wood chips, 1,000 MWth to waste incineration and 2,000 MWth to large heat pumps.

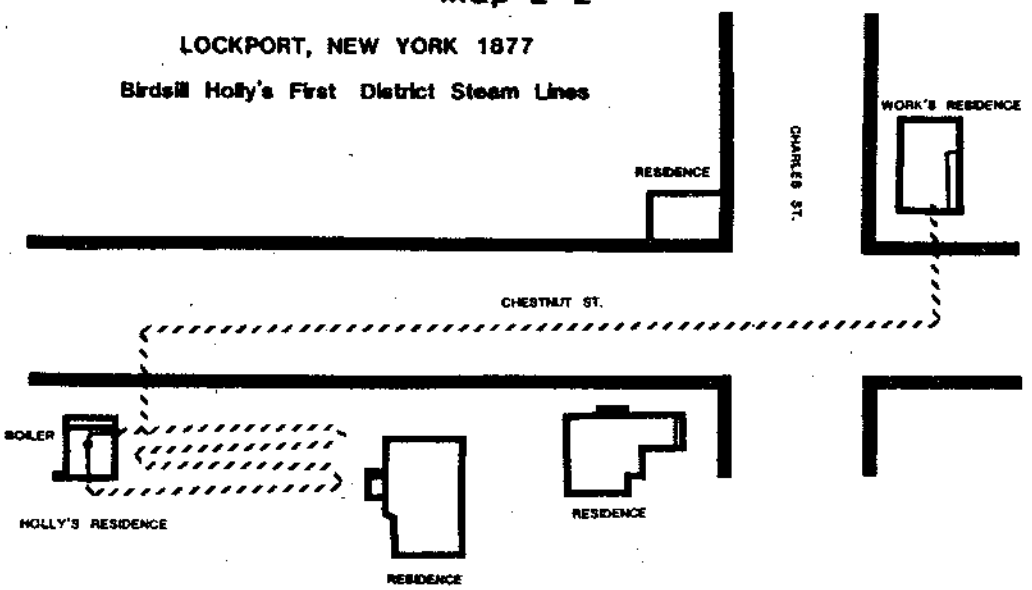
2.2 A BRIEF DHC HISTORY

The first successful (i.e., profitable) district energy system in the world was Birdsill Holly's district steam system in Lockport, New York. The Lockport district heating system began operation in 1877 and served several residences and other nearby users from a central boiler plant.

Map 2-2

LOCKPORT, NEW YORK 1877

Birdsill Holly's First District Steam Lines



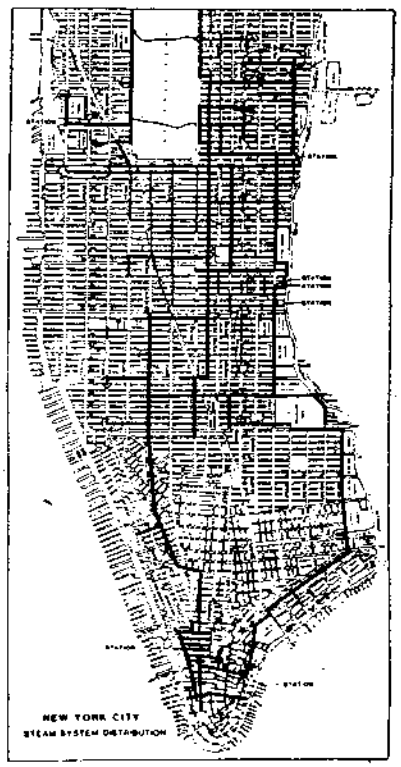
District heating quickly expanded, especially in the northeast and the midwest. During the first half of the 20th century, many district heating systems were constructed. These systems were generally fueled by industrial waste heat or developed as downtown (central business district) district heating systems with cogeneration. The convention of the day was steam distribution.

There are more than forty-five downtown steam svstems today which range in size from one of the world's largest in New York City, to much smaller systems. The Consolidated Edison Steam System is by far the largest commercial district

heating system in the world. It supplies two interconnected districts in Manhattan --the downtown district and the uptown district.

The downtown district includes the area that contains the large buildings between Battery and Reade Streets and constitutes the financial and business center of Lower Manhattan. The uptown district includes the business and adjacent large apartment-house section between Reade Street and 92nd Street.

Map 2-3

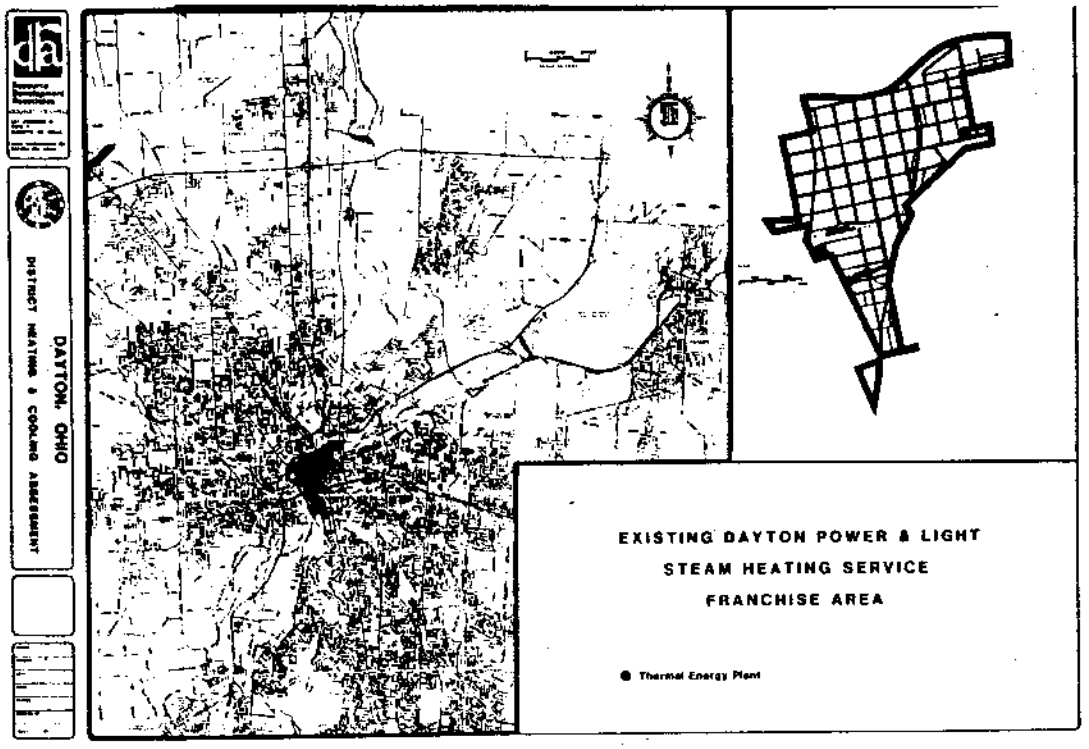


The corporation owns and operates several boiler plants and obtains more than 70% of the steam it sells from three electric generating plants. This method of operation uses the steam produced in the boilers of the Consolidated Edison Company of New York for the joint purpose of generating electricity and supplying steam service, i.e., cogeneration. A substantial improvement in efficiency and an overall savings in the amount of fuel required results from this action.

Dayton, Ohio represents a more typical system in terms of size. The present Dayton Power and Light Company (DP&L) steam system centers around the downtown of Dayton, an area that is generally commerical but also includes a considerable number of industries. Total size of the steam service territory is 0.71 square miles. The existing system does not include condensate return pipelines to the generating stations.

The two heat-only steam generating plants (one coal-fired on Longworth Street, the other oil fired on Third Street) serve the area through 89,000 feet linear of steam distribution piping.

Map 2-4



Steam-based district heating places constraints on system development in that it is economically infeasible to transport steam over great distances.

Transition of the U.S. energy service economy accelerated following World War II. Consequently, a combination of factors acted to select against district heating and cooling in favor of fuel intensive systems. These included the spatial distribution limitations of steam, cheap oil and natural gas, rapid urban development, and the aggregate economies of scale in developing condensing plants which resulted in their location relatively far from areas they serve.

Community scale district heating development in Eastern and Western Europe began in earnest after WWII. Differences between European district heating development patterns and those in North America are the result of several factors, including the application of different district heating technology, fuel resource availability, fuel cost, and national and local long-range energy planning policies and important institutional consideration.

Following WWII, European countries began to utilize hot water for their district heating systems. The use of hot water for the transport medium allows the transmission of energy over relatively great distances. It is not uncommon to see distribution systems which exceed 20 miles.

Europe historically has faced different fuel constraints than those found in North America. Many European and Scandanavian countries were already dependent on imported energy sources and have had to squeeze the most out of available energy supplies and insure their energy future by decreasing their dependence on any single energy source.

2.3 THE TRANSITION

The 1960's and 1970'S represent the beginning of a major transition in the U.S. energy economy which continues today. During this period total U.S. energy consumption grew at a rapid pace. While energy prices were relatively stable during the 1960's, this pattern quickly changed with the "oil crisis" of the 1970's. During these years energy suppliers, consumers, and governments struggled through the debate of demand-side solutions (energy conservation) verses supply-side solutions (increased production and alternative technologies).

Significant technological advances were initiated in the areas of emission controls, cogeneration and the combustion of solid fuels, i.e., coal and municipal solid waste. Investor owned utilities, entrepreneurs, the federal government, and state public service commissions began the arduous process of defining respective future roles in the energy supply system.

During this "pre-1980 period" DHC consisted primarily of the maintenance (and some scaling back) of existing investor-owned utility downtown steam systems and the growth of institutional or single customer DHC systems.

As development of institutional and single customer systems demonstrated the cost and operational advantages of DHC, entrepreneurs, cities and other interest groups began to investigate ways of implementing this technology on a multi-sectoral or multi-customer basis.

U.S. district heating and cooling's modern initiative began during this period with a series of small projects. Many of these included participation by the U.S. Department of Housing and Urban Development and were known under a varity of names such as Total Energy Systems, Municipal Integrated Utility Systems, Integrated Central Energy Systems, and Total Integrated Energy Systems. All of these were central, small-scale, district heating and cooling systems that often included cogeneration, initiated the use of hot water as a distribution medium, and provided thermal service to multiple buildings (usually a single owner). Cities with some support from the Environmental Protection Agency initiated the early resource recovery projects (municipal waste-to-energy).

The next step in the evolution toward a modern U.S. district heating and cooling program was the initiation of the U.S. Department of Energy sponsored "District Heating and Cooling Through Power Plant Retrofit and Community Distribution Network." Under this program several projects including St. Paul, Minnesota; Detroit, Michigan; and Piqua, Ohio evaluated potential for full-scale, multi-sectoral district heating systems and are now pursuing implementation of community-scale district heating and cooling systems which include cogeneration or combined heat and power.

1980 marks a clear turning point for DHC in the United States. When the Department of Housing and Urban Development and the Department of Energy sponsored district heating and cooling assessments in 28 cities throughout the U.S. A definitive interest in multi-sectoral DHC with combined heat and power

(CHP) was confirmed and documented. This program which became known as the "28 cities program", provided selected cities with cooperative agreements of approximately $40,000 to $60,000 to assess the potential for DHC development. On January 19, 1981 over 110 cities and other political jurisdictions submitted applications for the program's funds. In early spring, HUD informed the 28 cities that they had been selected and began the negotiations for cooperative agreements. In late summer -early fall, all cities were under contract and the nine month assessment projects started.

The 28 cities projects included coal-fired, power plant retrofits for cogeneration, resource recovery, and low temperature geothermal projects. Jurisdictions ranged in sizes from New York City to Richmond, Indiana. Some cities were able to move to implementation immediately without project packaging assistance, while others such as Baltimore, Maryland and Provo, Utah received Phase II Project Packaging Assistance and are now proceeding to project construction.

In summary, 1980 and commencement of the "28 cities program" serve as a useful point of demarcation from which to evaluate DHC status and trends. District heating and cooling in the United States should be viewed from two perspectives; the pre-1980 conventional view and post-1980 initiatives.

Pre-1980 Conventional View =
- investor held utility CBD steam systems (multi-sectoral)
- institutional systems
- single owner, single customer systems
- fledgling resource recovery systems
- military bases

Post-1980 Initiatives = ° continuation/sales/reorganization of CBD steam systems
° institutional/single customer systems
° new multi-sectoral DHC Systems
° accelerated resource recovery system development
° alternative system ownership structures including utilities, entrepreneurs authorities, cities, cooperatives
° alternative thermal distribution system implementation (hot water, steam, chilled water)

While DHC development was evolving in the United States during this period, both western and eastern European countries aggressively implemented large-scale, multi-sectoral systems. Western European countries reflect significant variation in fuel use. Continental European countries tend to burn higher proportions of solid fuels than Scandanavian. However, imported oil played a major role in all of these countries' energy systems.

The evolution towards multi-sectoral, multi-customer, multi-energy source system development requires DHC developers to engage a much broader set of interest groups and decision makers in project planning, configuration, implementation and operation.

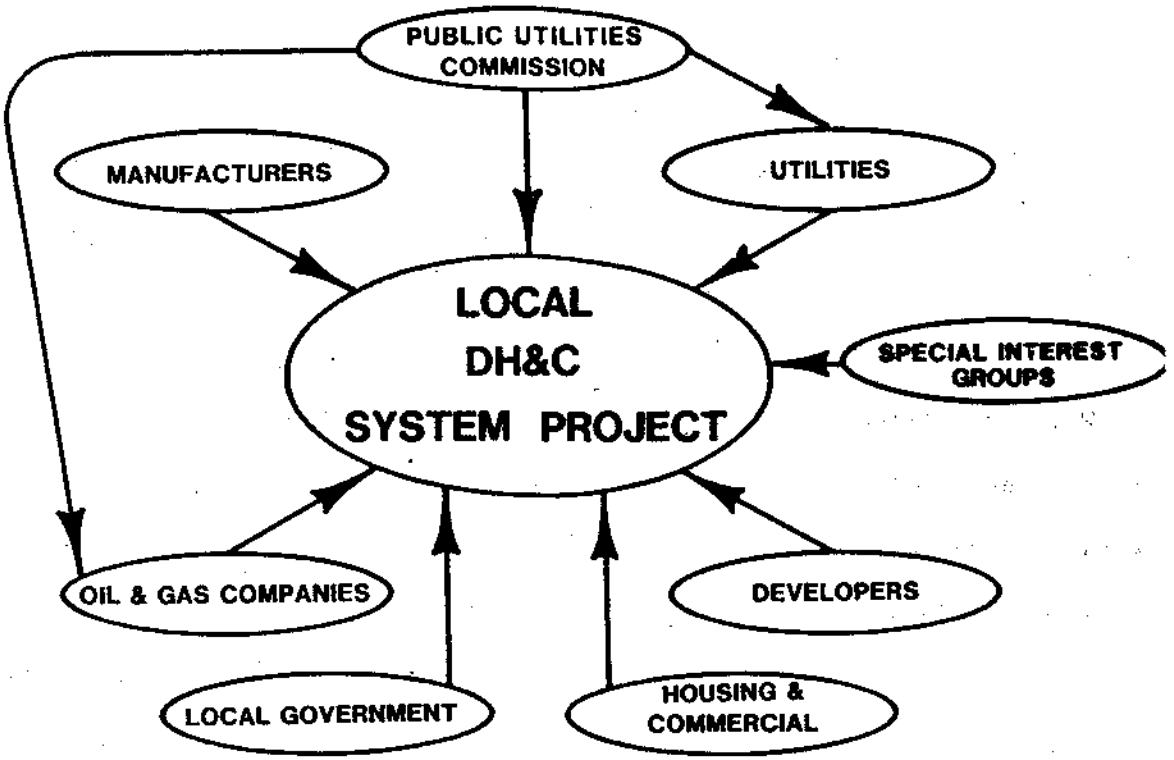


Figure 2-1

2.4 DISTRICT HEATING AND COOLING IN THE UNITED STATES

2.4.1 General Status: Pre 1980 Conventional View

As illustrated in sections 2.1 through 2.3, DHC has a long, rich history in the United States. In spite of this history, accurate quantification, description and evaluation of U.S. district heating and cooling is difficult. These difficulties are due to the diverse nature of DHC system development in the United States as opposed to Europe; the lack of an agreed upon definition of exactly what constitutes a DHC system; the nature of the U.S. energy supply system which emphasises a greater reliance upon market forces; and the relatively unorganized condition of the DHC/CHP industry in the United States.

While the 40,000 MWth estimate appears large in comparison with the installed DHC capacity of European countries, it isn't that large considering the DHC share of total delivered thermal energy in the United States. The figure appears even smaller considering the estimated potential for development of DHC and CHP systems in U.S. urban areas. In fact, it is estimated that district heating systems utilize approximately 10.6 Mtoe inputs annually, which accounts for only .6 percent of the total primary energy supply.

The 40,000 MWth consists of:

- multi-sectoral, CBD steam systems
- military facilities
- universities
- hospitals and housing complexes, industry

For the most part downtown steam systems are multi-sectoral district heating systems serving a number of independent customers. The other categories, military bases, universities, hospital and housing complexes are characterized by a central heat production facility serving multiple buildings. The heat source, transmission system and the end-users (buildings) are all owned by the same party.

A. MULTI-SECTORAL STEAM SYSTEMS

Downtown, multi-sectoral steam systems in the United States account for between 25 and 30 percent of the estimated 40,000 MWth DHC capacity. Even here an accurate count of the systems is difficult. In 1983, 35 systems were members of and reported statistics to the International District Heating Association (IDHA). For the most part these systems are owned and operated by investor owned utilities. The major part of their business is concentrated in electrical generation and/or natural gas distribution. In 1982, the last year for which statistics were available, these systems delivered a total of 65,131 MM pounds of steam. Total system capacity during that year was 38,534 M pounds

per hour or approximately 12,000 MWth. Consequently, it can be estimated that multi-sectoral, downtown steam systems account for between 25 and 30 percent of the afore mentioned DHC estimate (40,000 MWth). It should be noted, however, that all multi-sectoral downtown steam systems do not report to IDHA, e.g. Kansas City Power and Light and Youngstown Thermal. Further it should be noted that these statistics do not include the distribution which is negligible of chilled water by the reporting companies. The table on the following page, "Multi-Sectoral Downtown Steam System Statistics," provides a summary of these steam system characteristics.

During the the post World War II period a number of older downtown steam systems went out of business while others lost customers to plentiful, inexpensive natural gas and downtown urban renewal. Today there appear to be three catagories of downtown steam system companies. The first are seriously interested in the maintenance and expansion of DHC. These companies, e.g. Hartford Steam, Pacific Gas and Electric, have initiated efforts to expand their DHC systems, increase efficiencies, and pursue significant capital investments. The second category of downtown steam systems are charaterized by those companies who apparently intend to maintain their existing system but have no plans for system expansion and growth.

Table 2-7

MULTI SECTORAL DOWNTOWN STEAM SYSTEM CHARACTERISTICS

CITY	COMPANY	TOTAL (MM lb.)	MAXIMUM POSSIBLE HOURLY SENDOUT (M lb.)	ANNUAL SYSTEM LOAD FACTOR (%)
Allentown, PA	Pennsylvania Power & Light Co.	563	500	25.45
Atlanta, GA	Georgi Power Co.	332	680	19.90
Baltimore, MD	Baltimore Gas & Electric Co.	1,857	1,060	31.30
Birmingham, AL	Alabama Power Co.	457	476	23.90
Boston, MA	Boston Edison Co.	3,453	1,790	30.40
Cambridge, MA	COM/Energy Steam Co.	1,181	825	29.74
Cedar Rapids, IA	Iowa Electric Light & Power Co.	1,417	635	31.86
Cleveland, OH	Cleveland Electric Illuminating	1,512	1,320	26.94
Detroit, MI	Detroit Edison Co.	4,569	2,500	38.60
Erie, PA	Pennsylvania Electric Co.	431	-	-
Eugene, OR	Eugene Water & Electric Board	541	445	0.04
Hartford, CT	Hartford Steam Co.	321	339	18.40
Indianapolis, IN	Indianapolis Power & Light Co.	4,498	1,802	42.66
London, Ont.	Cities Heating Co. Ltd.	178	180	-
Milwaukee, WI	Wisconsin Electric Power Co.	2,079	1,640	29.06
Minneapolis, MN	Central Heating Co.	917	850	23.94
New York, NY	Con Edison	27,347	13,201	31.18
Omaha, NE	Energy Systems Co.	518	435	27.52
Philadelphia, PA	Philadelphia Electric Co.	5,086	3,857	31.43
Phoenix, AZ	Energy Development Co.	0	-	-
Portland, OR	Pacific Power & Light Co.	412	487	25.72
Rice Lake, WI	Rice Lake Steam Corp.	54	40	-
Rochester, MN	Rochester Public Utilities	161	160	36.10
Rochester, NY	Rochester Gas & Electric Corp.	1,888	-	32.77
Salt Lake City, UT	Utah Power & Light	119	120	24.67
San Diego, CA	Applied Energy, Inc.	-	-	-
San Francisco, CA	Pacific Gas & Electric Co.	480	450	31.21
Scranton, PA	Community Central Energy	213	369	17.85
Seattle, WA	Seattle Steam Corp.	924	1,078	23.16
Spokane, WA	Washington Water Power Co.	310	420	28.11
St. Louis, MO	Union Electric Co.	1,056	1,235	23.02
Toledo, OH	Toledo Edison Co.	205	310	23.42
Toronto, Ont.	Toronto Hydro Electric System	956	560	31.38
Vancouver, B.C.	Central Heat Distribution Ltd.	692	535	28.19
Winnipeg, Man.	Winnipeg Hydro	404	280	24.48

The third category of systems can be characterized as those companies who intend to leave the district heating and cooling business. Leaving the district heating and cooling market in many cases, however, is regulated by state public service commissions and involves a lengthy, complicated process which has and will continue to generate significant customer, community, business, and government disscussion and debate. Systems falling into this category include Rochester Gas and Electric, Baltimore Gas and Electric, and San Diego Gas and Electric. A number of these systems have recently been acquired by other parties and have embarked on major system improvements. Further discussion of this DHC trend is presented in the next section of this report, 2.4.2 Recent DHC Experience: Multi-Sectoral Trends.

B. DEPARTMENT OF DEFENSE INSTALLATIONS

The U.S. Military has extensively utilized central plants for district heating and cooling for many years. Although a complete inventory of DOD DHC systems is unavailable, some analysis has been completed by the Army and Navy. A compilation of aggregate use of central heating plants by the U.S. Army listed by commands worldwide and in the continental United States is available*. Similar aggregated information for the U.S. Navy is included. Another study recently performed for the U.S. Navy is available which evaluates the costs and benefits of a central plant with a district heating system fueled by coal, oil or natural gas against the use of decentralized heating plants dedicated to specific site applications.

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*Annual Summary of Operations for FY 1980, Facilities Engineering Command, U.S. Army Corps of Engineers, Office of the Chief of Engineers.

The Army and Navy have installed both high temperature water (HTW), low pressure steam (LP<15 psig) and high pressure steam (HP>15 psig) thermal energy distribution systems. The combined installations include more than 3000 miles of distribution piping.

Typically, the distribution systems include the commercial and industrial on-base applications and exclude personnel living quarters and single-family units.

Since 1951, the Navy has converted 630 X 10^6 Btu/hr of capacity of HTW systems in the Washington, D.C., area alone. The installations are located at the stations listed below.

Table 2-8

U.S. NAVY HIGH TEMPERATURE WATER IN WASHINGTON, D.C., AREA*

Location	No. of Units and Capacity 10^6 Btu/hr	Year of Conversion
Naval Academy	3 - 100 = 300	1969
Su Station, Nebraska Ave.	2 - 12.5 = 25.0	1951/1965
Boiling, Anacosta		
Camp Barret, Quantico	2 - 25 = 50.0	1965
NSC Chiltenham	3 - 10 = 30	1951
Day River Navy Yard	3 - 65 = 185	1959
Naval Research Lab.	3 - 10 = 30	1952
TOTAL	630 X 10^6 Btu/hr	

*Millard Carr, OSD, Personal Communication

The energy utilized in the Army and Navy district heating systems are shown in the figure below.

Table 2-9

FUEL USED IN ARMY AND NAVY CENTRAL PLANTS LARGER THAN 3.5 X 10^6 BTU/HR

Service and System	Fuel Type and Amount, 10^6 Btu (1979)				
	Oil	Coal	Gas	GOCO	TOTAL
(1980)					
Army HP Steam	8,600,000	13,400,000	3,800,000	8,200,000	34,000,000
Army LP Steam	1,700,000	1,600,000	14,000	700,000	4,014,000
SUBTOTAL					38,014,000
(1979)					
Navy (Steam & HTW)	NA	NA	NA	NA	50,300,000
Navy (Electricity)	NA	NA	NA	NA	3,400,000
SUBTOTAL					53,700,000
TOTAL					91,714,000

The energy used by the Army and Navy in central heating plants, cogenerators, and distribution systems was estimated at 91.7 X 10^{12} Btu in 1979 and 1980. Oil is the primary fuel used by the Armed Forces, representing two-thirds of the fuel burned by the Army and Navy in its facilities.

Two studies evaluating the costs of different heating strategies for Bremerton, Washington, and King's Bay, Georgia, have recently been completed for the U.S. Navy.

The King's Bay study compared the life-cycle costs of several alternate energy systems for supplying energy to (1) a central core load for housing, personnel, and industrial support, (2) additional heating and cooling for a waterfront area, and (3) a strategic weapons area. The recommended system is a central heating and cooling plant for the core area. This plant would burn coal for heating and employs electrically driven centrifugal chillers using commercially purchased electricity. A medium temperature water system will be used for

circulating thermal energy. This recommendation is based on cost consideration calculations. All government regulations for safety and environmental protection were met.

From the above report on the King's Bay, Georgia, Naval Station, it is clear that site-specific considerations determine if a particular energy load should be attached to a district heating system or be served by a satellite energy plant. Major factors in this decision process include distance, load factors, and nature of the heating or cooling load, in addition to fuel costs and electricity costs.

U.S. MILITARY FACILITIES WITH DISTRICT HEATING AND COOLING SYSTEMS IN WASHINGTON, D.C., AND BALTIMORE, MARYLAND METROPOLITAN AREAS

NATIONAL NAVEL MEDICAL CENTER, Bethesda, Maryland
U.S. NAVAL WEAPONS LABORATORY, Maryland
U.S. NAVAL ORDINANCE LABORATORY, Maryland
U.S. ARMY, FORT DETRICK, Maryland
U.S. NAVAL ACADEMY, Annapolis, Maryland
U.S. NAVAL SECURITY STATION, Washington, DC
U.S. ARMY, CAMERON STATION, Alexandria, Virginia
U.S. ARMY WALTER REED MEDICAL CENTER, Washington, DC
U.S. NAVAL RESEARCH LABORATORY, Washington, DC
U.S. ARMY, FORT MEADE, Maryland
WHITE OAK TEST FACILITY, Virginia
U.S. ARMY FORT BELVIOR, Virginia
U.S. ARMY FORT MCNAIR, Washington, DC
U.S. ARMY FORT MYER, Virginia
U.S. NAVY DAVID TAYLOR SRDC, Carderock, Maryland
U.S. NAVY SRDC, Annapolis, Maryland
US.S NAVAL AIR STATION, Patuxent River, Maryland
U.S. FORCE BOLLING AFB, Washington, DC
U.S. AIR FORCE ANDREWS AFB, Maryland
U.S. ABERDEEN PROVING GROUNDS, Maryland
U.S. DEFENSE MAPPING AGENCY, Virginia
U.S. MARINES QUANTICO MARINE BASE, Virginia

C. COLLEGE/UNIVERSITY CAMPUSES

Central generation and distribution of thermal energy have been successfully employed on college and university campuses for over eighty years. Many reasons exist for the successful application of district heating systems in the campus environment. The major reasons include:

- High density of buildings resulting in high heat loads and low cost distribution systems;
- Highly predictable load characteristics which permit improved system design and operation;
- Central plant and buildings owned by same party;
- Lack of legal/institutional barriers of the type imposed upon franchised utility operations;
- System financing by public funds or private capital;
- Central plant operation and distribution offering increased efficiency and reliability over individual building operations;
- Lower operating and maintenance cost; and
- Traditionally, college systems tend to be equated to a long range investment rather than a short-term profit venture.

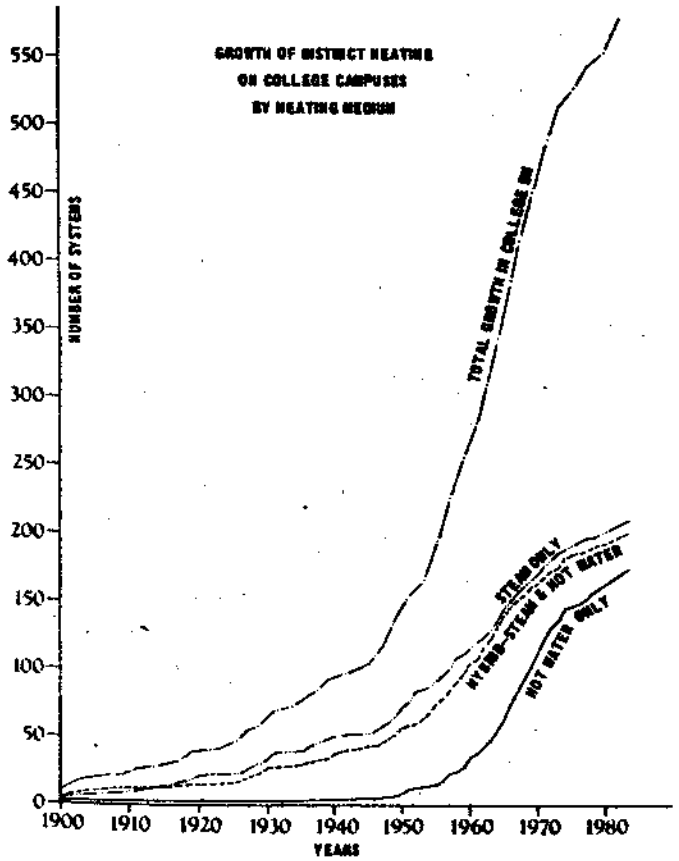
The widespread use of district heating systems is evident from a 1979 survey of 532 reporting institutions which indicates that 263 (49%) have central plants that generate steam, hot water, or chilled water. Of these 263 plants, 38 generate electricity on-site and 35 produce some combination of electricity, steam, hot water, or chilled water. Total generated energy in 1978-79 from these 263 plants includes 394 X 10^{12} Btu (.394 Q) of steam, 11 X 10^{12} Btu of hot water, 4.4 X 10^{12} Btu of chilled water, and 3.65 X 10^{12} Btu of electricity.

During the summer of 1984 the North American District Heating and Cooling Institute in conjunction with the energy task force of the association of physical plant administrators of colleges and universities conducted a comprehensive survey of colleges and campuses utilizing DHC systems. The survey which was sent to 2,000 institutions resulted in 744 responses.

The survey does demonstrate steady growth in the institutional segment of the DHC markets. Of the responses, 227 institutions had steam systems, 177

utilized hot water district heating, while 234 employed hybrid systems with both steam and hot water. The data collected as part of the survey confirms the growth of hot water systems beginning around 1950.

Graph 2-4



Graph 2-5

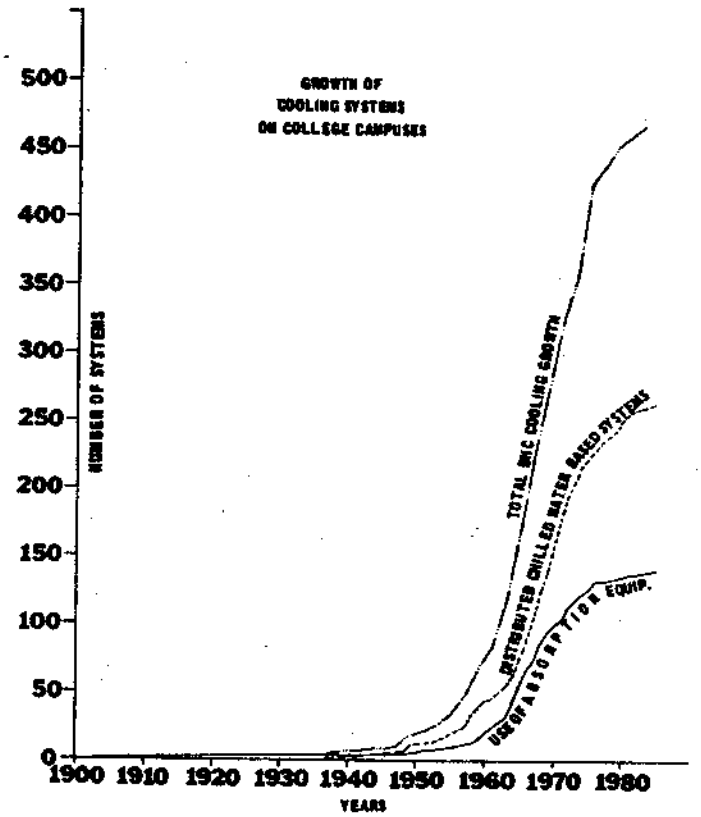


Table 2-10

ENERGY GENERATED BY CENTRAL PLANTS AT 263 CAMPUSES

	Steam (Btu)	Hot Water (Btu)	Chilled Water (Tons-Hrs)	Electricity (Kwh)
Energy Generated	3.94×10^{14}	108×10^{13}	4.37×10^{8}	1.07×10^{9}
No. Central Plants	173	25	74	38

Importantly, colleges and campuses display wide-spread utilization of district cooling. During the 1950's district cooling development began to accelerate. In 1950, only 11 district cooling systems were operational, while the 1983 survey documents a total of 493 colleges and universities with district cooling systems. Of these, 323 are chilled water distribution systems and 170 cool through the application of absorbtion equipment connected to their district heating system. In total, it is estimated that over 700 college and university campuses have DHC systems with a total of 2,157 miles of underground piping or 2.9 miles per campus.

D. INDUSTRIAL SECTOR COGENERATION AND DHC

The industrial sector is the largest user of central process heat and cogeneration in the U.S.. Estimates developed in 1979 concluded that the industrial sector uses central heating plants and thermal distribution systems totaling upward of six quads of fuel use or about one-third of the industrial energy use, excluding public utilities. At that time industrial applications also generated approximately .2 quads of electricity for their own use. Fuels used in industrial cogeneration central plants include oil, gas, coal and industrial waste bi-products. General Electric Company data estimated that the installed cogenerating capacity increased at a rate of about 450 MW of electric annually between 1960 and 1978 for steam and gas turbine plants alone. Recent estimates conducted by the cogeneration industry indicates that the United States will have approximately 16 gigawatts (one gigawatt = 1000 MW) of installed cogeneration capacity by the end of 1984. It is believed that cogeneration capacity could increase to nearly 39 million KW by the year 2000 (an optimistic forecast). Major industrial users of district heating include the chemical industry, pulp and paper products, iron and steel, and the food processing industry.

2.4.2 Recent DHC Experience: Multi-Sectoral Trends

Through the early 1980's transition in the U.S. energy supply economy continued. During this period cities, states and federal agencies continued to focus on conservation efforts; however, attention also turned towards efficient, energy supply solutions. The successful implementation of DHC projects in St. Paul, Minnesota; Piqua, Ohio; and Trenton, New Jersey along with the well documented European DHC experience encouraged selected utilities, system developers, cities, DOE and HUD to initiate broader, multi-sectoral DHC application.

Consequently, in 1981 DOE and HUD initiated a most important DHC program through the sponsorship of assessments in several U.S. cities. This program is important for several reasons. First, DOE and HUD (the two primary responsible agencies) developed a cooperative approach to providing DHC technical assistance. Second, the program placed emphasis upon institutional and financial solutions as well as technology application. Third, the program stimulated a broad representation of cities, technologies, approaches and interests for a very modest investment of approximately $40,000 to $50,000 per city.

A. HUD/DOE TECHNICAL ASSISTANCE PROGRAM

The jointly sponsored DHC initiative recognized the two predevelopment phases inherent in all new DHC projects; Phase 1--Assessment, Project Identification and Configuration; Phase 2--Project Packaging and Financing. Initially, 28 cities received cooperative agreements to assess the feasibility of DHC system development and to coordinate community support. The following cities participated in this latest multi-sectoral DHC initiative:

Albany, New York;
Allentown, Pennsylvania;
Atlanta, Georgia;
Atlantic City, New Jersey;
Baltimore, Maryland;
Bellows Falls, Montana;
Berlin, Maryland;
Cambridge, Massachusetts;
Campbellsville, Kentucky;
Columbus, Ohio;
Dayton, Ohio;
Devils Lake, North Dakota;
Ecorse, Michigan;
Fort Wayne, Indiana;
Galax, Virginia;
Gary, Indiana;
Holland, Michigan;
La Grande, Oregon;
Lawrence, Massachusetts;
Lewiston, Maine;
Missoula, Montana;
New York, New York;
Norwalk, Connecticut;
Provo, Utah;
Richmond, Indiana;
Santa Ana Peublo, New Mexio;
Springfield, Massachusetts;
Thermopolis, Wyoming

Several cities participating in the initial assessment program concluded not to pursue DHC system development. The reasons for not continuing varied from technical aspects to political considerations to financial constraints or site selection problems. However, 20 of the original 28 identified and configured apparently feasible systems upon completing the initial feasibility assessment. These cities include:

Albany	Devils Lake	New York City
Atlanta	Dayton	Norwalk
Allentown	Galax	Provo
Baltimore	Gary	Richmond
Bellows Falls	Holland	Springfield
Campbellsville	Lawrence	
Columbus	Lewiston	

Several of the smaller systems with few institutional, regulatory or financial hurdles decided to pursue system packaging, finance and development on their own. These included Richmond, Galax, Columbus, Devils Lake, and Holland.

HUD/DOE Assessment Results

Given the diverse characteristics of the initial 28 cities and the numerous DHC system variations which were identified, a thorough, consistent and comparative evaluation is difficult. The department, through Argonne National Laboratories, did prepare a comprehensive evalution of the technical economic and institutional findings in February, 1983 (District Heating and Cooling: A 28 City Assessment). Since that time the department has continued to monitor the progress of the various projects.

City Characteristics

Participation in the HUD/DOE cooperative program was limited to CDBG eligible cities. These cities were therefore required to meet the Community Development Block Grant Standards related to housing, poverty and economic development. As a result, the participating cities were mainly concentrated in the northeast and midwest, with most of the older cities often in need of revitalization. All but one city (Atlanta) had at least 4,000 annual average heating degree days, even in Atlanta; however, a district heating system has served the downtown for many years. Table 2-11 on the following page highlights several characteristics of the 28 participating communities.

Map 2-5

HUD DISTRICT HEATING AND COOLING SPONSORED ASSESSMENTS

• –Technical Assistance

◉ –Project Packaging

Table 2-11

ASSESSMENT CITIES: SELECTED PROJECT CHARACTERISTICS

CITY	POPULATION (1980 OR CURRENT ESTIMATE)	PROJECT NAME	PROBABLE FUEL	CAPITAL COST (1982 10^3)
Albany	127,000	Institutional Loop	oil	53,850
Allentown	103,000	Downtown Project	coal/gas	96,928
Atlanta	437,000	1. Peachtree Center	gas	8,356
		2. World Congress Center	refuse/gas	6,408
		3. State Office Tower	refuse/gas	4,114
		4. South CBD	refuse/gas	9,047
Atlantic City	50,000	Marina Cove	refuse/ice	5,170
Baltimore	783,000	1. Cherry Hill	refuse/gas	12,959
		2. Hopkins/East Baltimore	refuse/gas/ coal	7,587
Bellows Falls	5,500	Geothermal	geothermal	2,102
Berlin	2,000	Geothermal	geothermal	2,468
Cambridge	96,000	------	gas	ND[a]
Campbellsville	10,000	------	coal	ND
Columbus	593,000	Ohio State U./CBD	refuse	238,700
Dayton	193,000	St. Elizabeth/Delco	coal	156,400
Devils Lake	7,500	Steam Plant Conversion	straw/ geothermal	2,400
Ecorse	14,000	Frenchman's Cove	coal	7,500
Fort Wayne	182,000	Ultimate System	oil/gas	11,400
Galax	6,500	Hanes Underwear	refuse	1,557
Gary	152,000	CBD/Incinerator	refuse	65,000
Holland	26,000	Power Plant Retrofit	coal	14,300
La Grande	11,000	Institutional Corridor	geothermal	6,790
Lawrence	65,000	Refuse Incinerator	refuse	95,645
Lewiston	41,000	Refuse/Cogeneration	refuse	14,841
Missoula	36,000	------	------	ND
New York	7,000,000	Navy Yard	refuse/gas	1,400
Norwalk	77,000	Incinerator	refuse	15,000
Provo	74,000	CBD/North Loop	coal	27,000
Richmond	44,000	1. West Richmond	coal	644
		2. Areawide/CBD	coal	28,192
Santa Ana Pueblo	500	------	------	ND
Springfield	165,000	Downtown	coal	27,664
Thermopolis	3,800	Geothermal	geothermal	15,750

[a]ND = no data.

Summary Findings of the Assessment Program

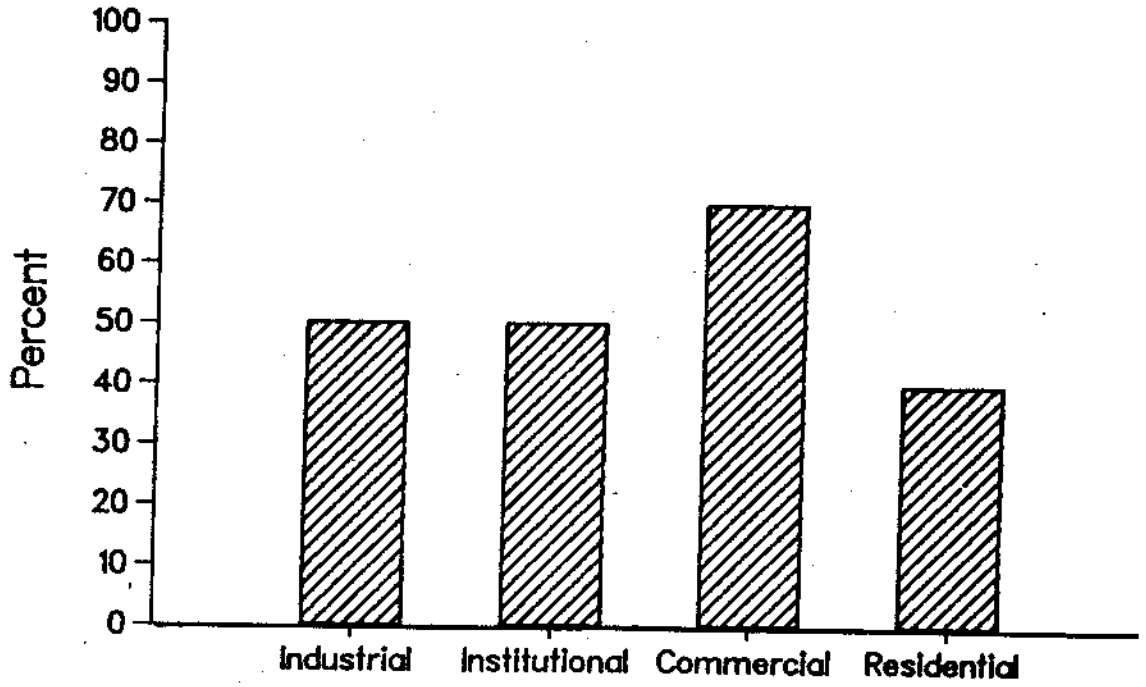
HUD/DOE Assessment Program began to indentify and quantify DHC's potential impact in America's cities. Initial results indicated that:

- Potential total investment in the identified projects could be in the range of $500 million to almost $1 billion.
- Total project construction could generate up to 6,700 on-site construction job-years, plus an additional 17,500 off-site jobs.
- As a result of project construction, the cities could expect to retain a grand total of $165 million annually in their local economies.
- The cities expect district heating systems to support their revitalization efforts by helping retain struggling businesses and industry, improving their competitive position, lowering governmental costs, helping stablize tax rates, reducing operating costs for housing (particularly public housing), improving air quality, and reducing waste disposal problems by using refuse as a heat source.

Distribution of Service Area by End-use Sectors

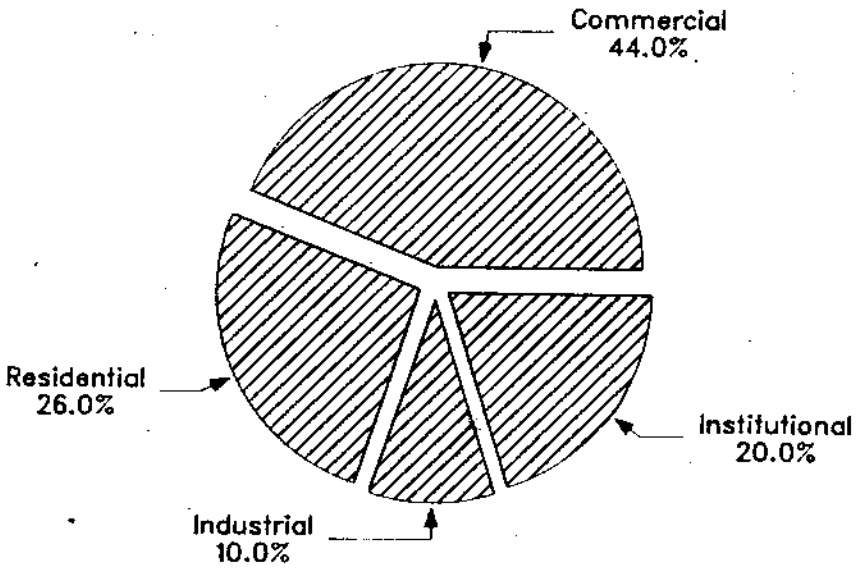
The distribution of service area by end-use sector to be serviced by DHC systems is shown by Graphs 2-6 and 2-7 on the following page. More than 228 million sq. ft of floor area has been proposed to be served by DHC in 25 cities. The largest percentage is targeted for the commercial sector, followed by the residential, institutional, and industrial sectors.

Graph 2-6



End-Use Sectors to Be Served by DHC,
by Percentage of Reporting Cities

Graph 2-7

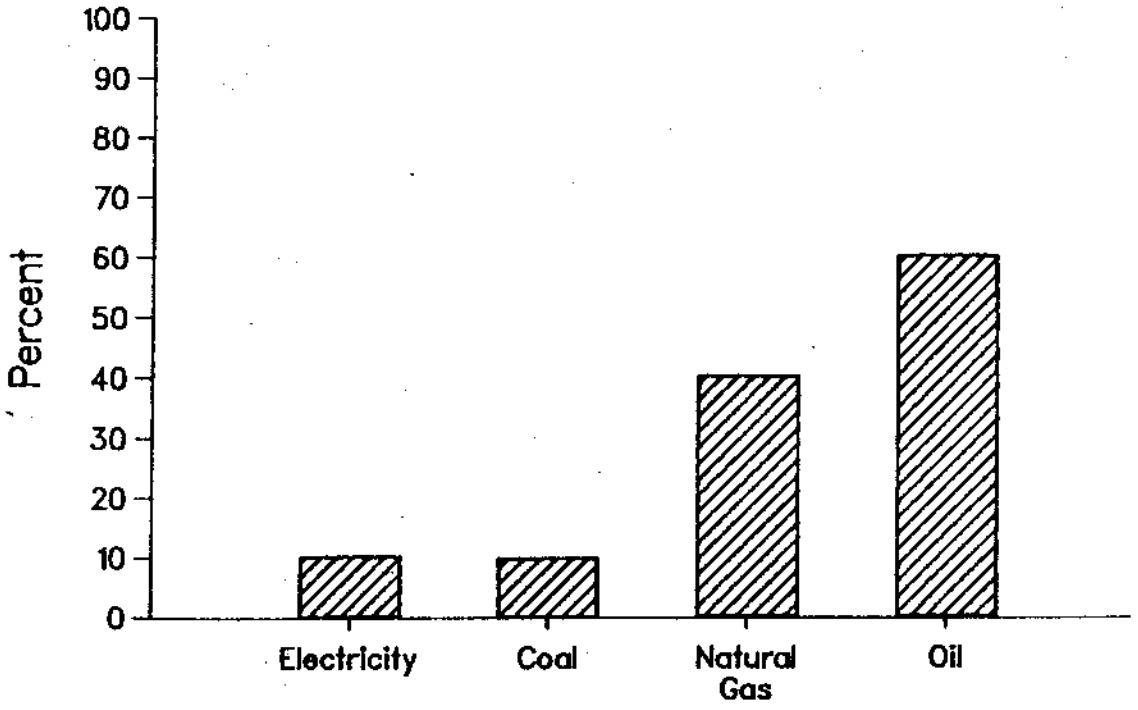


Distribution of Floor Space to Be Served by DHC
in 25 Cities, by End-Use Sector (total floor area =
>228 million sq. ft)

Competing Energy Forms

The competing energy sources in the potential service areas are shown by the Figure below. Based on the percentage of cities reporting competition with premium oil and natural gas, it is obvious that these communities are concerned about past supply disruptions and the prospects of continued price escalations of these fuels. DHC systems are being viewed as one strategy by which cities can regain control of their energy future and return a measure of energy reliability and stability to local economies.

Graph 2-8

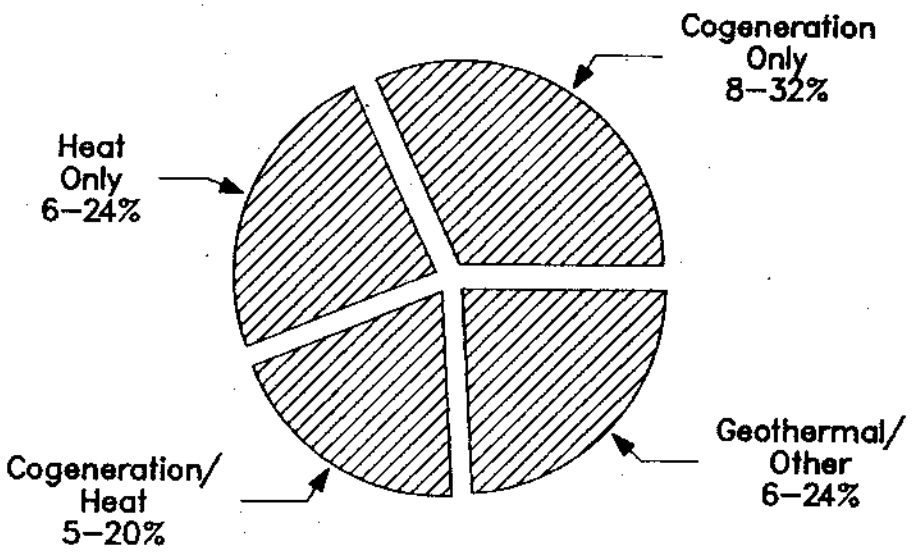


Sources of Energy That Would Compete with DHC, by Percentage of Reporting Cities

Technical Characteristics

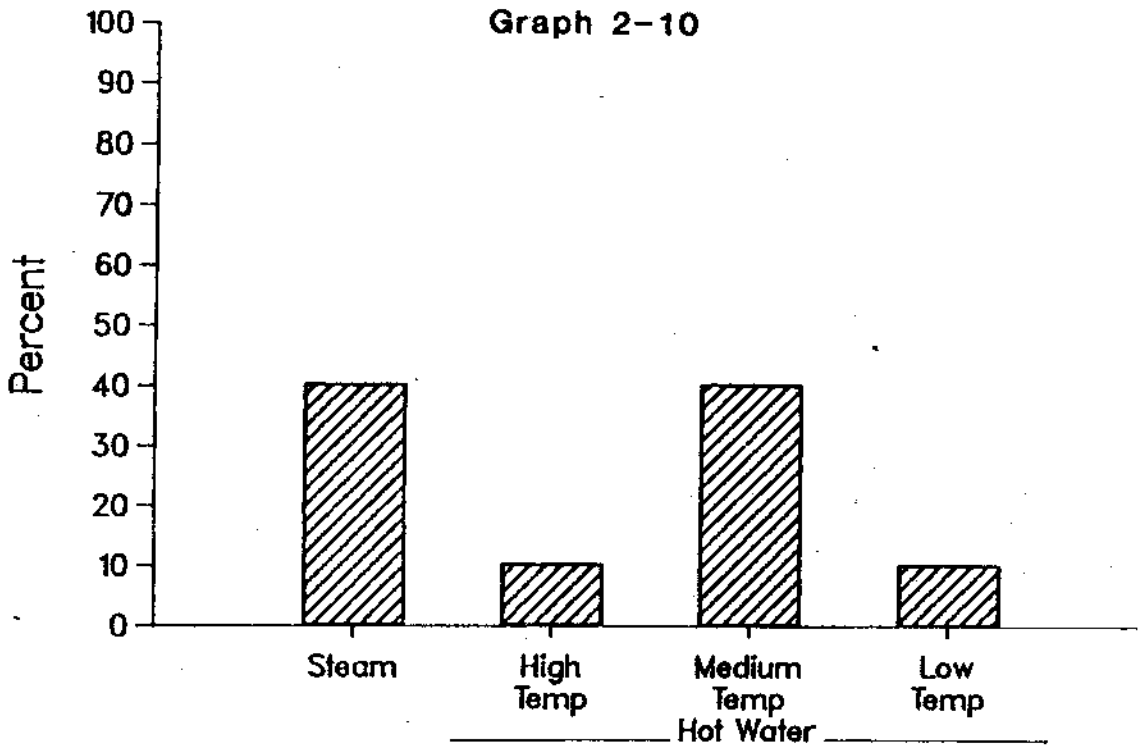
The types of systems proposed and their distribution are shown in Graph 2-9 below. The predominant systems include cogeneration, either alone or in combination with heat-only boilers. These systems take advantage of fuels capable of producing high-pressure and high-temperature steam for electricity production; they use residual steam for lower-quality heating and cooling demands. By simultaneously producing energy in the forms of electricity and heat, the systems operate at significantly increased efficiencies.

Graph 2-9



Heat Sources of Proposed DHC Systems

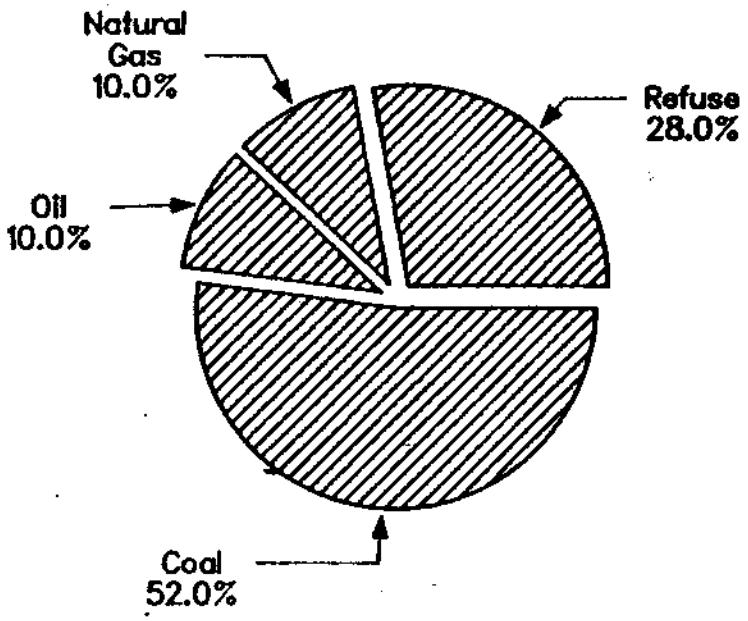
DHC distribution systems, or thermal networks, consist of piping through which a heated (or chilled) fluid, typically water or steam, is transported from heating sources and distributed to end-use points. The type of distribution depends on local needs and system characteristics. The types of distribution systems proposed are shown in Graph 2-10. The notable trend toward the more flexible hot water systems follows the European pattern.



DHC Distribution Systems Proposed by Reporting Cities

DHC systems can be designed to use alternative fuels. The fuel use distribution of proposed projects indicates that cities intend to take advantage of coal and refuse as fuel whereever possible. As shown in the figure below, 80% of planned fuel use in the proposed DHC systems is coal and refuse, substituting for the existing 86% dominance of premium fuels currently in use in the service areas.

Graph 2-11



Fuel Types for Proposed DHC Systems

Community Benefits

DHC projects initially focus on system configuration, i.e., the technical, economic, institutional, environmental, and other factors that determine whether a system has potential in a particular city. Merely because a project is judged to be feasible is not necessarily sufficient reason to pursue it. Rather, its investment potential must be determined on the basis of possible benefits as compared with alternative investment opportunities. In turn, these benefits are more than financial; to compete for public dollars, projects must demonstrate additional economic and community returns.

These benefits represent the public "bottom line, "which is why cities, states and the federal government survived DHC development. If district heating can be shown to support other public policy objectives related to community and economic development, as well as provide a savings in dollars spent on scarce or imported fuels, district heating warrants support.

The assessment indicates that the federal investment of approximately $1.5 million thus far could ultimately return as much as $500 million to almost $1 billion in capital investment in the cities. Projects that are under construction or that are likely to begin construction soon total about $100 million; an additional $410 million or more may be invested in the other early-start projects. In the unlikely event that all the projects identified by the remaining cities are built, the total investment could be substantially more than $1 billion in capital plant, transmission and distribution lines, and related capital costs. These figures generally do not include the costs of building retrofitting, which could increase the totals by about 20%.

As large enterprises, DHC systems produce many jobs. Job estimates can be classified under four headings: direct construction, other industry, service, and operations and maintenance. Table 2-12 shows the estimated jobs in the construction and industry. These figures are calculated estimates based on the specific systems identified by the cities. Job figures were estimated by using the constrction of sewage collection systems and treatment plants as a proxy (since no direct figures for DHC construction projects are avialable). In turn, a model developed by the Bureau of Labor Statistics is used to estimate the number of job years per number of dollars spent on construction.

Table 2-12

Jobs Created by District Heating Project Construction

City	Project Name	All Job Years	Construction Job Years
Albany	Institutional Loop	1,291	500
Allentown	Downtown Project	ND[a]	-
Atlanta	4 Early-Start projects	654	260
Atlantic City	Marina Cove	124	48
Baltimore	Cherry Hill	ND	-
	Hopkins/E. Baltimore	991	219
Bellows Falls	Geothermal	49	19
Berlin	Geothermal	63	24
Cambridge	———	ND	-
Campbellsville	———	ND	-
Columbus	Ohio State U./CBD	5,649	2,205
Dayton	St. Elizabeth/Delco	1,479	580
Devils Lake	Steam Plant Conversion	58	22
Ecorse	Frenchman's Cove	ND	-
Fort Wayne	Ultimate System	269	106
Galax	Hanes Underwear	37	14
Gary	CBD/Incinerator	1,330	532
Holland	Power Plant Retrofit	338	132
La Grande	Institutional Corridor	159	62
Lawrence	Refuse Incinerator	2,107	815
Lewiston	Refuse/Cogeneration	337	131
Missoula	———	ND	-
New York	Navy Yard	ND	-
Norwalk	Incinerator	457	177
Provo	CBD/Brigham Young U.	1,060	410
Richmond	W. Richmond and Areawide/CBD	697	272
Santa Ana Pueblo	———	ND	-
Springfield	Downtown	440	172
Thermopolis	Geothermal	ND	-
Total	———	17,589	6,700

Note: These are calculated figures based on data available as of October 1982.

[a]ND = no data.

Energy Consumption Characteristics

The results of the HUD/DOE assessment projects can be summarized in terms of energy consumption and the energy and premium fuel savings due to the use of DHC systems. Table 2-13 shows the annual energy savings of the DHC systems to be 8 x 10^{12} Btu/yr, or the equivalent of 1,356,000 bbl of oil. The results of fuel substitutions are even more dramatic, showing a net savings of 20 x 10^{12} Btu/yr, or 3,392,000 bbl of oil equivalent.

Table 2-13

Summary of Annual Energy and Fuel Savings by Proposed DHC Systems

Competing Thermal Service	28 x 10^{12} Btu/yr
Competing Electric Service	23 x 10^{12} Btu/yr
Total Competing Service	51 x 10^{12} Btu/yr
DHC Service	43 x 10^{12} Btu/yr
Net Energy Savings	8 x 10^{12} Btu/yr
Barrels Oil Equivalent	1,356,000

Table 9 Summary of Premium Fuel Savings by Proposed DHC Systems

Competing Service	29 x 10^{12} Btu/yr
DHC Service	9 x 10^{12} Btu/yr
Net Premium Fuel Savings	20 x 10^{12} Btu/yr
Barrels Oil Equivalent	3,392,000

In addition to the jobs generated as a direct result of the construction and operation of a district heating system, other economic benefits can accrue to communities and the nation as a whole. Estimates have been made of the amount of economic activity that would result. Individual city estimates vary by factors such as type and size of city, and fuel used (fuels such as gas or oil purchased outside the city cause dollars to be "exported," while dollars spent on indigenous fuels such as refuse are retained by the local economy).

The figures in Table 2-14 indicate that approximately $165 million would be retained in the cities' local economies in the first year of operation as a result of building district heating systems. The additional economic activity generated, considering the multiplier effects of dollars spent in the local economy, could be almost $500 million. The magnitude of these figures shows the level of economic activity that construction and operation of district heating systems would generate.

Table 2-14

Community Benefits of District Heating

City	Project Name	Net Indirect Economic Benefits ($\$10^3$)	Dollars Retained ($\$10^3$)
Albany	Institutional Loop	28,707	9,569
Allentown	Downtown Project	ND[a]	-
Atlanta	4 Early-Start Projects	14,647	4,881
Atlantic City	Marina Cove	3,965	1,322
Baltimore	Cherry Hill	ND	-
	Hopkins/E. Baltimore	18,953	7,846
Bellows Falls	Geothermal	299	199
Berlin	Geothermal	122	82
Cambridge	----	ND	-
Campbellsville	----	ND	-
Columbus	Ohio State U./CBD	144,715	48,238
Dayton	St. Elizabeth/Delco	98,217	32,739
Devils Lake	Steam Plant Conversion	468	312
Ecorse	Frenchman's Cove	ND	-
Fort Wayne	Ultimate System	4,445	1,482
Galax	Hanes Underwear	513	342
Gary	CBD/Incinerator	ND	-
Holland	Power Plant Retrofit	9,026	3,610
La Grande	Institutional Corridor	821	547
Lawrence	Refuse Incinerator	87,668	29,223
Lewiston	Refuse/Cogeneration	4,710	1,884
Missoula	----	ND	-
New York	Navy Yard	ND	-
Norwalk	Incinerator	19,528	6,509
Provo	CBD/Brigham Young U.	20,323	6,774
Richmond	W. Richmond and	ND	-
	Area-Wide/CBD	2,582	1,692
Santa Ana Pueblo	----	ND	-
Springfield	Downtown	25,375	8,458
Thermopolis	Geothermal	ND	-
Total		485,084	165,709

[a]ND = no data.

B. A CLOSE-UP LOOK

During the early 1980's DHC has experienced a modest rebirth in the United States. Efforts undertaken during the late 1970's by the Department of Energy begin to bare fruit, specifically in St. Paul, Minnesota and Piqua, Ohio. These two cities, orginally part of the eight sponsored by DOE, have now implemented the first phases of their new, hot water district heating systems.

St. Paul, Minnesota

In the mid-1970s the U.S. Department of Energy and the Minnesota Energy Agency initiated a study to determine the feasibility of a modern hot water district heating system for a U.S. city. The idea for such a study was the result of the large number of successful systems designed and built in northern Europe over the past 25 years.

The District Heating Development Corporation (DHDC) was incorporated in July 1979 as a non-profit company by the Mayor of St. Paul, the Executive Director of the St. Paul Building Owners and Managers Association and the Director of the Minnesota Energy Agency. The period from mid-1979 to the end of 1980 constituted the study phase of the St. Paul project. One of the goals of this phase was to assess a preliminary economic feasibility of a hot water district heating system serving the commercial core area of St. Paul. Given preliminary economic feasibility, the idea was to market the system, prepare the final design and bid specification, and obtain firm bids.

The final economic feasibility study was completed in September of 1982, with financing being arranged in December of the same year.

The St. Paul hot water district heating system offers consumers many major advantages over operating their own building boilers. These include:

- competitive space heating energy costs;
- lower maintenance costs and higher reliability;
- improved air quality in the community;
- improved safety (compared with fossil fuel-fired systems);
- smaller space requirements; and
- lower initial capital costs for new buildings.

Of these advantages, the most important to the consumer is the cost of the heat energy. The main feature that makes a district heating system competitive is its fuel flexibility which implies the use of comparatively inexpensive fuels such as coal.

The initial project cost, including construction, financing, and other expenses, but not building conversion, is $45.8 million. The cost has been financed as follows:

Tax exempt revenue bonds	$30.50 million
City/HUD-UDAG Loan	9.80
City equity loan	5.50
	$45.80 million

Customer heating system conversion costs in the initial system total approximately $22 million in 1982 dollars. Low interest loans to finance conversion costs are available to building owners from the St. Paul Port Authority.

Summary

The first year of DHDC's construction program is now complete. Twenty-two customers totaling 37 MW of thermal demand have installed new heat exchangers and converted their building heating systems to be compatible with the hot water provided by DHDC. When compared to the marketing and financing of the system, the technical engineering problems seem relatively minor.

The St. Paul project is the largest and most ambitious of the modern, multi-sectoral district heating developments. In spite of the success of this project, it is unlikely that circumstances will permit quick replication in numerous cities. However, it is instructive for others to note the circumstances that permitted the development of this large system.

1. Northern States Power, the utility which owned the St. Paul steam system actively supported the project, and sold facilities to DHDC at a reasonable price.

2. The Mayor of St. Paul -George Latimer, a strong and highly visible proponent of energy conservation and district heating-provided active support throughout the project.

3. The project had the support of building owners and managers from the onset.

4. The State of Minnesota has a very positive attitude toward district heating systems and development.

5. The project received funding from government which allowed the project developers the time and resources to overcome financial and institutional obstacles.

Piqua, Ohio

On December 6, 1982, the Piqua City Commission unanimously, on the recommendation of the Piqua Energy Board and the City administration, approved the development of a modern hot water district heating system. The system is owned and operated by the Piqua Municipal Power System. This is the first phase of a multi-phase district energy system designed to provide thermal energy to industrial, commercial, and residential energy customers in Piqua, Ohio. The system became operational in October 1983. Piqua's implementation of hot water district heating caps a process begun in 1978 to establish the feasibility of district heating and cogeneration through retrofit of the power plant.

Throughout the planning and feasibility analysis the Piqua City Commission and other community leaders were involved and in fact participated in the planning, evaluation and implementation activities. The following points illustrate the City Commission's role and position regarding district heating and cogeneration.

- The City Commission involved their local Piqua Energy Board, development corporations, and community leaders.
- The City Commission stressed the linkage between energy, the City-owned power system, and the City's long-term economic development strategy.
- The City Commission's decision reflects a philosophy of planned system expansion beginning now and proceeding through the decade.
- The City Commission determined that both thermal and electrical customers will benefit during the life of the project.

The Piqua DHC system is being implemented in planned phases which pace the required capital investment to thermal market growth. Importantly however, the Phase I thermal requirements are supplied by the Piqua Municipal Power System, a coal-fired power plant. This allows the PMPS system and customers to immediately capture the economic benefits of both coal and cogeneration.

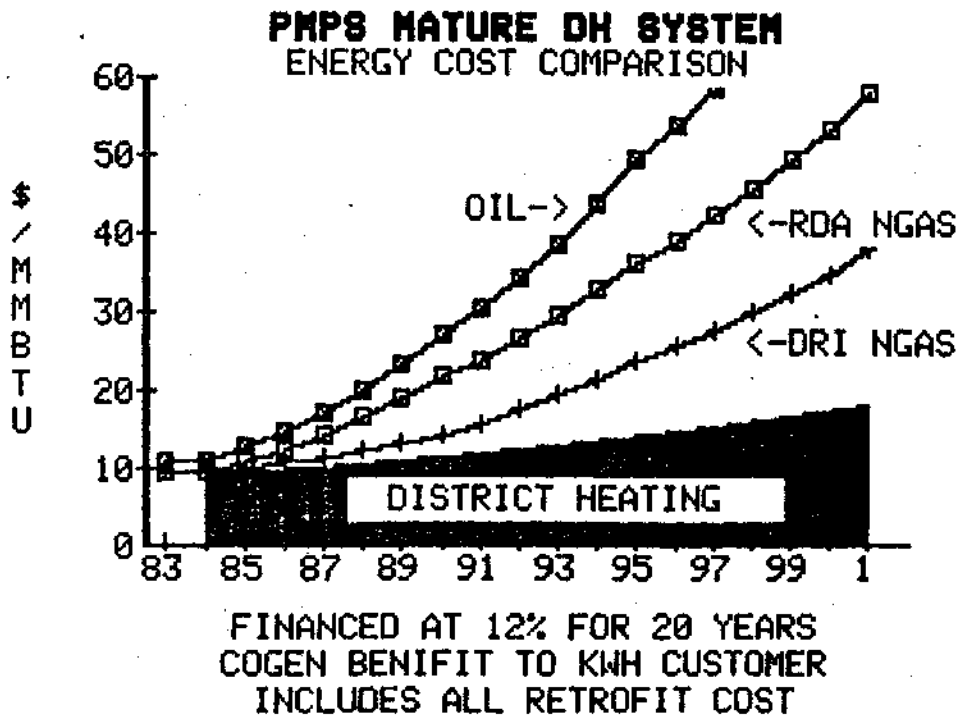
Phase I provides district heating service to new and existing customers within the City's Riverside Industrial Park. The initial phase consists of both in-plant modifications and a distribution system sized to allow additional district heating and industrial development. The first phase of the project provides thermal energy for a new manufacturer and a hydroponic greenhouse. Both facilities are located in Riverside Industrial Park, an area acquired and developed through CDBG grants from the U.S. Department of Housing and Urban Development Small Cities Community Development Block Grant Program.

Phase I will also accommodate the district heating system's expansion to the existing industrial and commercial area north and west of the power plant.

Concurrent with the above district heating work, the PMPS must complete installation of 4 million dollars of air quality control equipment in the power plant.

Graph 2-12 below illustrates the cost advantages accruing to customers connecting to Piqua's coal-fired, cogeneration based district heating system.

Graph 2-12



The City of Piqua is now planning Phase II efforts--expansion of the district heating system to serve the industrial/commercial area north and west of the Power Plant. During 1984 and 1985, market development within the Phase

II service area will continue. This will include refining distribution system and end-user retrofit cost estimates and finalizing expansion plans.

Current plans call for the Phase II expansion to begin in 1986 including the retrofit of existing end-users, and the installation of a new, nominal 30MW cogeneration turbine generator.

Summary

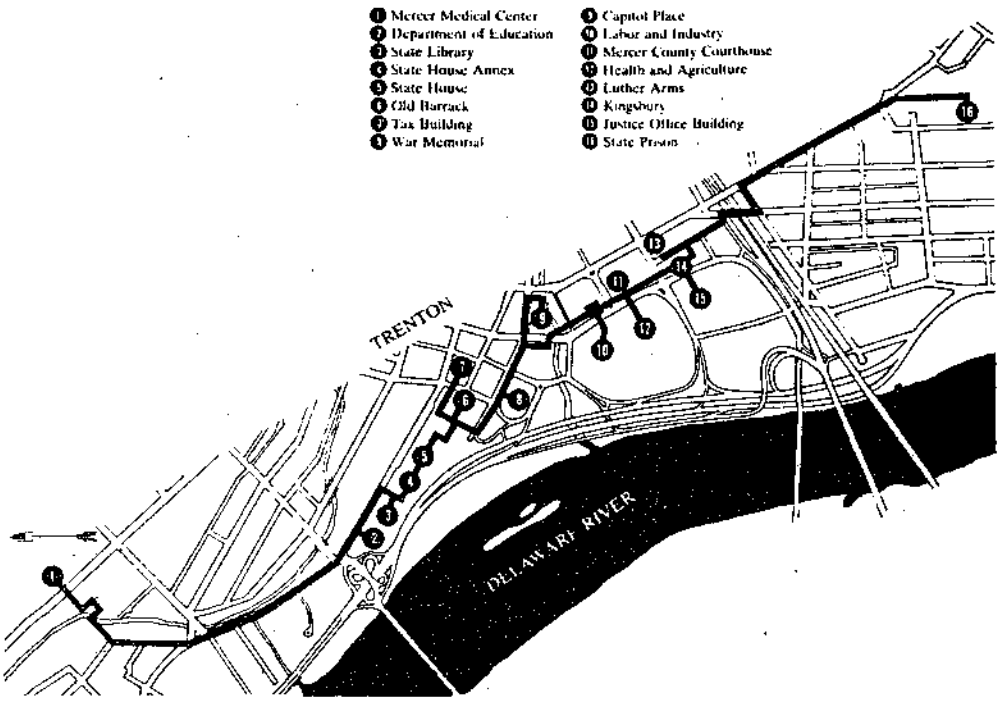
The project has been successful to this point for a number of reasons. These include Piqua's ability to coordinate programmatic missions, i.e., the redevelopment of the Riverside Industrial Park using CDBG funds; the decision of the City Commission and PMPS management that they were in the business of supplying thermal energy to the community not just electricity; and the realization that by coordinating energy, industrial development, and other local efforts, the outcome of each of these programs could be enhanced. Piqua was fortunate to have the flexibility to seize the opportunity, and the support of the federal government (DOE and HUD) providing the necessary "staying power" to take advantage of the development opportunities. Initially, Piqua, like other early district heating study cities, started out with a grandiose scheme to provide thermal energy throughout the majority of the community. As the city realized though, that such a scheme would be beyond the resources of the city, it then moved to identify system development opportunities that were within the city's means. It was this shift that allowed Piqua to be successful.

Other Projects

In addition to the progress of Piqua and St. Paul two cities at opposite ends of the United States commenced new, hot water system construction in 1983 - 1984. After enduring a long struggle, the Trenton District Energy Company began construction of a steam and hot water DHC system in Trenton, New Jersey. With approximately 4.5 miles of district heating lines operating at multiple presures and temperatures, the Trenton system will serve commercial, office and institutional customers in downtown Trenton. Although, the Trenton project ultimately was privately developed and financed, the original project identification and analysis was conducted under the sponsorship of DOE's integrated energy system program.

Map 2-6

The map shows the system with the 16 initial customers.



Trenton District Energy Project

Fairbanks, Alaska had historically served over 140 buildings in the downtown with steam supplied from a coal-based, cogeneration plant. In November 1982 the city commenced operation of its new hot water DHC system serving a high school, junior high school, swimming pool center and a library. The Fairbanks long-term DHC development plan provides for a 20 year program to supply thermal energy to 25,000 city residents and approximately 35,000 residents residing in nearby communities. The pilot demonstration program sponsored, in part, by the State of Alaska was initiated to demonstrate hot water based district heating utilizing indigenous Alaska coal from the Nenana coal reserves in Healey, Alaska.

HUD-Phase II

By far the broadest and best documented, modern, multi-sectoral DHC initiative results from the Department of Housing and Urban Development DHC program. In 1983 HUD solicited competitive proposals from those original 28 assessment cities who had identified feasible projects and wished to complete planning, design and financial packaging prepatory to system construction. This original round of "Phase II Projects" included Baltimore, Maryland; Lawrence, Massachusetts; Springfield Massachusetts; Lewiston, Maine; New York City, New York; and Provo, Utah. The status of these projects is discussed on the following pages in detail. Subsequently the department held competition for another round of Phase II - Preliminary Design, Marketing and Financial Packaging Cooperative Agreements. Cities, utilities and DHC system developers competing for these cooperative agreements did not have to have had prior participation in the HUD Technical Assistance Program. In October of 1984 the department selected four cities to receive HUD grants to complete DHC design and other preconstruction activity. The cities selected are San Francisco, California; San Jose, California; Chicago, Illinois; and Hibbing, Minnesota.

San Francisco plans to link an existing municipal steam system with a second steam system operated in the downtown area by the local investor-owned utility, Pacific Gas and Electric. The combined system will then be expanded to new, adjacent service areas. San Jose will develop a capital investment plan for development of a DHC system to serve a new convention center and hotel district. San Jose's plan calls for a gas-fired combined heat and power plant to be built adjacent to the complex.

Chicago, in cooperation with a private developer of central energy systems, plans to use heat from an MSW facility to provide steam and hot water to manufacturing firms in the Stock Yards Industrial Area. Hibbing, Minnesota will work under the Phase II cooperative agreement to develop a wood waste based DHC system to serve industrial tenants in the newly developing Wood Industrial Park. The Hibbing DHC system will also serve two near-by residential areas, public buildings, a community college and an assisted housing project.

The following ten case summaries present recently planned and packaged multi-sectoral DHC projects. The first six: Baltimore, Maryland; Provo, Utah; Lawrence, Massachusetts; Lewiston, Maine; New York City, New York; and Springfield, Massachusetts; are participants in the first round of department sponsored design and financial packaging cooperative agreements. The following four: Richmond, Indiana; Columbus, Ohio; Gaylax, Virginia; and Holland, Michigan; are examples of those projects that participated in the original Technical Assistance Assessment Program and choose to pursue project implementation without further project packaging assistance. Results from the most recent four Project Packaging Cooperative Agreements, i.e., San Francisco, San Jose, Chicago and Hibbing will be available in late 1985.

(1) Baltimore, Maryland

In early 1985, Baltimore Mayor Schaefer, Maryland Governor Hughes, and other dignitaries will gather on Russell Street to cut a ribbon inaugurating a new solid waste disposal facility. The occasion will be doubly noteworthy because it will also mark Baltimore's first step towards developing a modern district heating system.

Refuse supplied to the 2250 ton per day facility will be burned in large incinerators to produce high pressure steam. The steam will be used to supplement Baltimore's existing steam district heating system and simultaneously generate electricity for sale to the Baltimore Gas and Electric Company. Steam extracted from electricity production will be used to heat hot water that will then be transported by pipeline to the Cherry Hill neighborhood where it will be used to heat more than 1,600 units of public housing owned and operated by the Housing Authority of Baltimore City.

The proposed district heating system will be built and owned by BRESCO, the entity which is building and will operate the solid waste facility. The system will involve building a heat exchanger at the incinerator site capable of using low pressure steam to heat water to 250°F. Dual insulated pipes will transport the hot water energy from the incinerator two miles south to Cherry Hill. Once on site, the hot water energy will flow through heat exchangers, which in turn will transfer the energy into the Housing Authority's closed loop distribution system for circulation throughout the housing complex. The energy from the incinerator will be utilized for both temperature dependent heating and domestic hot water.

Map 2-7

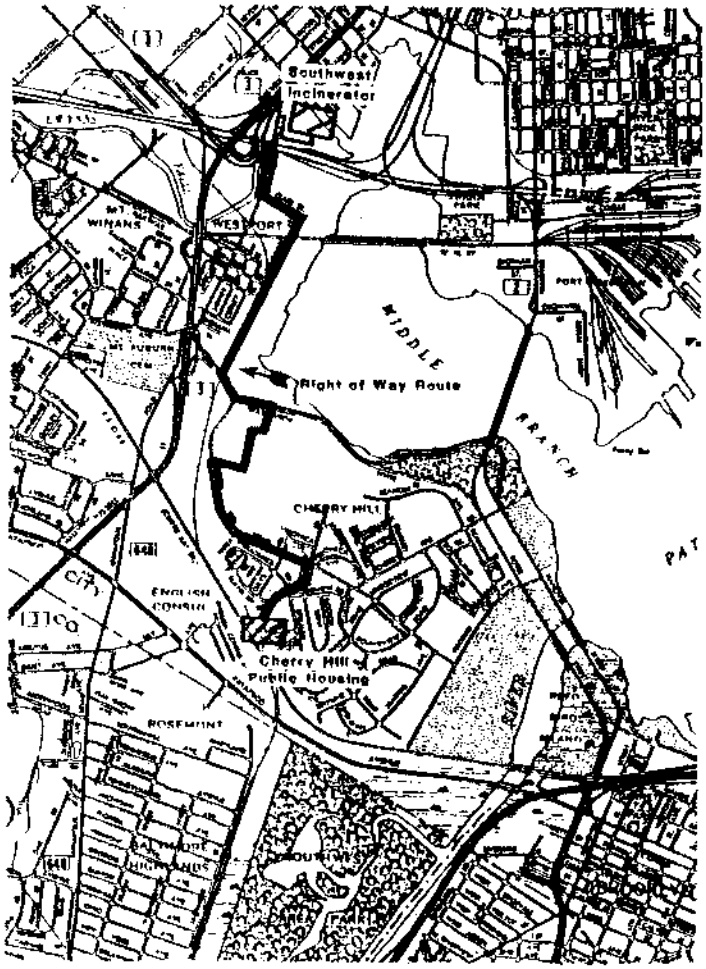


FIGURE 2-2

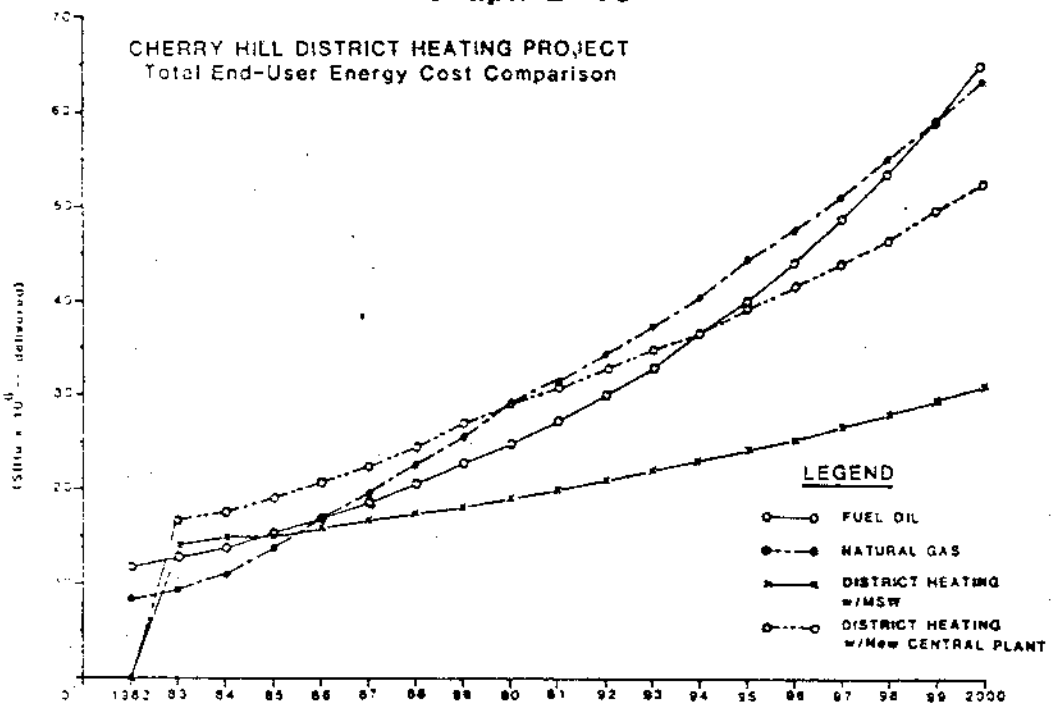
THERMAL TRANSMISSION LINE
Proposed Right of Way

SCALE: 1" = 1000'

Because district heating can make productive use of energy which would otherwise be wasted, an economic asset is created, with benefits flowing to the city and adjacent counties as well as the Housing Authority. The Housing Authority will benefit because it will not only receive a stable, assured, and attractively priced energy source, but it can also look forward to a fuel escalation rate below that of alternative fuels (natural gas or oil). The region's air quality will be improved by the district heating system because

the boilers in the various Housing Authority facilities as well as schools and hospitals, can be shut down, with thermal energy to be drawn from the large waste disposal facility which will operate in any case. Lowering air pollution emissions will make it easier to locate industry within the region which is currently in a non-attainment status for particulates, hydrocarbons, and carbon monoxide.

Graph 2-13

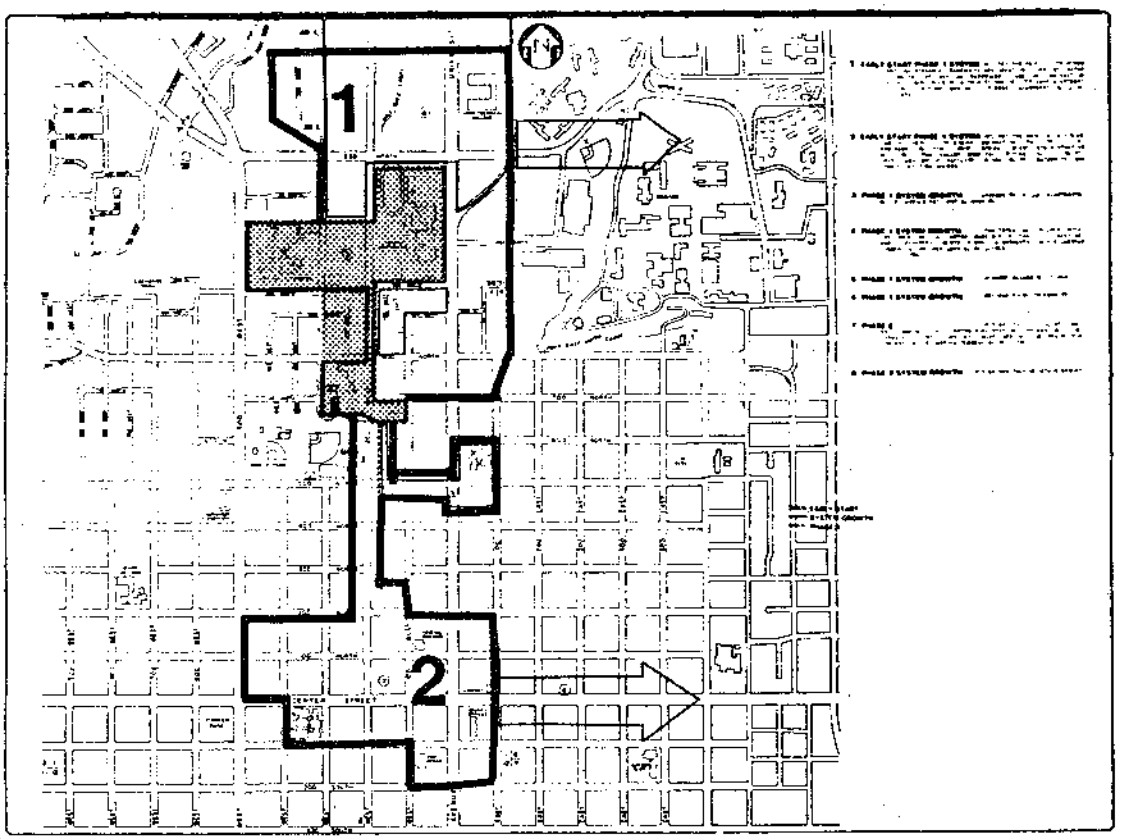


Preliminary estimates suggest that the district heating system, including both the retrofit of the waste disposal facility and construction of the transmission line will cost less than $10,000,000. Retrofitting of Housing Authority and school facilities will cost approximately $7,000,000. Preliminary estimates of benefits suggest that the system will easily pay for itself, and can return benefits to the city and to the Housing Authority in the next 20 years.

(2) Provo, Utah

The Provo City Council recently unanimously approved a modern hot-water cogeneration district heating project for the city. The approval is the result of preliminary feasibility Phase I analysis, and the Phase II design study funded by HUD and cost-shared by the community. Engineering and final design work has begun with plans calling for the system to be in operation by the 1985-86 heating season. Map 2-8 presents the proposed service areas.

Map 2-8



Plans call for converting Provo's existing municipal coal-fired electric power plant to cogeneration and using otherwise rejected heat to supply buildings in the vicinity of the plant that are now heated by natural gas. The Utah Valley Hospital

and new Regional Medical Center, Provo High School buildings, the city recreation center, and numerous other buildings near the plant will be heated by the system from steam that would otherwise be wasted.

Table 2-15

PROVO, UTAH
District Heating Preliminary Design
Initial System - Principal Customers

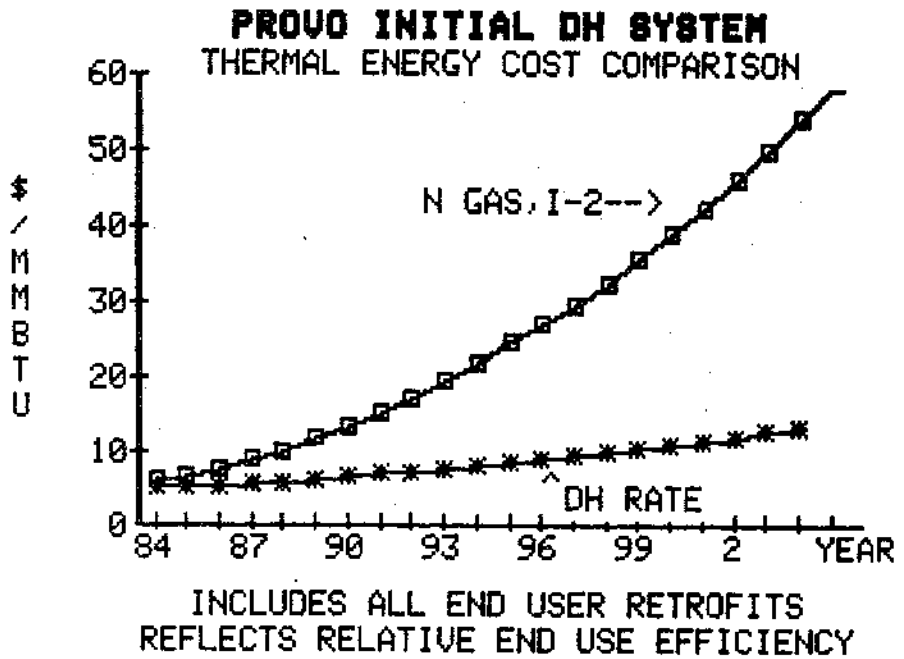
BUILDINGS	SQUARE FEET	PEAK THERMAL LOAD	ANNUAL THERMAL THERMAL LOAD X 10^6 BTU	HEATING SYSTEM TYPE
Recreation Center	28,040	3,633,754 BTUH	6,750	Gas Fired Handling Units
High School				
a) Main Building	156,430	8,115,913 BTUH	12,750	Boiler With Steam Heat
b) D Wing	28,800	992,215 BTUH	1,566	Steam Heat
c) Industrial Arts	16,400	509,175 BTUH	804	Gas Fired Units
L.D.S. Seminary	10,101	427,722 BTUH	675	Steam Heat
School Board Administrative Building	15,100	680,000 BTUH	1,050	Hot Water
HUD Elderly Housing	26,820	769,958 BTU	1,200	Hot Water
Hospital	307,000	12,000,000 BTUH	31,200	Hot Water, Steam Heat Pump
Provo City Power Block	33,310	1,143,669 BTUH	1,800	Steam Heat

Pipelines designed to carry hot water from the plant to the buildings will be installed by the city for an estimated $1,500.00 Each customer will handle the cost of renovating their building to hook up to the system and for their internal distribution system Projected fuel savings estimates are $662,000 for the high school and $1,600,000 for the hospital over the next fifteen years. Both have received grants from the U.S. Department of Energy totaling $234,000 to cover one-half of the building's retrofit costs.

Eventually, the district heating system is planned to expand to serve Provo's downtown business district. The use of municipal refuse derived fuel at the city power plant is another option currently under consideration.

Provo's City Council members believe the system is valuable because it will use an alternative energy resource-Coal, which in turn will lower the cost of It will also decrease the cost of energy production thereby improving the city's competitiveness in attracting new businesses and industry. Furthermore, this action will create an energy source that will allow future generations the greatest flexibility in obtaining economical energy.

Graph 2-14



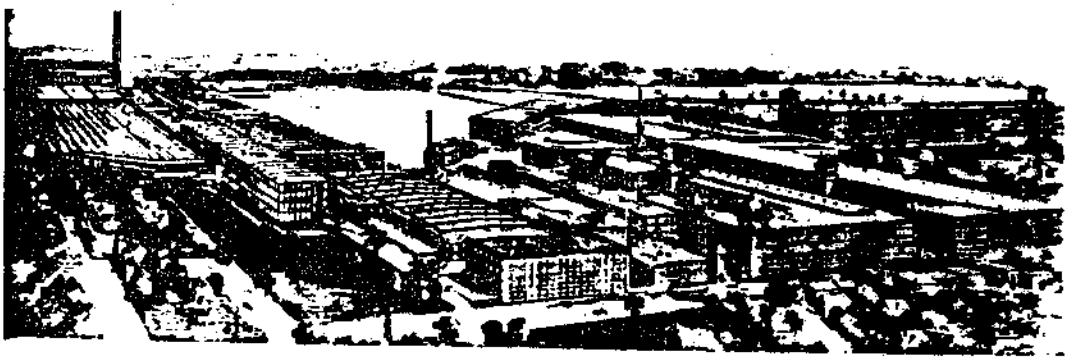
(3) Lawrence, Massachusetts

Lawrence, Massachusetts, a once thriving textile mill city 25 miles north of Boston, is completing a study to determine whether it is feasible to expand its new refuse-to-energy system to serve an industrial area and a residential neighborhood. The new $99.5 million system converts municipal and commercial refuse from eight nearby communities, to electricity and steam. Steam is

piped through a 1.5 mile high-pressure line to provide process steam and space heating to Merrimac Paper, and space heating to 324 units owned by the Lawrence Housing Authority. By replacing oil-fired systems, the two customers are expected to have their energy bills lowered by at least ten percent, starting with the 1984-85 heating season.

A prime example of public/private cooperation, the system is operated by a local firm, Refuse Fuels Associates, with additional equity participation from private investors. A state bond issue, and UDAG loans of $4 million each to Lawrence and the City of Haverhill, provide the balance of the financing. Refuse is separated and shredded at the Haverhill resource recovery facility with a 1,300 ton per day capacity. Trucked to the Lawrence Power Plant, the shredded refuse is used to heat water to create 250,000 pounds per hour of steam, at a temperature of 750° and 600 pounds per square inch. Most of the electricity generated is sold to the New England Power Company.

Ongoing studies are exploring opportunities to serve other customers, in two areas. The first is the Arlington Neighborhood, an older, residential area of mostly frame three-and six-unit flats adjacent to the Arlington Powerhouse. Lawrence Neighborhood Housing Services has been providing rehabilitation services to this dense 6000-person area for several years; district heating, along with building weatherization, is seen as a catalyst to help upgrade one of the city's neediest neighborhoods. A successful project here would demonstrate the ability of district heating to serve low-rise residential areas, rare in this country.



ARLINGTON MILLS COMPLEX
(Circa 1920)

Figure 2-2

Prospects for both projects are encouraging. In the Arlington Neighborhood, analysis continues on ways to finance the steam lines and retrofit the units to receive district heat (total estimated cost is $30 million), ownership and operation of the proposed new line, and the retail price of the energy. In the NCIA, discussions are continuing with several prospective customers over energy prices to be charged, and the size of the steam line to be constructed. The nearby Lawrence General Hospital has recently expressed interest, with its old heating plant in need of major overhaul. Funding for the $180,000 study is being shared equally by RFA, the City Lawrence, and HUD, under a Cooperative Agreement administered by the Energy Division.

(4) Lewiston, Maine

Lewiston, Maine's second largest city, is considering building an electricity and heat producing power plant using a combination of municipal refuse and wood waste for fuel. Municipal refuse disposal is a serious problem in

southern Maine, where available sites are few and tipping fees are high. A plant that would convert the refuse into a source of power is a potentially attractive opportunity to this city of 41,000 people.

Along with many other old New England mill towns, Lewiston's economic base has changed in recent years. Some mills have been in continuous ownership for years. Many other building are occupied by smaller manufacturing or warehousing firms, now the mainstays of the city's economy. The Androscoggin River formerly provided power via a series of canals. The water wheels are long gone, but the city is again looking to the river for power; a dam to produce hydroelectric power is also under consideration.

Lower cost electric energy and heat would help the city's industries maintain their competitive position. Preliminary studies, supported by HUD, have shown the potential for economically producing power by burning a combination of municipal refuse and wood waste, abundant in this area. A plant site has been identified in the center of the industrial area, and several prospective customers are financially supporting continuing study of system feasibility.

Immediately adjacent to this area is Little Canada, a low-income neighborhood of frame, mostly rental buildings. Many have no central heating above the ground floor, with space heaters providing the only protection against harsh Maine winters. Although Community Development funds have resulted in some infrastructure improvements, district heating, and attendant building upgrading, could dramatically raise the residents' living standards. The state also looks to a new power plant to help lower air pollution levels, and has contributed $70,000 to the study as a result.

Should the plant be built, it would represent a return to the original design of district heating systems, where electric generating plants were built in central cities with excess heat drawn off to provide heat and process steam to nearby buildings. In Lewiston, there would be the additional benefits of resolving important environmental problems of landfilling and air pollution.

(5) New York City, New York

In New York City, the Brooklyn Navy Yard Development Corporation (BNYDC) is looking to the possibility of joint district heating and electricity generation as a means of increasing the attractiveness of its industrial park to present and prospective customers. Sold to New York City by the U.S. Navy in 1970, the Brooklyn Navy Yard (BNY) now employs 2,200 people in its 45 firms, which include a ship builder, furniture designers, crystal importers, printers, and many others. Its 261 acres are located on prime waterfront land surrounded by the Bedfor-Stuyvesant, Williamsburg, and Fort Greene communities, all with high unemployment. The non-profit BNYDC operates the Yard under a 99-year lease with the City's Department of General Services.

Attractive energy prices for its tenants are essential for the BNYDC to achieve its development objectives. Current energy prices paid by the tenants are higher than in the rest of the Ctiy, already the highest in the country. The Yard was originally served by its own coal-fired plant, generating both electricity and high-pressure steam. The power plant was mothballed about ten years ago. Today, electricity is purchased from Consolidated Edison which also provided steam until 1982. Steam is now being supplied by temporary on-site

gas-fired boilers, using the existing distribution system. The cost of the substantial line losses in the old pipe system are borne by the tenants, accounting in part for the high prices.

Engineering and economic studies concluded that much of the power plant and both the steam and electricity distribution systems could be upgraded as part of a self-contained district heating system. Steam could be provided at perhaps 45 percent or less of the current cost, with credit given for electricity sales. Substantial further community benefits could be obtained by serving adjacent public housing complexes with over 5,000 units, and a large sewage treatment plant within the Yard, now under construction. Methane produced by the plant could also provide fuel to supplement the natural gas supplied by Brooklyn Union Gas.

With the prospects for joint production of heat and electricity so promising, and the community benefits so favorable, the city in December 1983, requested proposals from private entrepreneurs to act as developers, owners, and operators of a BNY energy system. As of the Fall of 1984, negotiations with one bidder were continuing, with the discussions centering on configuring a financial package that would provide long-term service assurances to the customers and a satisfactory profit to the developer, while limiting the city's liability. Concurrently, additional studies are underway to specify technical characteristics of the system, including line losses, as a basis for finalizing the financial package.

Support for the $319,000 study now underway is being provided by New York City, the BNYDC, the New York City Housing Authority, and Brooklyn Union Gas, supplemented by $75,000 from HUD. Total estimated cost of the system is approximately $40 million, to be financed through a combination of tax-exempt

bonds, private equity raised through either a leveraged lease or limited partnership, and a UDAG loan. The city's expected share of the profits would be used to finance further capital improvements in the Yard.

(6) Springfield, Massachusetts

In the five decades prior to 1975, Springfield had suffered economic deline in its downtown area similar to other northcentral and northeastern cities. The closing of the city's largest department store in 1975 was the catalyst for the formulation of a coalition of businesses, government, and the press to bring about the revitalization of downtown Springfield. Through an innovative investment strategy called a "mortgage pool", the city has been able to leverage a dramatic economic development turnaround that has become a model for other older middle-sized cities. While $30 million in HUD, UDAG and CDBG grants have been used, over 75% of the development funding has come from private sector sources. The district heating project designed to serve the downtown and adjacent areas is viewed as a further step in the strategy for providing an economically stable and attractive energy base for continued development in Springfield.

Fuel flexibility was a key concern in supplying customers in the downtown area during a Phase I feasibility study funded by HUD. The study area, consisting of a high density central downtown commercial area, an industrial area adjacent to the immediate north, and a high density residential district adjacent to the immediate south, was comprised of 1200 acres and over 2000 buildings.

Nine heat source systems were identified and selected for preliminary engineering and economic analysis. Three of these sources were selected as components of a phased system to be designed under the follow-up Phase II HUD

grant. Rehabilitation of three existing central boiler plants owned by the city are inital heat sources to be replaced later by hot water generated at the new refuse-fired incineration and energy recovery facility located directly across the Connecticut River from the downtown area. Finally, retrofit of the existing West Springfield electric generating station to cogeneration will supply later phases of system expansion.

The initial phase of the system will be designed to serve approximately 1,110,000 square feet of floor space in the downtown area including new hotel, commercial and residential space now in the planning stages. Estimates indicate that 8 megawatts of peak heat capacity will be required.

In the final configuration, the district heating system will result in a considerable reduction in fossil fuel consumption. It is estimated that consumption of heating oil will be reduced by over 8 million gallons per year, coal consumption will be reduced by more than 4,000 tons per year, and natural gas consumption will be reduced by up to 637 million cubic feet per year. These reductions in fuel consumption are in accord with our national policy for energy independence.

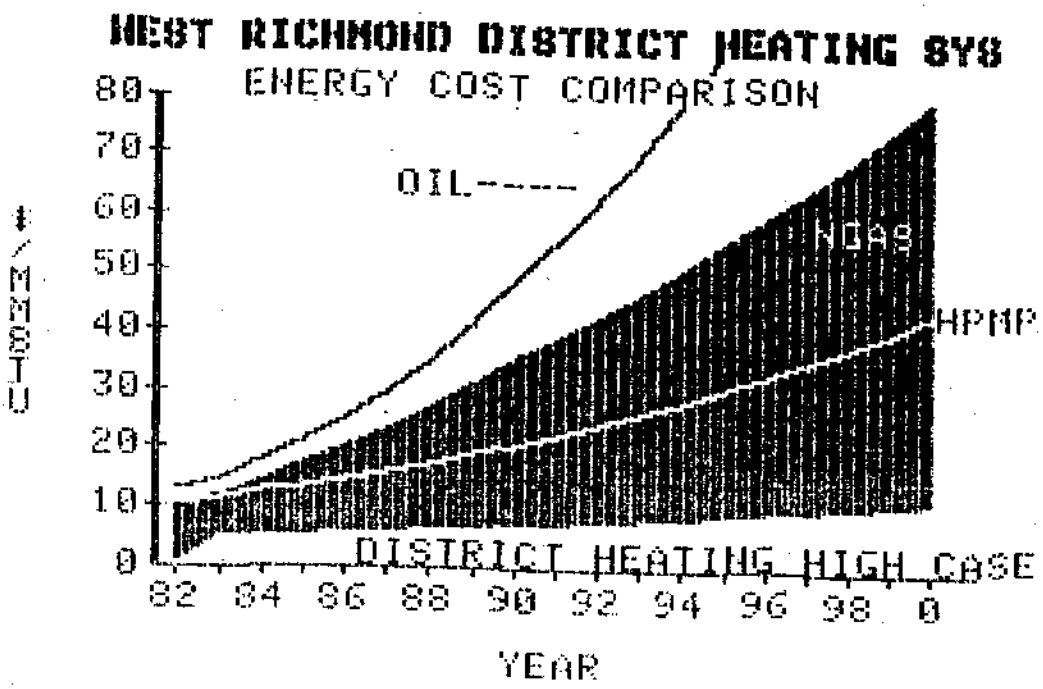
(7) Richmond, Indiana

In the Spring of 1985, the City of Richmond, Indiana, expects to begin construction of a new district heating system that will provide long-term stable energy for 60 acres of rose-growing greenhouses, a mainstay of Richmond's economy. Heat will be provided through a quarter mile long, hot water pipe from the Richmond State Hospital coal-fired boiler plant.

Richmond, a city of 44,000 people located approximately 70 miles east of Indianapolis, includes the largest concentration of rose growers in the country. Rose growing is highly energy-intensive with about 40 percent of

production costs going to purchase energy. The E.G. Hill Company, one of the city's largest growers, has undertaken many conservation measures to reduce energy costs, but total energy costs remain high. Currently, the company burns over 700,000 gallons of fuel oil annually, to heat its seven acres of greenhouse.

Graph 2-15

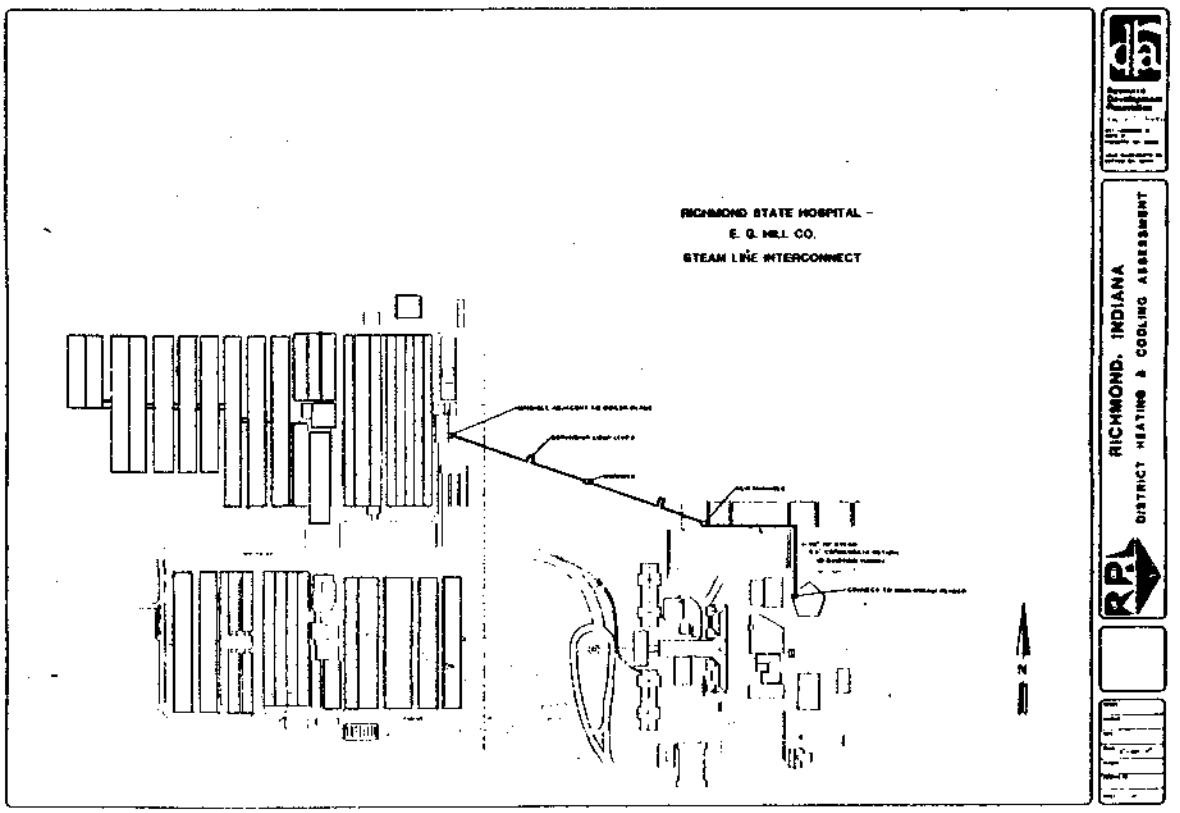


The opportunity to obtain stable, secure energy by tapping the Hospital's excess boiler capacity is attractive to the Company because it would enable it to make long-term budgeting decisions. But several obstacles had to be overcome.

District heating was first identified in a 1982 assessment report to the city, funded by a HUD grant. The hospital's four coal-fired boilers can supply 140,000 lbs of steam per hour, far more than needed, but are in need of major refurbishing. Questions also were raised about additional pollution to be generated by burning more Indiana coal. And the source of financing for the approximately $2,000,000 project needed to be resolved.

Cooperative, diligent efforts on the part of the company and many public entities have produced results. With the city's Energy Department and municipal electric utiltity (Richmond Power and Light) leading the way, the Indiana Department of Administration (owner of the boilers) supplied funds to refurbish the hospital boilers, air pollution permits were granted after determining that the system would be in compliance, other state approvals were received, and the rose company agreed to invest about $200,000 in the system. The project received a significant boost when the U.S. Department of Commerce supplied $500,000 in an Emergency Jobs Program Grant. The following map indicates the spatial relationships of the hospital and the greenhouses, and the proposed routing for the distribution system.

Figure 2-3



The city's role also includes ownership of the distribution system. In effect, the hospital will wholesale energy to the city, which in turn will retail it to E.G. Hill. The distribution system will be sized with sufficient capacity to serve other potential customers. Should the system prove successful, new customers may be added with the possibility of even lower rates later. And that, in turn, may provide incentives for further serious analysis of other district heating opportunities in Richmond, including the possibility of supplying cooling tower thermal energy from the RP&L generating plant to a prospective new industry.

For its successful efforts to develop the hospital-greenhouse district heating project, Richmond was awarded by the Department of Energy a Technology Transfer 80's National Award for Energy Innovation.

(8) Columbus, Ohio

Heat energy from municipal refuse is a viable approach for a proposed district heating system for the Columbus area. That is the conclusion of a study recently completed by Danish government expert consultants as part of an international cooperative effort to bring modern European district heating technology to the U.S. The Danish officials selected Columbus as a good candidate for district heating following a Phase I study grant given to the city by HUD.

The Phase I study results proved to be inconclusive since it covered a broad analysis of city service areas, but did not focus on specific projects. The European approach differed by identifying viable district heating service areas, termed "heat islands", to start a system. Later, these heat islands could be connected by hot water pipelines to form a larger system. They also looked for nearby sources of heat that could be used to supply the district heating system.

Attention was centered on the recently completed Columbus Refuse and Coal-fired Municipal Electric Power Plant with a capacity of 3,000 tons per day. The plant can generate up to 90 megawatts of electricity. The power plant could also be used to supply a nearby prison workhouse with about three megawatts of peak capacity heating requirement. This relatively small amount of heat capacity could either be supplied directly from the power plant boilers or extracted after electricity had been generated. Heat distribution to the workhouse would consist of 1,800 feet of pipe carrying 200°F hot water. Subsequent stages of the system would serve a planned state penitentiary hospital, a conference center, and possibly downtown Columbus including a nearby redevelopment area.

The initial project, which has been verified as economically viable over conventional gas boilers in the building, provides a source of revenue for the refuse plant. Columbus views the approach of district heating to be a way the community can use the refuse plant as a resource for supplying stable, competitive energy as part of the effort to retain existing and attract new commercial and industrial interests to the city.

(9) Galax, Virginia

Refuse-to-energy systems can work to the mutual benefit of cities and local industry even in small communities. That's the conclusion to be reached from the experience of Galax, Virginia, a town of 6,600 people in southwestern Virginia.

Disposal of all domestic and industrial solid waste in the city is in sanitary landfills, all of which are near capacity. Considering alternative disposal methods, the city applied for and received a grant from HUD under

its district heating and cooling demonstration program. This 1982 study determined that sufficient refuse was available to supply virtually all the process and space heating needs of Hanes Knitwear Company, Galax's largest employer with 1,200 workers. After a period of negotiations and further design, construction contracts were let for fabrication of the heat recovery incinerator in June 1984.

The system will consist of an 80 ton per day rotary kiln type incinerator which will supply approximately 21,000 lbs per hour of steam to Hanes, sufficient to meet all the Company's summer needs. Winter peaking will be served through the existing fuel-oil fired boilers. All the city's 48 tons per day of refuse will be trucked to the new plant; the remainder will be supplied by Hanes.

The incinerator will be located on the Hanes property and leased to the city for a nominal sum. The city will own and operate the plant and transmission pipes, selling steam to the Company, initally at a price of $5.47 per thousand pounds, escalating at the sixth and tenth years of the 15-year contract. This price is substantially below the Company's present steam costs. The system has been designed to meet all applicable air pollution standards; a permit from the Virginia Air Pollution Control Board is expected to be approved shortly.

Funds for the just-under $2,000,000 system will come from the city's share of Community Development Block Grant funds and funds from the Applachian Regional Commission, a combined total of about $700,000. In addition, $1,300,000 in general obligation bonds will be issued by the city. Initial bids for building and steam line construction exceeded the project budget; modifications now being made are expected to keep cost within the original budget. Plans now call for the system to be available for testing in May, 1985.

(10) Holland, Michigan

The possibility of using a coal-fired municipal electric power plant as a reliable, affordable heat source for local industrial base customers and Hope College motivated the City of Holland to apply for a HUD Phase I district heating feasibility assessment grant. The results of the Phase I study demonstrated that energy could be supplied for as little as $7.00 per million Btu, a considerable savings over escalating conventional supplies. Holland has proceeded with city funding to design and subsequently construct the system.

Initially, Hope College, Park-Daves and Heinz Co. have signed letters of intent and have financially supported the design study. The first phase of the district heating system will be steam distribution since these existing customers are currently located near the power plant and are using steam for heating and manufacturing processes. Later expansion phases will use hot water to serve the downtown area and users located further from the power plant.

The economic analysis indicates a promising outlook for a Holland district heating system. The investment of $14 million in local facilities to cogenerate electrical power and thermal energy for local customers will generate annual savings of about $3,000,000. The savings represent a net number after payment of all debt service, operation and maintenance costs. The annual savings will escalate substantially in future years as the price of natural gas escalates at a greater rate than that anticipated for coal. This investment in local energy facilities, as compared to purchase of entitlement in a remote generating facility enhances the economy of the local community. A sizeable portion of the annual operating expenses will also be spent locally. The total for these items is estimated at roughly $1,000,000 per year contributed to local economic activity. This number also rolls over several times in the community when considering total economic activity.

The City of Holland has concluded that the overall benefits of a district heating system would outweigh the inital capital investment, and would indicate Holland's commitment to: a) achieving a community-wide improvement in fuel use efficiency, energy conservation and energy costs; b) improving the future natural environment of Holland by limiting the number of air emission sources and by reducing thermal discharges into Lake Macatawa; and c) attaining the national energy goal of reducing scarce fuel consumption and the dependence on imported energy sources. A district heating system in Holland would provide a lower cost source of thermal and electrical energy. This will contribute to local community and economic development activity in the form of jobs, the stabilization and growth of the downtown district, and the retention of funds that otherwise might be spent outside the community.

C. DOWNTOWN STEAM SYSTEMS

While substantial interest in new DHC system development is being demonstrated, the future of existing downtown steam systems remains uncertain. As indicated earlier, investor-owned utility central business district steam systems have declined as a result of locating new condensing power stations in remote areas; competition with cheap oil and gas after World War II; urban renewal programs sponsored in major central cities; and the environmental movement towards gaseous and liquid fuels during the 1960's.

During the transition period of the late 1970's and early 1980's, several utility-owned downtown steam systems have been offered for sale. Where this has occurred, e.g., Pittsburgh, Pennsylvania; Baltimore, Maryland; St. Louis, Missouri; and Rochester, New York; private businesses, entrepreneurs and customers have moved to acquire these systems. New owners can sometimes enjoy the advantage of not being regulated by the state public service commission. On the other hand, in Baltimore, Maryland, the new owner, Baltimore Thermal,

continues to be regulated by the Maryland Public Service Commission. In part, the change in ownership itself acts to revitalize these downtown steam systems as the DHC system can now aggressively compete in the energy marketplace against natural gas and oil suppliers. The following paragraphs summarize local efforts in four cities to revitalize existing downtown steam systems.

Pittsburgh Allegheny County Thermal, Limited

"Today, in downtown Pittsburgh, there is a viable alternative to large capital expenditures for individually owned and operated heating systems--Pittsburgh Allegheny County Thermal, Ltd. (PACT), a non-profit corporation.

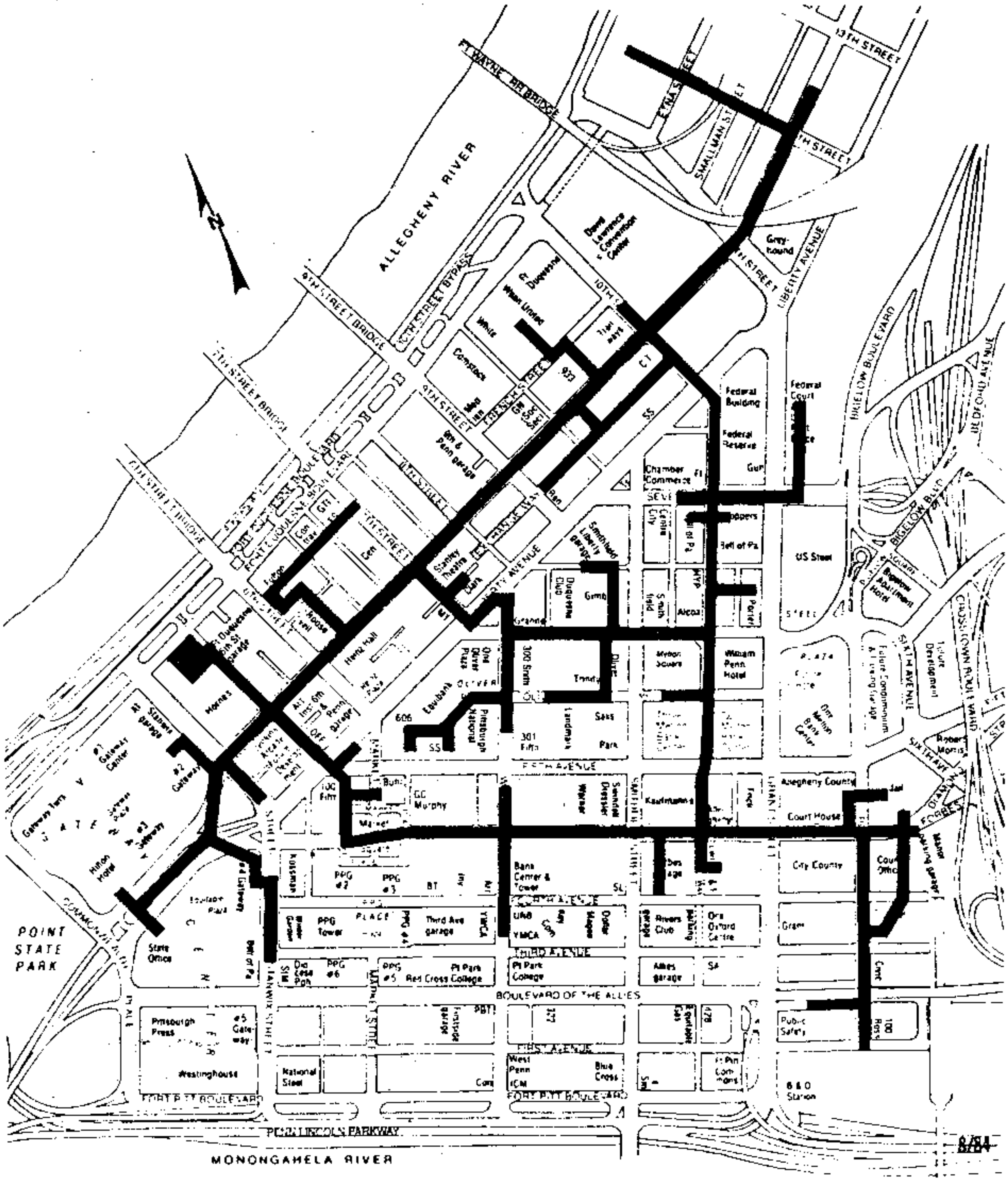
PACT is an aggressive heating organization of downtown Pittsburgh businesses and institutions in the public and private sectors. PACT is reliably providing centralized steam heating for the Golden Triangle.

Formed in 1982, PACT took over the steam heating system from Allegheny County Steam Heating Company. With a $6.5 million capital investment, the system has undergone many major improvements and now PACT is moving ahead in serving its members with reliable steam heat. PACT serves more than 100 businesses and government organizations on its steam distribution system. These PACT members used more than 400 million pounds of steam in the first year alone. And PACT has the additional capacity to service new downtown business or buildings . The PACT centralized steam heating system eliminates the need for inhouse heating equipment. The boiler facilities are housed at PACT's new Stanwix Boiler Plant and steam is piped through insulated lines to customers.

PACT is investigating the use of alternate fuel sources and options like "self-help", i.e., direct purchase of natural gas from the producers, gas to keep the steam distribution system the most economical form of heating in Pittsburgh.

Map 2-9

PACT DISTRIBUTION SYSTEM



Use of PACT's centralized steam system provides subscribers with substantial cost savings in two ways--savings from the cost of purchasing in-house heating equipment and savings from the cost of operating that equipment. By eliminating on-site boilers and water heating systems in downtown buildings, valuable space is made available for other uses. In addition, the continued maintenance, chemicals and utilities required to operate an in-house boiler system are no longer the responsibility of the building owner when the building is serviced by the steam system. PACT can provide a more economical source of heat for downtown buildings than in-house systems.

PACT's new steam generating plant operates at much higher efficiencies than the previous central steam boiler plant due to four new computerized boilers plus economizers that recover heat from flue gases. In addition, fuel costs for the PACT central steam system are substanially lower than in-house systems because of reduced fuel rates for large volume users like PACT. The graph below indicates average costs of steam from various sources."

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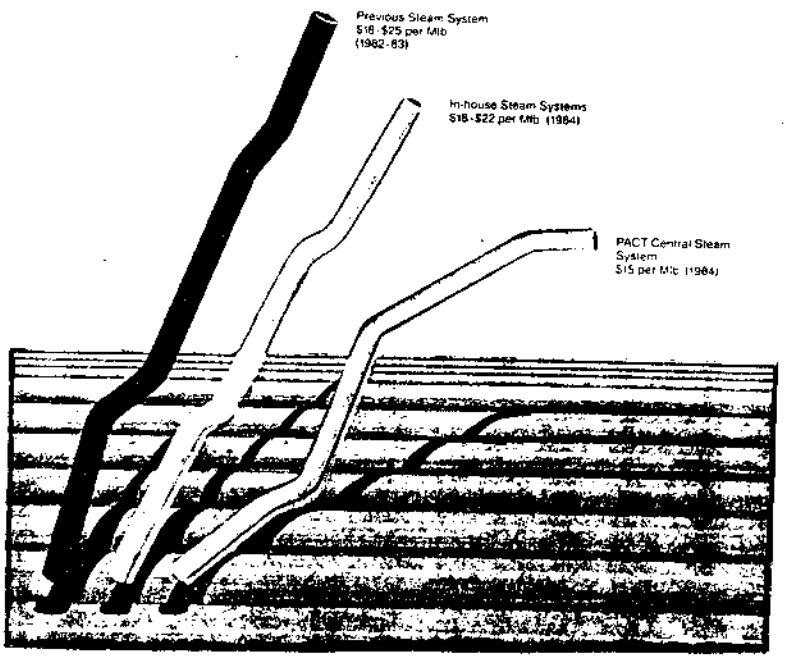
Graph 2-16



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St. Louis District Heating

During the 1970's Union Electric evaluated alternatives for revitalizing the downtown St. Louis district steam system. This process involved Union Electric, the City of St. Louis, and the Bi-state Development Authority. It was determined by all parties that a new owner/operator could best undertake revitalization efforts. It was further determined that both the downtown steam system and the city's municipal solid waste program could be effectively linked and benefit one another.

Consequently, a multi-phased revitalization plan was developed over a two year period. This plan, which is now well into implementation, includes:

- Bi-state Development Authority acquisition of the downtown steam system
- Securing non-regulatory status from the Missouri Public Service Commission
- Converting the Ashley Street gas-fired boiler plant to coal
- Construction of a new mass-burning resource recovery plant
- Involvement of a third party full-service vendor

The city and Bi-State Development Authority have now selected a full service vendor to build, own, and operate the new resource recovery plant, and to operate the downtown district heating system. The Missouri legislature has exempted the steam system from regulation and the parties are now finalizing the acquisition/transition plan from Union Electric to the owner-operator.

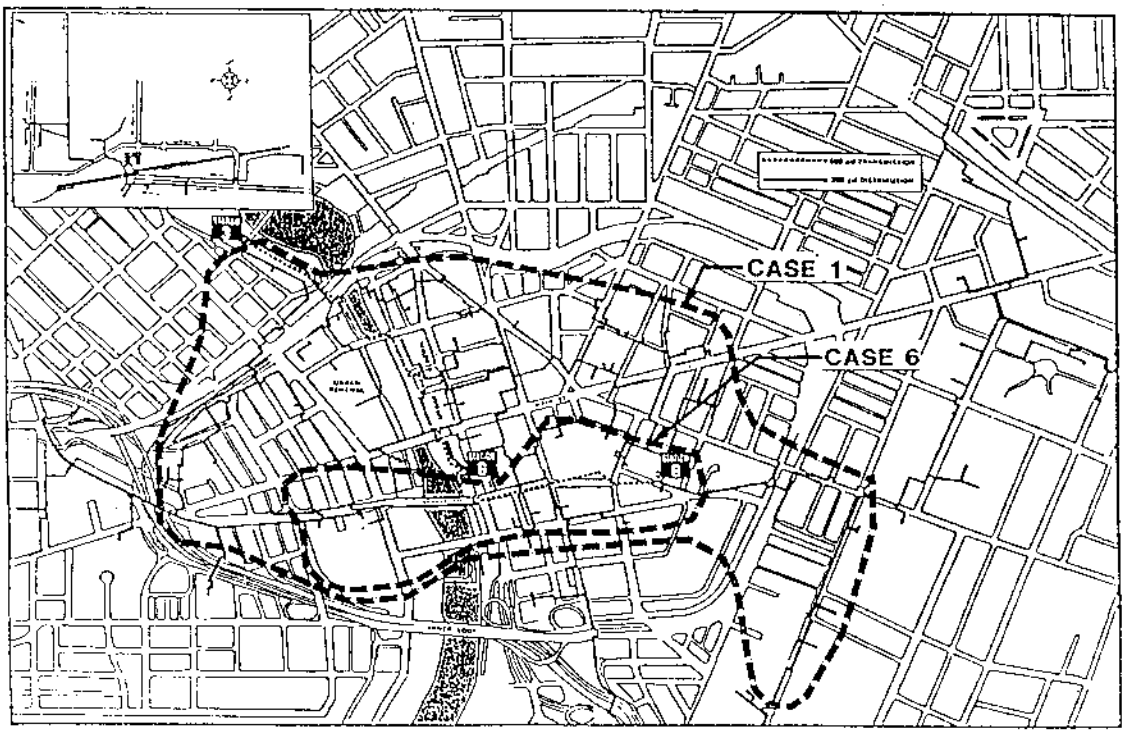
Interestingly, HUD through its sponsorship of the U.S. Conference of Mayors Technical Assistance Team played a key role in developing the revitalization strategy. Many of the recommendations that are being implemented today were identified and described as part of the Technical Assistance Team's visit to St. Louis in 1983.

Rochester, New York

Rochester District Heating Cooperative, initiated a detailed analysis and evaluation of the downtown district heating system in May, 1984. The purpose of this analysis was to evaluate the community's technical, financial, and institutional alternatives for reconfiguring and revitalizaing the steam system.

Several conclusions were reached as a result of RDH technical analysis and evaluation. First, technical opportunities exist for reconfiguring an efficient downtown steam system. Although service will have to be discontinued to a limited number of lines, a substantial number of the existing customers can be efficiently served from the reconfigured system. Second, the existing power plant will be unattractive as the base load steam station because of the relatively low fuel efficiency of this older steam plant. A new, modern, efficient boiler plant will be constructed to supply 97% -98% of the base load, with the existing power plant serving as a reliable peaking and backup plant.

Map 2-10



ROCHESTER STEAM SYSTEM

RDH also analyzed and evaluated alternative ownership options for the reconfigured, revitalized downtown steam system. Specifically, RDH considered:

- Continued RG&E ownership
- Private Company
- Municipal utility
- Cooperative

As a result of the analysis, RDH determined that the cooperative ownership option was the most feasible and attractive. The RDH members have thoroughly analyzed and evaluated the cooperative ownership option and have determined it to be technically, fianacially, and institutionally feasible and attractive. The co-op option will allow the customers themselves to directly influence the economics of energy supply to their facilities. Many current customers including the Xerox Corporation, Kodak, Genesee Hospital, local banks, the City of Rochester, Monroe County, and others have made a commitment to pursue the successful implementation of RDH.

An attractive alternative to system abandonment is now available to the Rochester community, customers, RG&E, and the Public Service Commission. A smaller, reconfigured version of the existing system will result in more efficient energy distribution given that a number of the system's run-out pipes operate with a relatively high loss to load ratio. RDH has evaluated system reconfiguration by analyzing and evaluating six scaled-back configurations. Each of the configurations or cases resulted in viable operating scenarios from the largest reconfigured system to the smallest. The configurations were analyzed on a yearly and monthly basis to determine the respective energy consumption profiles. RDH will pursue system acquisition/stabilization under reconfiguration Case No. 1.

Table 2-16

UNIT STEAM COST *
PER 1000 LBS.

CASES	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 1 W/COAL	CASE 1 COAL & COGEN
FUEL COST	7.35	7.36	7.30	7.29	7.15	7.05	5.22	5.89
MAINTENANCE & OPERATION	2.26	2.63	2.47	2.74	2.44	2.99	2.97	2.99
NEW DEBT	1.84	2.09	2.03	2.16	2.01	2.67	2.69	3.36
COGENERATION CREDIT	0	0	0	0	0	0	0	-1.74
TOTAL	11.45	12.08	11.80	12.19	11.60	12.71	10.88	10.50

Baltimore District Steam System

The remainder of the 1980's will continue to be a period of transition for downtown, central business district steam systems. Changes in ownership will likely occur for several systems, while others, e.g., Hartford, Connecticut and San Francisco, California will experience revitalization and expansion by the respective investor-owned utilities. Still others will suffer indecision and neglect by utilities who view themselves as exclusively electric or gas companies. In all cases the transition will require active participation by utilities, cities, customers and state agencies as communities move to reorganize, revitalize, and switch to solid fuels and cogeneration.

Baltimore Gas and Electric has recently negotiated the sale of the downtown Baltimore steam system to a new private corporation, Baltimore Thermal. The Baltimore system, one of the nation's largest, is now embarking on a revitalization and expansion program. The Northeast Maryland Waste Disposal Authority, the City of Baltimore, Baltimore Thermal and SIGNAL RESCO

have recently negotiated an agreement which provides for the sale of approximately 150,000 lbs. an hour of steam to the downtown steam system from the new RESCO owned, resource recovery plant.

D. DHC AND RESOURCE RECOVERY

Following a somewhat shaky start during the 1960's, resource recovery (municipal waste-to-energy facilities) (MSW) are now coming of age. In 1975 the Environmental Protection Agency estimated that urban centers of the United Sates produced 150,000,000 tons per year of municipal solid waste.

As energy prices rose during the 1970's and early 1980's and as the cost of land disposal increased to burdensome levels, cities, counties, industries and businesses began to seriously pursue the development of waste-to-energy facilities. Initially, many of these systems were financially secured by tipping fees (cost per ton for MSW disposal) and revenues from the sale of electricity; however, in an effort to make the economics of resource recovery more attractive, system developers have moved to consider a third revenue stream --thermal sales. Although, under certain site-specific circumstances it is possible to develop a municipal waste-to-energy facility adjacent to a large thermal process load, the development of a thermal market often requires the ability to sell thermal energy on a multi-sectoral basis. Consequently, resource recovery project developers are becoming cognizant of the advantages derived from system configurations which include thermal as well as electrical and tipping fee revenues.

The trend towards linking MSW facility development and DHC was documented during the initial HUD/DOE feasibility assessments. Although, linking the local MSW project and the local DHC project complicates the project planning and development, total system economics are improved at both ends with benefits accruing to both the thermal customer and in the resulting tipping fee.

Today, DHC and MSW move towards one another in spite of the institutional obstacles. The long-term plans of DHC systems often anticipate the ultimate development of a municipal waste-to-energy facility in order to provide indigenous, solid fuel cogeneration. Similarily MSW projects which were initially undertaken based on tip fee and electric revenues are now working to develop DHC thermal markets, e.g., Columbus, Ohio.

As of the Spring of 1984 there were 29,835 tons per day of MSW/ resource recovery capacity in the United States. At that time, an additional 7,701 tons per day was under construction with an additional 17,962 tons per day in the final planning and financing stages of development. The total projects in operation, under construction and in final planning, account for less than 2% of the potential indigenous urban energy resource potential represented by waste-to-energy facilities.

Table 2-17 on the following pages, identifies and describes several illustrative municipal waste-to-energy facilities in the United States. A more complete listing of these facilities can be found in the National Resource Recovery Association's Annual Report for 1984.

Table 2-17

ILLUSTRATIVE RESOURCE RECOVERY MUNICIPAL WASTE-TO-ENERGY FACILITIES

LOCATION & MAJOR PARTICIPANTS	PROCESSES	PRODUCTS & USES	CAPACITY (TONS PER DAY)	STATUS
ALASKA Sitka City & Borough of Sitka; McGraw Custom Homes & Sigoure Freres (joint venture);	Mass Burning of MSW and sewage sludge in modular combustion unit	Steam for heating use at Sheldon Jackson College	25	Under construction; operation expected in 11/84
CALIFORNIA Susanville Lassen Community College; Lassen County; Lahontan Alternative Energy Systems	Mass burning of municipal waste and wood chips, electricity generation	Steam & electricity for use by College; excess electricity sold to utility; excess steam sold to industry	96	Under construction; start-up expected in 1984
KENTUCKY Campbellsville City (owner); Consumat Systems, Inc. (builder/operator)	Mass burning in modular combustion units	Steam for process use by Union Underwear Co.	100	Construction expected to begin in 1984
ILLINOIS Chicago (Northwest Waste-to-Energy Facility)	Mass burning in water-wall incenerators	Steam for process use on-site and by Brach Candy Co.	1600	Operational
MAINE Auburn City (owner); Consumat Systems, Inc. (operator)	Mass burning in modular incenerator	Steam for heat and process at Pioneer Plastics	200	Operational since 4/81

Table 2-17 cont.

MARYLAND Baltimore (Southwest Resource Recovery Facility) City; Baltimore County; Northeast Md. Waste Disposal Authority; Baltimore Refuse Energy Systems Co. (a Signal RESCO partnership)	Mass burning in water-wall furnace, electricity generation, ferrous recovery from ash	Hot Water Sales - Cherry Hill; Steam Sales - Baltimore Thermal; Electric Sales - BG&E	2250	Under construction; operation expected 4/85
Harford County Northeast Maryland Waste Disposal Authority; Harford County; Consumat Systems & RECO Industries (joint venture)	Mass burning in modular combustion unit	Steam for space heating & process use by U.S. Army at Aberdeen Proving Ground	300	Bonds expected to be issued in late 1984; construction to begin in late 1984 with operation in 19 months
MASSACHUSETTS Saugus Thirteen Communities including Saugus and part of Northern Boston; RESCO	Mass burning in water-wall furnaces, magnetic separation	Steam for electrical generation and industrial use, ferrous metals	1500	Operational
MICHIGAN Detroit City; Combustion Engineering, Inc.	Flail milling, trommel screening, secondary shredding, burning RDF in on-site dedicated boilers, electricity generation in 47 Mw turbogenerator	Steam for Detroit Edison's central heating system; electricity for sale to Detroit Edison; ferrous metals	3000	Negotiating with Combustion Engineering prior to contract signing; tax counsel review & permit applications in process; preparing revenue bond issue with equity participation to finance the facility
NEW HAMPSHIRE Durham (Lamprey Regional Solid Waste Cooperative)	Mass burning in modular incinerator	Steam for heating & hot water at Univ. of N.H.	108	Operational since 9/80

Table 2-17 cont.

NORTH CAROLINA New Hanover County New Hanover County (owner); Clark-Kenith	Mass burning in water-wall boilers; cogeneration of steam and electricity	Steam for use by W.R. Grace Co. (agrochemical mfr), electricity for sale to Carolina Power & Light	200	Under construction; start-up expected in Fall 1984
OHIO Akron City; (owner); Tricil Resources, Inc. (operator)	Shredding magnetic separation, burning RDF in semi-suspension stoker-grate boiler	Steam for urban and industrial heating and cooling, ferrous metals, hot water for residential and commercial heating	1000	Modifications & performance test successfully completed 12/82; plant is certified & fully operational; steam & hot water being generated by burning refuse
Columbus City (owner/operator)	Shredding, magnetic separation, burning of shredded refuse with supplemental coal in semi-suspension stoker-grate boiler to produce steam and generate electricity	Electricity for city customers	2000	Two units operational (60MW); third to be on-line by mid-1984
OREGON Marion County County; Ogden-Martin	Mass burning in water-wall furnaces, magnetic separation from ash	Electricity for local utility, ferrous metals	550	Contracts signed between County & Trans Energy, and utility & Trans Energy; construction expected 1984 with operation, 1986
TENNESSEE Nashville Nashville Thermal Transfer Corp. (owner/operator)	Mass burning in water-wall incinerator	Steam and chilled water for urban heating and cooling; expansion adds electricity for sale to TVA	720	Operating since 1974; expansion to be complete early 1986, increasing design capacity to 1120
VIRGINIA Harrisonburg City (owner & operator)	Mass burning	Steam for heating & cooling at James Madison Univ.	100	Operating since 12/82

E. STATE PROGRAMS

While the federal government, through HUD and DOE, has sponsored a limited district heating and cooling program on a national level, certain state governments also recognized the impact that DHC could have in furthering economic development and in stablizing energy costs. The state programs are principally administered through energy departments or other agencies charged with supporting energy conservation and development programs.

The states that specifically support DHC projects and their applications in cities are Minnesota, Michigan and New York. There are other states that indirectly evaluate DHC through resource recovery, geothermal, solar, indigenous fuel utilization, or other programs, but in these cases the source technology is the principal focus and DHC investigations are limited.

Of the three states with legitimate, organized district heating programs, Minnesota represents the oldest and most established. Still in the developmental stages, Michigan's DHC program promises potential; however, it reflects the lowest level of state financial commitment. The New York program is the best funded of the three and the most ambitious.

The following pages present brief summaries of how these three states are pursuing district heating as one element in a total energy development program.

Minnesota and Michigan's programs are summarized while a more detailed treatment of New York's is presented. New York's state DHC program can serve as a model for other states.

Minnesota

Minnesota Department of Energy, Planning and Development - Energy Division

Minnesota has the oldest program to support district heating. This is due in part to the state's long experience with district heating and local community acceptance of thermal energy, e.g., St. Paul, Willmar. Part is likely due to the cost of heating in Minnesota with conventional fuels, and part is due to the state's awareness of the long-term need to develop local alternative energy resources. The following paragraphs describe Minnesota's recommended program for communities that wish to look at DHC. The state encourages these efforts and financially supports project development through assessment grants and capital assistance.

In order to assist the cities, the State of Minnesota prepared District Heating Planning in Minnesota- A Community Guidebook. This book offers a city essentially a step by step description of how to conduct a district heating assessment. These steps are:

Independent Assessment - This is the first step in the process which the state recommends the cities undertake with their budgets. The independent assessment is a "community survey" that identifies whether or not basic conditions favorable for district heating are present in a community. This is accomplished by local effort.

Feasibility Screening - If the independent assessment yields positive results, the next step is to prepare priliminary estimates of loads, costs, heat sources, etc., and to begin to establish community consensus. The state indicates that this process is again mainly a local effort.

Planning and Conceptual Design - This step is when Minnesota recommends hiring professionals to begin to detail thermal sources, piping system, retrofits, and to identify ownership and financing. Minnesota district heating planning grants of up to $20,000 per city are potentially avialable for assistance in this step.

Detailed Design - Here, the goal is to bring the project to a point at which it can be financed and built. Short-term loans are one possible source of funding for this step and could be repaid through the construction borrowing.

Construction and operation obviously follow for those cities that can successfully identify systems and attract customers. The State of Minnesota has a state-wide loan program in place to assist in construction financing. Minnesota has assisted several smaller cities within the state and anticipates continuing their program.

Michigan

Michigan Department of Commerce, Energy Administration

The State of Michigan sponsored a statewide reconnaissance program to identify cities that demonstrated DHC project potential and community interest. The state contracted with the Michigan Energy Resource Research Administration (MERRA) who identified a number of cities with real DHC potential including Kalamazoo, Bay City, Ypsilanti, HillsDale, Marquette, Muskegon, Battle Creek, Mount Pleasant and Galdstone. The state, through MERRA, held workshops in each of these cities to discuss district heating potential, energy savings, project financing options, and other relevant issues.

The response of the communities to the district heating reconnaissance and workshops was favorable. Each of the communities demonstrated significant interest in pursuing the identified DHC option. However, all of the communities expressed concern about the institutional and contractural packaging of the project and securing necessary financing for development. To help overcome these obstacles the state has structured a program to assist communities in further developing their projects. State assistance has ranged from $5,000 to $25,000 depending on the city's specific needs. Michigan's program is still in the early developmental stages, but the state has indicated the desire to continue support of DHC and the projects identified to date.

New York

Of all the state district heating and cooling programs, New York's is currently the most aggressive. The program is housed within the New York State Energy Research and Development Authority (NYSERDA). NYSERDA is a public benefit corporation whose purpose is to "develop and implement new energy technologies consistent with economic, social and environmental objectives, and to develop and encourage energy conservation technologies." The Energy Authority's research development and demonstration (RD&D) program is funded in part through an assessment on the State's gas and electric utilities pursuant to the Public Service Law which reads: "The total amount which may be charged to any gas corporation and electric corporation for any state fiscal year shall be .6 cents per one thousand cubic feet of gas sold and .006 cents per kilowatt hour of electricity sold by each corporation in their intrastate utility operation the last preceding calendar year."

In FY 1983-1984, the RD&D budget for the Energy Authority was $12 million. Of that total, $9.6 million came from the utility assessment. The additional $2.4 million was a voluntary contribution from the New York Power Authority.

The Energy Authority's Five Year RD&D plan states that the NYSERDA program objective is: "Research site-specific feasibility of retrofitting existing power plants and using other heat sources for district heating in urban areas; assist developers of candidate sites in conducting engineering studies and marketing heat to potential users; assist in conducting demonstrations and disseminating results to local government officials and developers."

NYSERDA's DHC goal is to implement DHC throughout the State. The implementation of DHC is viewed as occurring in three phases. The objective of a Phase 1 NYSERDA DHC project is to assess the marketing, engineering, economic and financial feasibility of DHC in a community and develop a financial commitment from local participants to proceed to the development and implementation phases. The objective of the second phase is to continue the analysis and develop the project to the point where it will be financed. During the third phase, the project is financed, constructed and operated.

The Energy Authority's financial support is most critical in the first phase. New York realizes that a lot of effort must be devoted to a site before its feasibility is demonstrated and before people will invest in a DHC project. Many locals have never heard of DHC. Those who have, may have negative perceptions based on experiences with antiquated steam systems. When confronted with spending hundreds of thousands to millions of dollars on a system they do not appreciate, and that will take significant resources before it shows results, most areas simply have more urgent priorities. New York has found, however, that once initial feasibility has been demonstrated, local cost sharing increases dramatically in Phase 2. Phase 3 is effectively accomplished with little or no NYSERDA funding.

Phase 1 DHC projects address the barriers mentioned above and thereby facilitate the implementation of DHC in New York. The private and local government sectors have not stepped forward to initiate DHC projects and DHC will not develop in New York without initiative from the state. At relatively low cost ($50k to $80k per site) New York has been able to evaluate the site specific feasibility of DHC, configure workable systems, and raise significant local capital for follow-on development and implementation phases.

New York's Site Selection Criteria

The Energy Authority is selective in choosing sites to award Phase 1 contracts. It will only consider proposals which identify a potential DHC developer. This can be a public or private organization which could be expected to own and operate the DHC system. Its paramount criteria is "likelihood of implementation." A site will not be considered unless its proposal makes a compelling argument that the project is likely to lead to near-term, low-cost implementation of DHC. In evaluating the likelihood of implementation, the Energy Authority has the following four criteria. The criteria are of approximately equal importance. A significant weakness in any one of the four is sufficient to reject a proposal.

1. Technical Quality of the Site. This includes availability and suitability of the thermal load and source and site-specific factors impacting on the cost of the DHC system.
2. Local Support and Commitment to Implement the DHC System. This includes the quality and degree of support and commitment from local participants including the heat source owner, potential DHC customers and local government.

3. Statement of Work, Management and Schedule. This includes the quality and suitability of the site-specific work statement, reasonableness of effort devoted to each task and schedule.

4. Personnel and Corporate Qualifications. This includes the experience, credentials, and DHC track record of the proposer's consultants, the experience of the proposer's project manager and his authority over the proposer's resources including staff, budget and travel.

F. OTHER ACTIVITY

Unlike European countries, the U.S. district heating and cooling organizational framework has been historically diverse, loose and relatively unorganized. To a large extent this diversity and modest organizational cohesiveness is attributable to the transition in the U.S. energy supply economy and DHC which began in the 1970's and continues today. More specifically the reasons include:

- diverse nature of the U.S. energy supply economy
- the diversity of DHC in the United States
- variations in DHC regulations within the 50 states
- traditional steam-based DHC vs. the trend towards hot and chilled water
- traditional utility ownership schemes vs. new alternative ownership arrangements
- the emerging role of cogeneration
- professional and legislative responsibility for standards and codes
- multiple DHC interest groups and beneficiaries

The historic representative of district heating and cooling is the International District Heating Association (IDHA). Now in its 75th year, IDHA is undergoing a reappraisal of its role and direction.

While IDHA has traditionally represented investor-owned downtown steam systems, a new aggressive group was organized in 1982 to support, organize and focus U.S. DHC efforts. The North American District Heating and Cooling Institute (NADHCI) has continually broadened its membership and now includes manufacturers, engineers, system owners and physical plant operators.

Recently these groups (IDHA and NADCHI) have discussed and are negotiating consolidation. Consolidation of the two leading DHC interests groups could serve to increase DHC institutional capacity, research, marketing, and organizational efforts.

American Public Power Association (APPA) has become one of the leading DHC proponents during the transition. APPA, working with their member municipal utilities, has concluded that utilities, cities and customers will benefit from a change in role of municipal electric companies to energy companies. Thus APPA is in the forefront as they encourage members to develop efficient energy supply systems using cogeneration, DHC, MSW, load shedding, conservation, and other appropriate energy technologies.

The U.S. Conference of Mayors, a leading public interest group representing America's larger cities, is active in the support and implementation of both resource recovery and DHC. During the last several years the Conference of Mayors has evaluated the role of DHC in American cities and initiated several actions aimed at increasing its implementation.

The American Society of Heating Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE) is the preiminent engineering technical society that supports engineering considerations of internal building environments. DHC is of interest to ASHRAE in that it offers an efficient energy alternative for building HVAC systems. ASHRAE has two standing committees that deal with DHC.

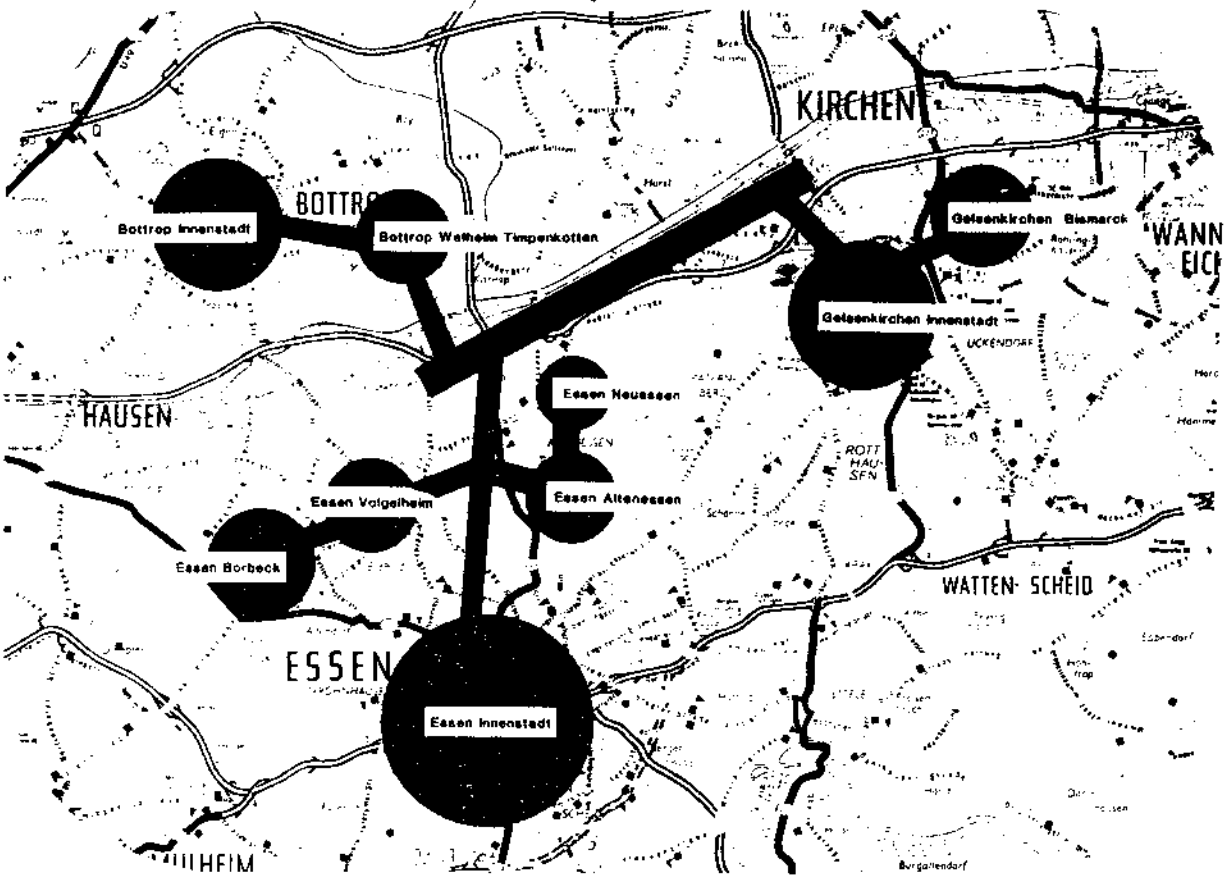
The TC 6.I - Hot Water and Steam Heating Systems and the TC 9.5 - Cogeneration/Total Energy Systems committees deal with the engineering issues related to end-user and the heat sources that support DHC systems.

Other interest groups and organizations including ASME, the National League of Cities, the Building Owners and Manager's Association (BOMA), the Association of Physical Plant Administrators, environmental groups, manufacturer's associations, labor unions and regional interest groups all have an interest in, and support DHC efforts.

2.5 SUMMARY

With this review of European and U.S. district heating and cooling it is possible to posit certain findings which, in part, explain the differences between DHC penetration in Europe as opposed to the United States. First, Europeans have determined DHC to be a sound and proven technology. Its extensive application during the post World War II period, successful system growth through the 70's and 80's, and the emphasis placed upon hot water distribution systems, all contribute to European confidence in DHC technology. Second, although European fuel resources vary significantly among nations, national leaders continue to be concerned about their reliance on scarce, imported liquid and gaseous fuels. This national concern continues to be expressed despite recent relief in the spot market price of oil, availability of North Sea natural gas, and the importation of Russian natural gas. Third, European nations are well ahead of the United States in the implementation of district heating and cooling. This lead is explained, in large part by, their successful implementation of community scale or multi-sectoral DHC systems. German and Danish examples of DHC system development connecting several cities and towns into a common district heating network supplied from solid fuel fired CHP plants illustrates the extent of the European commitment.

Map 2-11



Fourth, all European nations have structured a political, institutional, environmental, and economic environment which is supportive of DHC development. This environment places emphasis upon the development of energy policies and plans--specifically district heating development plans and programs. Each European nation has developed its own specific approach and methodology to DHC development, however, all European countries in common share the development of partnerships between local, regional and federal governments and in particular, mutually supportive arrangements between private and public sectors of their specific nations. For example, the Federal Republic of Germany has projected an investment of six billion deutsche marks (approximately $2.4 billion U.S.)

in support of DHC. This program, which will continue into the 1990's, is expected to advance over 140 new DHC projects throughout the FRG. Beginning in 1984, the French government anticipates a two billion French franc allocation for district heating and cooling development (approximately $260 million U.S.). France expects that this investment will result in 1.3 billion dollars U.S. of new, private DHC investment or a five to one leverage ratio.

By contrast, DHC efforts in the United States have been ill-defined unorganized and lack consistent policy direction. Certainly, the size and diverse nature of the United States, in part, accounts for this condition. The allocation of responsibilities and authority between and among the federal, state and local governments in the United States, will require the U.S. to evolve its own specific district heating and cooling approach.

The following chapter, "Barriers to DHC Development" identifies and evaluates a number of obstacles confronting U.S. district heating developers and begins to identify issues appropriate for consideration during the formulation of a U.S. district heating and cooling strategy.

Chapter 3

BARRIERS TO DISTRICT HEATING AND COOLING

3.1 THE CONTEXT FOR CONSIDERING BARRIERS

Implementation of a district heating and cooling system represents a comprehensive approach to energy supply and conservation at the community level. As such, it should combine approaches to energy supply and conservation by incorporating proven technologies, energy conserving community designs, and financial and regulatory mechanisms that encourage its widespread growth and market acceptance. DHC system applications may consist of either a partial or complete integration of these approaches, as deemed necessary and appropriate, to fully utilize the nation's and a specific community's energy resources; and to strike the desired balance among economic, social, environmental and energy goals.

A primary goal of DHC systems is to increase efficiency in supplying the energy services required by a community, thereby reducing the community's demand for costly fuels. However, energy conservation must be achieved within the constraints imposed by other equally important considerations. Strategies for development of district heating systems must seek to achieve energy efficiency while maintaining a community's broad economic, social and lifestyle objectives.

District heating systems' regulatory issues are in part defined by the flexibility inherent in system development and growth. Even though each system will produce heat and transport it to customers, each community will

construct its own suitable technical, institutional and financial structures based on a myriad of system considerations which include:

- o system size
- o growth and planning
- o system location
- o community dynamics
- o local goals and problems
- o alternative ownership schemes
- o fuel availability
- o state law
- o PSC regulation
- o end-user requirements
- o load distribution
- o alternative financing tools

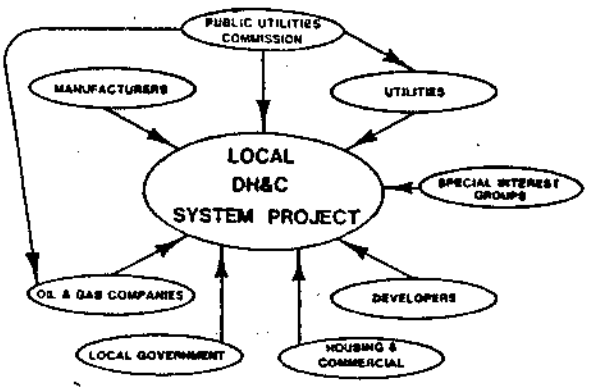


Figure 3-1

The interests, goals and objectives of many local and state parties will be major topics in regulatory discussions and considerations. Accommodating these diverse interests while recognizing the site and community-specific nature of district energy systems poses a rigorous test for regulatory bodies. By looking at this situation from the perspective of a system developer (utility, city or entrepreneur) we see that a supportative regulatory framework and the possibility of profit are necessary conditions for successful project implementation.

The balance of this chapter turns to discussion of obstacles or barriers which confront the widespread development of district heating and cooling systems. These topics will influence the direction, level, form and content of district heating and cooling system development in the United States. From an organizational standpoint there are numerable categories within which

specific barriers or obstacles can be categorized. Importantly, many of these barriers are not independent or mutually exclusive of one another. In fact, a substantial degree of overlap exists between and among various specific barriers. Nevertheless, an attempt has been made to group barriers which confront district heating into several categories in order that rational conclusions can be drawn and development of federal policy can be "tuned" to be more supportive.

The following barrier discussion is organized into four sections or categories:

1. Market Entry
2. Financing
3. Legal and Regulatory
4. Air Quality

Obviously, there are regulatory implications in any discussion of air quality. Similarly market entry barriers in part consist of financing issues. Although these categories are somewhat arbitrary they serve to highlight several policy areas which need to be considered in evaluating the potential for district heating in the United States and the role of federal agencies.

3.2 MARKET ENTRY BARRIERS

Although district heating and cooling has a rich history in the United States and is widely applied throughout Europe and the Soviet Union, efforts to develop new district heating and cooling systems based upon modern technology are, in effect, an attempt to enter the U.S. energy market with a "new product". Conventional energy supply systems using natural gas, oil, and electricity have experienced explosive growth following World War II, and today, dominate the space heating market. Notwithstanding the calculable advantage and efficiencies of district heating and cogeneration, these

systems, which essentially deliver energy as opposed to fuels, require that customers change their energy consumption equipment and patterns. Achieving systematic changes within the context of a free market economy can be an ordeal during the early years until such time as both consumer preferences and supply approaches have changed and are widely recognized.

Four barriers have been identified and defined which can best be labeled market entry barriers. These are:

- Predevelopment Complexity
- Risk Capital for Initial Identification and Analysis
- Market Aggregation Risks
- Limited Knowledge of DHC

These four obstacles all contribute to a shared burden for new district heating and cooling projects, i.e., all four lengthen the time required to successfully plan, analyze, organize and finance DHC projects, and all four contribute substantially to the front-end or predevelopment cost which must be incurred by a DHC system developer.

1. Predevelopment Complexity. Elevating district heating and cooling to a major role in U.S. energy delivery schemes raises complex issues of ownership, operation, finance, and regulation for the purpose of investor and customer protection. Resolving these issues and building consensus to support a district heating and cooling program in a community requires the interaction and cooperation of diverse energy, business and government interests which share some goals but also at times may have competing or conflicting objectives. The complexity of this public/private negotiation process may quickly dampen enthusiam for a district heating and cooling project even though substantial benefits to the community can be demonstrated.

2. Risk Capital for Initial Identification and Analysis of District Heating Projects. The economic viability of district heating systems varies considerably according to site, prevailing local fuel types and prices, and the availability of electric generation equipment suitable for conversion to cogeneration. Therefore, in order to determine the economic viability of an individual district heating project, detailed analysis is usually necessary. This work must be undertaken with the possibility that some barriers will be discovered which will preclude proceeding with the project.

   Most new district heating systems currently under consideration in the United States have received moderate yet critical federal assistance funds for feasibility studies and initial design. Several prominent investment bankers including, Prudential-Bache, Donaldson Luffin and Jennette, and E.F. Hutton have identified the financing of feasibility studies as a major barrier to private sector investments in district heating systems.

3. Market Aggregation Risks. In order for a district heating system to be economically viable, there must be a high enough density of energy demand within the service area. Achieving this economic "demand density" in a large enough area to make the construction of the system viable is generally referred to as achieving the "critical mass" for the system.

The single most difficult obstacle system developers face is overcoming the inherent inertia of customers to replace their existing heating, cooling and/or process systems with district heating and cooling services. The problem is compounded by the fact that a convincing "proof of market" will be

required by banks and underwriters in order to secure project financing for the central plant and distribution system.

The problem of predicting consumer behavior within the private marketplace as it relates to a specific good or service is not new. Every private company throughout the nation which markets goods on a national, regional or local scale faces this exact concern. Simply installing a thermal distribution network and observing whether or not consumers actually connect to the system is an unacceptable approach for owners, underwriters and investors. Similarly, test-marketing is equally out of the question in that the cost required to produce even the first connection is substantial.

Quantifying thermal markets for new projects requires a combination of empirical market analysis and marketing of customer contracts. The empirical methods include building surveys, use of community data and information, and market research. Empirical approaches are most useful during concept development and concept planning phases. They are also useful when there is a very large number of potential users, and future market penetration rates must be forecasted for use in advanced system planning and phasing.

The strongest expression of market strength is the customer contract. There is almost an infinite number of contract variations, many of which have popular names such as charter flight, hell or high water, take or pay, fixed rate, floating rate, firm, and contingency. The type of contract is determined by the ownership arrangements and financial constraints of the project. A popular myth posits that businesses will enter into meaningful contracts before they have satisfactory answers to numerous questions regarding reliability, rates, and in-building conversion costs. It is a myth. Obtaining enough contracts to cover all of the system capacity will be

difficult except in small central utility system and some new urban development project cases. Consequently, other approaches may be useful or necessary in securing thermal markets.

In practice, three methods have been utilized to assure adequate subscription to the system;

- Contracts to take delivery of steam/hot water. If enough customers sign "take-or-pay" contracts for delivery of the product before the system is built, then the revenue stream is assured. The major risks in this approach are that if contracts are signed and the system is not built the developer may be liable for breach of contract.

- Pricing of thermal energy below competing energy sources. The objective is to price thermal energy low enough so that it will be clearly in the interest of users of oil and gas to convert to district heating. The St. Paul system has, for example, priced its product at the equivilant delivered BTU price of natural gas. This has inherent difficulties depending on the price of competing fuels and the revenue requirements of the proposed system.

- Generating bond payment from sources other than system revenue. The major method of accomplishing this would be through the use of General Obligation Bond Financing. This transfers the risk of system failure from the bondholders to the residents of the city or state which issues bonds. Alternatively, related revenue streams from the project, such as cogenerated electricity, can in part secure the financing.

In general, the viability of DHC systems has been demonstrated to investors through combining take or pay contracts, pricing, internal revenue/-

cost allocation, direct government grants, and General Obligation Bond (G.O.B.) financing. The investors' assessment of the risk of the entire package is then reflected in the interest rate demanded for the issue and ease of bond sale.

4. Limited Knowledge. A final market entry barrier confronting the private development of district heating is the present limited level of knowledge of district heating as an alternative energy concept. The absence of privately funded and successfully completed modern hot water systems, and the negative perception of many of the existing, technically antiquated steam systems suffering from disinvestment in the U.S. does not offer encouragement. After 20 or 30 new systems are successfully developed and financed (including such recent projects as Provo, Utah; Baltimore, Maryland; Trenton, New Jersey; and Saint Paul, Minnesota), marketplace acceptance, knowledge and financial support for future district heating projects will become easier to obtain. Convincing customers to connect to the district heating and cooling system will require less effort and be accomplished quicker.

This section, reviewing barriers to market entry has touched on some overlapping issues in system financing. The following section deals more directly with the problems of obtaining financing.

3.3 DHC SYSTEM FINANCING ISSUES

3.3.1 Financing Framework

Generally the DHC central plant component will constitute 25% of total system cost while the distribution and storage system will total 50% of all costs. The remaining 25% will be spent on customer connections. Regardless

of the system component ownership arrangements, both DHC owners and investors require a profitable operation secured by sufficient thermal demand, adequate rates and competent operation. Consequently, structuring system financing which meets planning, design, construction and start-up requirements is critical for successful DHC development.

Strict control of front-end costs and appropriate systems will definitely contribute to the solution; however, financing ultimately becomes critical to the success of all district heating and cooling systems because of the large capital investments required to design and build a system before revenue can be generated from thermal sales. Discussed below are four financing issues or factors which represent barriers to the rapid penetration of district heating and cooling in the US energy market:

1. High Capital Cost and Long Construction Lead Time
2. Risk of Unknown Future Energy Prices
3. Customer Hook-up Cost
4. Industrial Development Bond Uncertainty

To a large degree, the costs associated with the risk of a specific project can be distributed through available financial instruments. However, the complicated and involved process adds substantially to predevelopment packaging costs and leads developers to smaller projects which delay capturing the advantages of solid fuels (coal and municipal solid waste) and cogeneration. Other major financial barriers to district heating are the direct result of Federal government policy, such as the subsidization of other energy supply sources and the control of natural gas prices. Policy changes which would mitigate these market distortions are considered later in this report.

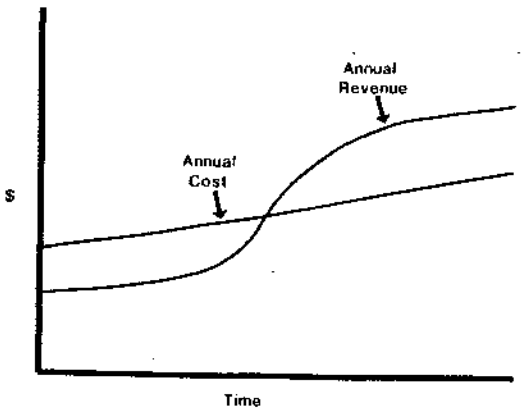
1. <u>High Capital Costs and Long Construction Lead Time.</u> District heating systems share with electric power plants, gas pipelines, and sewer/water systems the requirement for large capital investment to construct most of the system before any revenue can be generated from sales. Even for regulated utilities, the position of Public Service Commissions has traditionally been that these construction costs should be born by the stockholders of the company constructing the plant until such time as the plant entered service. However, difficulty in raising capital, caused by high interest rates and increasing uncertainty about future energy demands, has necessitated the inclusion of increasing amounts of the costs known as Construction Work in Progress (CWIP) in utility rate bases. This means that the consumer of electricity pays this cost through the rate used in calculating his monthly bill.

Since new district heating systems usually have no established customer base, it is impossible to transfer the risk associated with CWIP to the customers. Investors, lenders and the government are the entities able to accept portions of this risk. Hence, other instruments may be needed.

Industrial revenue bonds can benefit a district heating system by providing tax exempt financing, but default risk is still born by the lenders since the only source of repayment is the revenue from the district heating project. This greater risk will command a 3% to 4% higher interest rate on the bonds, making the financial feasibility of the project more difficult.

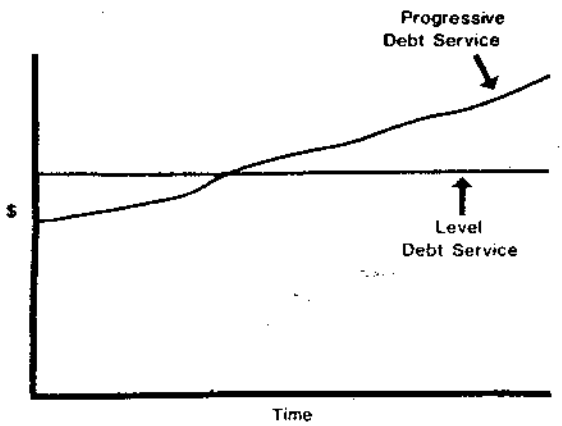
The fundamental system financial obstacle faced by new and expanding DHC's is that annual system cost often exceeds revenues during the early years. This situation is analogous to construction of community sewer systems in that all of the plant and distribution capacity is not used at start-up. As the system grows and serves a greater percentage of the establishments within its service area, the ratio of income to invested capital will improve. But low revenues in the early years of system operation make it difficult for system operators to meet bond payments and maintain financial ratios which will satisfy bond covenants.

Innovative financing mechanisms, such as graduated or balloon payment loans can reduce required payments in the critical early years of system operation. Progressive Debt Service used judiciously, shifts benefits to early years and cost to later years. This allows unit energy cost to more accurately reflect the true value of thermal energy over time.



Revenue-cost Implications of District Energy System Start-up and Expansion

Figure 3-2



Comparision of Level and Progressive Debt Retirement

Figure 3-3

District heating and cooling projects recently developed in the U.S. have leveraged both public and private financial resources by combining these and other mechanisms identified below. Using a joint private/public financing package requires rigorous front-end or pre-development planning and project organization. Other approaches that can offset high capital costs and early debt problems are:

Joint Ownership offers the opportunity to structure financing which draws upon the strengths of public and private parties. Illustratively, an investor-owned utility might supply heat from an electric power plant to a municipally-owned distribution system financed by tax exempt bonds.

Cost Allocation methodologies can be structured in order to allow substantial portions of the cogeneration benefit to accrue to thermal users during the early years of operation. As the system matures, benefits can be shifted in favor of electric customers.

Connection Charges immediately paid by individual customers based on their distribution system cost share result in system equity thus lowering the debt capital requirement. In some European countries long-term, low-interest loans are available to customers for use in paying the connection charge.

Private Corporate Bonds can be used to generate monies for any corporate project. The strength of the firm will determine the interest rates of the bonds. These bonds carry the highest interest rates.

General Obligation Bonds are bonds backed by the tax base of a city, and pledge the "full faith and credit" of the city and its tax revenues for repayment. These bonds are secured by the city's tax base and the interest rate that the bonds carry will be based on the financial capability of the city. Since the general operating funds of the city are being pledged to bond

repayment, there are limits placed by states on the dollar or percentage of total valuation of general obligation bonds a city can have outstanding at any one time without requiring a voter approval. These tax-exempt bonds generally are popular with investors and, subsequently have interest rates lower than private sector bonds.

Municipal Revenue Bonds are bonds pledging the revenues of a thermal energy system for bond repayment. Revenue bonds are riskier to an investor than general obligation bonds in that if the revenues of the system are insufficient to cover the debt then the bond is defaulted. Since the risk is higher on revenue bonds, so is the interest rate that the system revenues are required to cover.

Industrial Revenue Bonds are bonds that pledge thermal system project revenues to the debt retirement and are sponsored by cities or development corporations to insure certain public goals such as jobs or redevelopment. IRB's are generally placed at interest rates lower than rates on corporate bonds. IRB's also are limited by federal tax regulations as to what they can be used to finance, certain components of a district heating and cooling system may or may not be eligible. This should be carefully investigated on a case by case basis. Additionally, there are upper limits placed on the size of the IRB offering. These limits are twenty million dollars when in combination with UDAG funds or ten million dollars without UDAG participation.

Leasing is another method that can be in system components. For example, if a utility and a city determine that a thermal system is desirable, but neither party has sufficient financial capability for owning and building the entire system, the utility could either build or retrofit a thermal source and

the city, using its tax-free financing capability, could build and own a distribution system. The city could then lease the distribution system to the utility for the cost of the bond retirement.

Leveraged Leasing is a methodology of passing on the tax advantages of the system to the leasee. This improves the financial position of the leasee in that he now has some of the tax advantages of ownership without the costs of ownership.

Another method of leasing is to use Lease Increment Bonds. These bonds effectively are revenue bonds, based on lease charges to the system operator. The interest rate will depend on the capability of the system to produce the necessary revenue to retire the debt.

2. Risk of Unknown Future Energy Prices. Long construction lead times force district heating developers to project energy prices and demands for 10-30 years in the future in order to project system revenue. These projections are made exceedingly difficult by the wide variety of supply and conservation technologies which are competing with district heating. A further major complication is uncertainty about federal and state government pricing policy, particularly with respect to the pricing of natural gas and electricity, which are controlled at prices far lower than their marginal cost of production.

Most system developers use energy price projections based on or supplied by econometric forecasting firms such as, Data Resources, Inc., and Chase Econometrics. These firms periodically publish, long-term price scenarios using complicated econometric models. As is the case for all models, the projections are only as good as the assumptions and techniques. The models are generally more accurate in the near-term than in the long-term. Even though the models predict prices, the developer still assumes the risk of

future energy prices. Perhaps John Kenneth Galbraith most succinctly stated the case on forecasting reliability when he stated "We must remember that economists make forecasts not because they know but because they are asked."

3. Customer Hook-Up Costs. Thermal energy supplied by district heating systems is similar to conventional heating and cooling fuels in that its utilization requires an investment by the customer in on-site equipment, principally heat exchangers and their associated piping and control equipment. The federal government and a number of states have granted tax credits and a variety of other incentives for the installation of energy-conserving, on-site equipment. The potential district heating customer does not receive any such incentive to install the equipment required to utilize district heating thermal energy because DHC was so little known at the time these incentives for conservation were passed. This oversight is one that could be corrected by introducing legislative modifications to existing energy and investment tax credits to put District Heating and Cooling systems on an equal footing.

Customer hook-up costs have three basic components - the connection from the distribution system, the energy meter, and the energy delivery system in the building. Each of these costs can be borne by either the system, in which case the capital costs would be recovered in the rate, or by the customer directly. Like other elements of the system, a mixed ownership approach is also possible. There is no average cost data available for total customer hook-up due to insufficient case data. However, evaluations of retrofits in St. Paul have shown that by retrofitting buildings from steam to hot water, building owners have not only benefitted from lower cost systems in terms of operation and maintenance, but also from actual reduced consumption of energy

through improved control of the building system controls. Thus the pay back in the connected commercial buildings in St. Paul was better than anticipated, and will off-set the cost of connection in a reasonable time period. Whether or not this experience can be transferred to other communities remains to be seen due to the nature of buildings and the heating systems in St. Paul.

4. Industrial Development Bond Uncertainty and its Impact on District Heating Development. Industrial Development Bonds (IDB) have played a crucial role in the financing of new district heating and cooling systems. Recent changes cause uncertainty for the system developer's future, confident use of IDB's. Therefore, the use limitations, constraints, and uncertainty are discussed here in detail.

The Tax Reform Act of 1984 imposed a state by state limit of per capita $150 or $200 million dollars total, whichever is greater, on the issuance of industrial development bonds (IDB's). The theory of this act is that since IDB's are tax exempt financial instruments that divert investment from taxable to non-taxable debt, something should be done to limit this investment diversion. The undercurrent to the theory is that IDB's are an unnecessary and abused debt instrument. That is, the purpose of IDB financing was to provide units of government the opportunity and debt instrument to assist the private sector in making investments that contributed to the public purpose. Pollution control, industrial development, multifamily housing, mixed-use developments and other projects that would be difficult with market interest rates were more feasible with the reduced interest rates tax-exempt financing could offer, normally 70-75% of market-rate financing.

Based on increasing local government use of IDB's for projects of questionable public purpose, Congress reviewed its options for stemming the resulting diversion of tax revenues. Congress had three basic options:

(1) Eliminate IDB's entirely, which could have hindered projects and developments which truly had "public purpose" elements that needed financial "encouragement" to move forward. (2) Establish complex rules to define exactly what projects and developments would be eligible, which would have created a regulatory morass and likely would have been unachievable. (3) Establish an upper limit on how much financing could occur in any year and in any state, which leaves the decision as to what constitutes "public purpose" to each state and thus allows for "local" decision-making. Congress elected to use the third alternative.

This change in tax law will have an unequal effect on the financing of district energy systems based on each state's use of tax-exempt financing. Certain states that are large issuers will face a greater adjustment in terms of how debt is used, and which projects are to receive priority for tax-exempt status. In other states, this will have little if any, impact on project finance.

The immediate result is that district heating and cooling systems no longer enjoy the assumed advantage of guaranteed, unlimited access to tax-exempt markets. (Certain systems and components have always been limited or excluded from tax-exempt status). However, in addition to the imposed per capita limitation which will require DHC projects to compete for IDB financing, the new tax law imposes a trade-off which each system developer must carefully assure. That is, if a system is developed using tax-exempt financing, the system can no longer also take advantage of accelerated cost recovery (ACRS). The impact of this on how systems are packaged and financed will depend on the ownership of the system, and the ownership of specific system components. The private developer will have to evaluate the financing of the project carefully to determine the preferred financing and ownership

arrangements. At a minimum, the new IDB rules will add to the pre-development complexity and related cost.

In 1987, the state-by-state authority will drop to a $100 per capita. The authority to issue Small Issue and Industrial Park IDB's also expires. This appears to be off-setting if not beneficial to municipal district heating development, since local district heating and cooling bonds will fall under the limit but are not under the small-issue category. In many states this would free up bond authority for all projects. For example, in Maryland the 1983 level of activity exceeded the $150 cap, but of the $155 per capita issuance, $74 per capita was small issue and industrial park IDB's. Many other states have similar situations. In 1987 the bonding authority should tend to loosen up.

It is difficult to predict the overall impact of this law in terms of new system development or additional BTU's sold. In general, it is safe to say that there may be a problem financing high capital cost projects in states that extensively use IDB's, or in states that restrict the levels of bonding authority by bond category. In some states, the timing of financing will be affected and altered to match the availability of bonding authority. These situations will particularly impact the development of capital intensive projects for urban areas in states with formula allocations and multiple urban centers. DHC system's ability to coordinate market aggregation and project financing may also be affected.

It is also likely that the law will favor public development of projects due to the "either/or" status of IDB's vs. ACRS. It will certainly encourage private sector developers of new systems who need the accelerated depreciation to offset cash flow in early years to look to Urban Development Action Grants (UDAG) for interest rate relief instead of IDB's.

On the other hand, since the volume of bonds will decrease, particularily in 1987 and beyond, it should be easier to attract investors to higher quality bonds at potentially more favorable interest rates. [Supply is restricted, demand is the same or increased thus bidding up the price of the commodity. Tax-exempt issuers should be able to reap lower interest rates since buyers are willing to pay a higher price. This effect should "trickle-down" to some lower grade bonds]. In theory, this will benefit the borrower in reducing debt service in real terms.

In general, the legislation will have an initially negative impact that will affect private sector developments more severely than publically-owned projects; and that in the mid-term, public sector project impact will be generally neutral and slightly positive for smaller projects.

3.4 REGULATORY BARRIERS AND UNCERTAINTIES

3.4.1 General Regulatory Risk

General regulatory risk is associated with government intervention in the energy marketplace on the federal and state levels, in the interest of social welfare and consumer protection. The current national policy, through deregulation of oil and gas prices, aims at increasing production and restricting consumption by allowing fuel prices to settle at world market levels. In contrast, regulation of energy services at the state and local levels through public utility commissions emphasizes minimum end-user costs and thereby promotes consumption. Treatment of major new energy investment efforts, such as cogeneration and district heating and cooling, is still diverse, inconsistent and uncertain. Profitable investment in district heating and cooling hinges on resolving issues such as pricing of energy services, allocating benefits and costs between customers and investors, and

limiting service to franchise service areas. The uncertainty surrounding regulatory treatment of these issues constrains promotion of district heating and cooling.

3.4.2 Federal Issues

DHC systems are subject to varying degrees of Federal, state and local regulation. Several Federal regulations are of importance to DHC, but much of the regulatory control over these types of systems has been left to the state and local authorities. The following section presents an analysis of current Federal and state regulations that affect the pricing and access of primary energy received by DHC systems, and influences owners and customer decisions. Then, Federal environmental statutes and policies that affect DHC are analyzed in the next section (3.5). The conclusion is that Federal regulation, in some instances, may be somewhat of a nuisance to DHC utilities, but the vital regulatory decisions are made by state and local authorities. Minor adjustments to Federal regulation could be made (and are recommended) that would remove these minor barriers. From a technical standpoint, these changes by themselves would facilitate investment in DHC. However, the signal that the Federal government is behind the concept of DHC and wants to clear any obstacles, perceived or otherwise, to its implementation may positively influence local regulations.

1. Natural Gas Policy Act (NGPA)--Gas Prices and Decontrol Wellhead Prices.

The Federal pricing authority of energy is generally confined to the interstate transmission of energy and the pricing of some primary fuels. The interstate movement of thermal energy is minimal and no Federal pricing authority exists or has been exercised. All pricing control for the transport

of thermal energy has been exercised by either the state or local authorities. In the case of primary fuel price controls, the Federal Government has been taking steps in recent years to remove itself from the picture. Recently, the last vestiges of oil price controls were removed. In 1978, Congress enacted the NGPA which abolished the distinction between intrastate and interstate markets for gas, and established a timetable and process for the deregulation of natural gas wellhead prices. According to the legislation, the wellhead prices for all categories of "new gas" are to be decontrolled by January 1, 1985. However, the President or either House of Congress may reimpose controls at any time between July 1, 1985, and June 30, 1987. Controls could be reimposed for a period of 18 months. Thus, although decontrol is normally considered to be scheduled for January 1, 1985, it could be delayed until as late as January 1, 1988. Moreover, decontrol applies to "new gas" only; stocks of "old gas" would remain subject to price controls. Eventually, "old gas" supplies will be depleted and replaced by "new gas" so that, by 1985, roughly half of total gas supplies will be "new gas."

Decontrol of gas prices is the most important regulatory step that the Federal Government can take in terms of impact on the development of District Heating and Cooling systems. Many current natural gas users are potential DHC customers. Without controls, gas prices would tend to track world oil prices. Thus, full decontrol would result in price adjustments to most gas users which would stimulate the development of a variety of lower cost alternatives, including DHC. Moreover, because decontrol is controversial and far-reaching in its economic impacts, it will constitute a significant point of uncertainty for investors until it is an established fact. This will lead many potential developers of DHC to defer major commitments until they think the issue has been conclusively resolved.

In enacting the NGPA, the Congress endorsed--in principle--the concept of decontrolling wellhead prices for new gas to give appropriate economic incentives to both gas producers and gas users. To ease the economic dislocations associated with the transition to decontrol, the Congress devised a phased approach known as "incremental pricing". Large industrial users were to face higher, "alternative fuel" prices shortly after enactment ("Phase I"); certain other users, mostly smaller industrial and commercial customers, were to pay alternative fuel prices in Phase II; the remainder, including residential customers, commercial customers, and electric utilities, were to feel the effects of decontrol last. Phase I has been implemented by the Federal Energy Regulatory Commission (FERC), but Phase II has been deferred, due to intense opposition from industrial user groups. At the same time, world oil prices have fluctuated more sharply than the Congress anticipated. These developments have made the conclusive transition to decontrol both more important and more difficult to achieve without large economic impacts.

In general, it appears that completed decontrol would have favorable but modest impacts upon DHC. Any assessment of DHC's long-term market penetration prospects must take into account the price trajectories expected for various fuels--including gas--and the schedule for decontrol of new gas by 1985-88. Thus, completing decontrol of new gas would probably not increase DHC market penetration dramatically, although it would cause many gas users to examine alternatives to gas as they become available.

Alternatively, if consideration is given to the element of uncertainty from the investor's perspective, one must conclude that a skeptical entrepreneur would discount somewhat the prospects for decontrol as scheduled under NGPA. Hence, accelerated decontrol, if brought to fruition, could have a

substantial impact upon DHC; but more because it would establish decontrol conclusively than because of the schedule.

Finally, it should be noted that the impacts of partial decontrol will vary somewhat from region to region and utility to utility. This is because the stocks of low-priced old gas vary significantly among pipeline companies and the distribution companies they serve. Gas users in areas served by distributors relying mainly on new gas will feel the impacts of decontrol more than users in other systems. The extension of decontrol to old gas would produce more uniform impacts, but the overall impact on the economy would be substantially larger.

Incremental Pricing Under the NGPA. Title II of the NGPA provides an incremental pricing mechanism for passing some of the increased prices for natural gas through to end-users and implements incremental pricing for industrial users in two stages. The FERC was required to develop detailed regulations to determine which industrial facilities would be subject to the higher incremental gas prices and which ones would temporarily pay the lower, "rolled-in" gas prices.

2. Access to Fuels--Fuel Use Act (FUA) and Natural Gas Policy Act (NGPA)

District heating systems often require oil or gas, despite the fact that current interest in district heating is motivated largely by its potential for reducing use of these fuels. For example:

- A new, growing, multi-user district heating system may, during its early years, require a small package boiler serving isolated clusters of users that would eventually be served by a large, centrally-located facility. Oil or gas is the only practical fuel for these small units.

- Even a large, mature system may have a variable thermal load requiring the occasional use of "peaking" boilers. The low usage rate of these boilers would not justify the high capital costs of using fuels other than oil or gas.

- Some proposed district heating systems are based on cogeneration. In most urban areas, the existing steam power plants that would be suitable for conversion to cogeneration are oil- or gas-fired, and environmental or site limitations may preclude their conversion to coal.

However, district heating systems may have more limited access to oil and gas than the smaller, decentralized units they seek to replace. Their use of these fuels could potentially be limited by two major bodies of Federal regulations.

- The Power Plant and Industrial Fuel Use Act of 1978 (FUA) discussed in this section; and
- The gas curtailment priorities for customers of interstate pipelines which are discussed below.

The FUA is one of five parts of the National Energy Act enacted in 1978. It restricts the use of oil and gas in power plants (boilers, combined cycles, and combustion turbines) and large industrial boilers. Specifically, the FUA

- prohibits the use of oil and gas in new electric power plants and major fuel burning installations (MFBIs);
- prohibits the use of natural gas in existing power plants in 1990 and thereafter; and
- grants DOE the authority to issue orders prohibiting the use of oil or gas in specific existing power plants of MFBIs, based on certain findings regarding the technical capability of the unit to burn coal or an alternative fuel and the financial feasibility of the conversion.

Impact of FUA on DHC. Under the current set of regulations implementing the FUA, there is virtually no chance that any existing unit that is part of a district heating system could be affected by the Act. Only a new unit, for

which construction began after 1978, could be restricted by the Act, and then only if it is large enough to exceed the threshold for FUA coverage, that is, if its maximum fuel input heat rate exceeds 100 million Btu/hour (or if the units larger than 50 MMBtu/hr. at a single site have an aggregate input exceeding 250 MMBtu/hr.). Even more important, modifications of the fuel use oil regulations by the Secretary of Energy may eliminate future questions about problems with exemptions.

Gas Pipeline Curtailment Plans (NGA and NGPA). The DOE Organization Act of 1977 assigns the Secretary of Energy the responsibility to establish and review priorities for interstate pipeline curtailment. The Natural Gas Policy Act of 1978 mandates that the Secretary establish certain curtailment priorities (i.e., essential agricultural, industrial feedstock and process uses). Under the DOE Act and NGPA, FERC is assigned the responsibility to implement and enforce these curtailment rules. The Natural Gas Act provides authority related to curtailments by interstate pipelines to their customers which are primarily gas distribution companies; some pipelines also have direct customers. The delivery and curtailment of gas by the distribution companies to their end-use customers is subject to the jurisdiction of the state regulatory commissions.

On June 24, 1980, DOE issued proposed rules concerning the review and establishment of natural gas curtailment priorities for interstate pipelines (FR 45, No. 129, p. 45098, July 2, 1980). Presently, and since about 1973, natural gas curtailment priorities applicable to interstate pipelines have been considered and determined on a case-by-case basis under the guidelines set out in FPC Order No. 467-B (18 C.F.R. 2.78), which provides for establishment of curtailment priorities on the basis of the end-use of the

gas. The proposed DOE rule continues to use this fundamental end-use type of approach, which was also generally recognized by Title IV of the NGPA. It creates five categories of priority for deliveries of gas by interstate pipelines during periods of curtailment. The end-users of the distribution companies served by the pipeline are assigned priorities in accordance with these five priorities, and the volumetric requirements of each end-use priority level are established with respect to use during a past period. During a curtailment situation, the interstate pipeline would apportion its available gas supplies to the distributing companies and its direct customers in accordance with its curtailment plan, first satisfying all priority one users, then priority two, and so on until the gas supply is exhausted. Priority one users generally consist of residential and small commercial users, with large boiler fuel users being the lowest priority.

Potential Impact of the Curtailment Rules on District Heating. Neither the current Federal curtailment priorities (Order 467-B) nor those proposed by the DOE rule provide for any special treatment of district heating boilers of comparable size. Therefore, it is possible that a gas-fired district heating system might not be able to offer its potential residential subscribers the same gas supply security during periods of curtailment that they would have as individual gas customers. For reasons discussed below, it appears likely that this situation may not occur or could be alleviated.

Although a district heating system might buy gas directly from an interstate pipeline, it is more likely to buy gas from a gas distribution company. The curtailment of end-user gas service is determined by state or local regulators. Only the overall amount of gas allowed to the company under curtailment conditions (from each of the pipelines that serve it) would be determined under Federal curtailment plans.

Generally, the distribution company's index of end-users, which is the basis for its allocation of pipeline supplies, is changed only when the base period is updated. This updating of base periods has traditionally been done infrequently and only at the initiative of the gas company and its customers, and not at the FERC's initiative. The base period concept could help a gas-fired district heating system that is trying to attract new subscribers who would otherwise be high-priority gas users.

- As long as the base period is not updated, the overall amount of gas available to a distribution company from its interstate pipeline supplier during curtailments would not change due to a customer switching from gas to district heat. Therefore, the state authorities could allow the gas that becomes available from the end-users that switch to be used by the district heating system.

- The decision concerning the allocation of gas to end-users would be a state or local one.

Therefore, it appears that state or local authorities, if they wish to support the development of a gas-fired district heating system, have a means of providing incentives for district heating systems related to gas curtailment phases.

If a district heating system could not obtain relief under the aforementioned circumstances or other means at the state or local level, it could:

- Apply to the FERC for an exemption under Section 502 of the NGPA on the basis of special hardships, inequity, or unfair distribution of burdens or "extraordinary relief" by filing a petition for such relief; or

- Install a back-up energy source which uses a fuel other than gas.

In summary, it appears that special consideration for district heating plants, in relation to curtailment plans, will have to be initiated at the state or local regulatory level to be effective. But policy guidelines from

Federal authorities indicating the priority concern that is placed in developing new district heating systems would facilitate such regulatory changes.

3.4.3 State and Local Issues

DHC systems can be divided into two types, those that could be classified as "public utilities" in the sense that they offer service to the general public, and those that serve the needs of a single owner or private group of owners. This discussion is limited to "utility-type" DHC systems which may or may not be regulated.

Each state has its own body of regulatory law governing public utilities and division of authority between itself and local jurisdictions. Many of the states where broad powers exist at the state level to regulate thermal services (DHC systems) have chosen not to exercise these powers and have allowed the local bodies to assume control. This choice may be due to the small number and sizes of these systems. However, if DHC were to start to gain a significant portion of the energy service market, the state legislatures and Public Utility Commissions would be likely to re-examine current statutes and regulatory policy. The division of regulatory authority among state and local agencies varies widely among the states. However, the combined effort of state and local regulation appears to constitute very broad and substantive control over these systems. Utility regulation can be divided into a number of general areas, including:

- Initial granting of a franchise to offer service in a defined area, either on an exclusive or non-exclusive basis;
- Certification of new facilities;
- Establishment through a public procedure of rates for service including methods for cost allocation among various services and customer classes;

- The siting of plants and associated equipment;
- The establishment of environment standards;
- The control of access to fuels including curtailment provisions during short fall periods;
- Subdivision regulation;
- Building and housing codes; and
- Zoning.

It is obvious that unfavorable treatment in any one of these areas could prevent the development of a DHC utility.

The central issue faced by state and local regulations is the selection of the varied regulatory options which are available. These options range from no regulation to the type of extensive regulation exercised over the electrical utilities.

Just as important as the degree of regulations, is the timing of the implementation of this regulation. A mature DHC system like an electric utility may be ready for, and indeed benefit from, full scale regulation. However, unlike an electric utility, a DHC system does not provide a unique, indispensable service. There are other options available to a consumer for thermal services, including their own independent gas, electricity, and fuel-oil-fired heat plant. DHC in its modern form, is an infant industry, much the same as the electric power industry was a half century ago. DHC has substantial initial capital costs and must have some way to amortize this investment to the satisfaction of its creditors. DHC sponsors cannot attract customers unless their prices are competitive. Under such circumstances, there is no reason to regulate the price of DHC services at any level lower than what the market will bear. Later, after a DHC system has amortized its investment and realized a reasonable profit, different regulatory treatment may be considered.

3.5 AIR QUALITY ISSUES

3.5.1 General Discussion

Two aspects of air pollution can create adverse environmental effects: the concentration of pollution in ambient air at any given moment, and the total amount of pollution released over time. To date, Congress has directed EPA and states to focus on controlling ambient concentrations of air pollution by regulating emissions from major source categories. The Clean Air Act (CAA) has not directly addressed environmental problems such as acid rain that are associated with total loadings of pollution.

EPA has established maximum allowable pollution concentrations called National Ambient Air Quality Standards (NAAQS) for major air pollutants to protect public health and welfare with an adequate margin of safety. Also to prevent significant deterioration of air quality in clean areas, EPA has established limits (Prevention of Significant Deterioration or PSD Increments) on the increases in pollutants by establishing specific emission limits for new and existing major stationary sources.

The CAA requires states to develop, as part of their state implementation plan (SIP), programs for preconstruction review of new and modified sources, and to require:

- new sources in certain major categories (including boilers, power plants, and incinerators) to comply with New Source Performance Standards (NSPSs) at a minimum;
- major new sources sited in PSD areas to apply the best available control technology (which may exceed NSPS in stringency) and show that they would not cause any violation of a PSD increment or NAAQS; and
- new sources sited in non-attainment areas (areas dirtier than the NAAQS) to emit at their lowest achievable emission rate and obtain emission reductions that more than offset the emissions introduced by the new source.

Thus, the effect of air pollution regulations on a district heating energy source depends primarily on the nature of its emissions, its status (existing, modified, or new) and on constraints imposed by the existing air quality in the area. Two general points deserve highlighting. First, air quality regulation has a more restrictive effect upon the use of coal. Second and more importantly, regulation does not recognize the efficiencies of cogeneration. Current regulations do not evaluate units of emmissions per unit of useful energy. Below, is a discussion on the effect of specific regulations on specific DH energy sources.

1. New Source Performance Standards (NSPS). Section 111 of the Clean Air Act requires EPA to establish standards of performance for certain major categories of new or modified stationary sources that sufficiently contribute to air pollution so as not to endanger public health or welfare. EPA has established NSPS's for three source categories that may be a part of district heatings systems; power plants, industrial boilers, and waste incinerators.

In 1971, EPA issued an NSPS for large fossil-fuel-fired steam generators (power plants and industrial boilers over 250 mmBtu's/hr heat input). This standard regulated emissions of sulfur dioxide, particulate matter (TSP), and nitrogen oxides by establishing a maximum allowable emission rate for each pollutant. In complying with this sulfur dioxide limit, sources could burn either low sulfur coal without further controls or high sulfur coal with scrubbers (flue gas desulfurization systems). To comply with the particulate limits, sources could install electrostatic precipitators (ESPs) or other equivalent techniques.

2. Applicability of NSPS to DHC Systems. The revised NSPS for steam electric units will apply to any large, new power plants that contribute waste heat to the district heating system. However, we expect that many DHC systems will be designed with existing power plants--which are not subject to the NSPS--supplying most of the thermal energy. Modification of an existing power plant to operate in a cogeneration mode does not subject that plant to the NSPS if the turbine--not the boiler--is modified, because the boiler's emission rate (in kg/hr) will not increase. Also, an increase in a plant's hours of operation is specifically exempted from designation as a modification.

DHC systems may be designed with small, new boilers that will provide peaking capacity. Although these small boilers are probably below the size cutoff for the 1971 NSPS (the 1978 applies only to power plants boilers) the revised industrial boiler standards could apply to these boilers.

3. Prevention of Significant Deterioration (PSD) Requirements. Part C of the CAA directs EPA to develop regulations that prevent significant deterioration of air quality in areas cleaner than the ambient air standards. The Act requires that new or modified sources siting in these areas that have the potential to emit more than a specified level of pollution must undergo an air quality review before construction. All sources above the cutoff must be equipped with the Best Available Control Technology (BACT), which equals NSPS as a minimum and perhaps a higher level of control depending on many factors, including whether the PSD air quality increments or the NAAQS are a constraint. The specified cutoff for new fossil fuel-fired steam generators

and steam electric units over 250 mmBtu/hr and for all municipal waste incinerators is the potential to emit (after pollution control) 100 tons per year or more of any pollutant. The cutoff for smaller fossil fuel-fired is 250 tons per year.

4. The Bubble Policy. EPA's bubble policy was developed to add flexibility to and increase the cost-effectiveness of air pollution control strategies for existing sources. Under the policy, polluters can change the emission limits for existing sources in a certain area, so that they control pollution more where costs are low and less where costs are high, as long as ambient air quality after the emission limits are changed is equal to or better than before. Emissions limits that are altered under the bubble policy must be made enforceable through revisions to the state implementation plan (SIP).

Although EPA developed the bubble policy, states regulate existing sources and thus have authority over its implementation. Some states may choose not to allow bubbles. To expedite review and approval of bubbles, EPA can now approve a generic state rule and thus avoid involvement in every bubble proposal. However, EPA maintains the authority to review complex, large-scale bubble proposals that the states approve. Typically, bubbles involving district heating would be complex.

3.6 SUMMARY AND CONCLUSIONS

Although some new district heating and cooling development has been implemented in the United States during the late 1970's and early 1980's, these systems, because of the sizeable nature of the investment in a changing economic environment, faced numerous institutional and financial barriers to implementation. Successful projects developed to date have approached these barriers as obstacles to be overcome or circumvented. The sheer number of

obstacles and the length of the course have, in fact, deterred all but totally resolute entrepreneurs and developers. Importantly, of the district heating and cooling systems currently under construction, these barriers have been addressed by utilizing available financial instruments, but they have also received predevelopment federal or state support.

Preceding sections of this chapter identified, organized and described barriers to DHC development in four categories:

1. Market Entry Barriers
2. System Financing Issues
3. Regulatory Barriers and Uncertainties
4. Air Quality Issues

The very order of these four categories is significant in that DHC systems first face market entry barriers. If the project developers are successful in structuring a workable partnership between private and public enterprise, the project then tackles the financial and regulatory barriers. Finally, the developer moves through the protracted air quality permitting process.

Experience to date (private developments, the HUD 28 cities program, DOE's district heating demonstration project, and other state-initiated programs) indicates that projects clearing the first set of obstacles, i.e., market entry barriers, become, for the large part, successful. During the predevelopment phase of project implementation, district heating and cooling developers continually confront federal and state policies which discriminate in favor of other alternative energy supply systems and technologies. Through its energy pricing and subsidy policy, the federal government has distorted the cost of energy supply and conservation systems which compete with district heating and cooling. These in fact contribute to project complexity, the

risk incurred during initial project identification, the risk associated with aggregating customers and the risk of unknown future energy prices.

Finally, recent congressional action has further added to the uncertainty of DHC project financing. Industrial development bond financing, critical to the implementation of many projects, remains available for DHC projects. However, the impact of the IDB issue cap coupled with the future ineligibility of small issue IDB's further increases the uncertainty surrounding project financing.

It is unlikely that sweeping institutional change will occur which removes these uncertainties or breaks down most barriers. This would require coordinated action by both federal and state government, and specifically would require action on the part of several federal regulatory agencies. Therefore, any near and mid-term efforts to encourage district heating and cooling would have to be targeted to the ability of developers, cities and financers to negotiate the obstacle course.

Chapter 4

MARKET POTENTIAL OF DISTRICT HEATING AND COOLING

4.1 INTRODUCTION AND BACKGROUND

District heating systems can be used to serve the demand for many energy services in the residential, commercial, and industrial sectors. In this section of the report, the potential role for district heating in the U.S. energy delivery system is developed as follows:

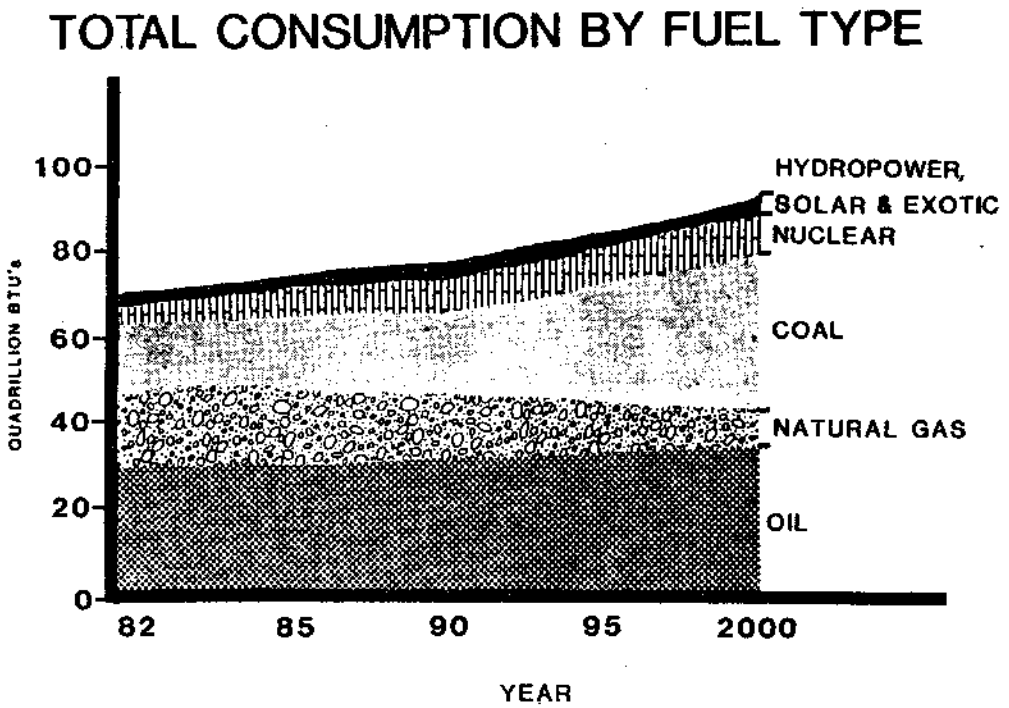
1. The current energy market outlook is reviewed;
2. The overall energy service demand which DHC systems can serve and the competing supply options are reviewed;
3. The market penetration of DHC systems is estimated.

4.1.1 The Current U.S. Energy Outlook

The demand for energy services has grown steadily since the beginning of the industrial revolution in the United States. Currently, Data Resources, Inc. estimates that the U.S. will have consumed approximately 73 quadrillion Btu's (quads) of energy in 1984. Except for a slight dip in consumption during 1981 through 1983, reflecting conservation adjustments to higher fuel prices, Graph 4-1 shows this growth trend continuing to about 93 quads per year by the year 2000.

This growth trend will be heavily influenced by increased demand by the electric utility industry. DRI estimates that comsumption of primary energy by this sector will increase from 26.3 quads in 1984 to 41.9 quads in 2000. This represents an increase of almost 60%, and accounts for over 80% of the total increased consumption.

Graph 4-1



Oil and gas are predicted to continue at existing levels of consumption and price through the remainder of this decade. However in the 1990's and beyond, the price of these fuels, along with the price of electricity, increase dramatically. This cost escalation, with modest levels of inflation, erode the disposable income of consumers and add to the cost of production of industry. It is always possible that oil supplies will be restricted due to political reasons in oil producing regions of the world, thereby distorting these predictions. While the U.S. has reduced its dependance on imported oil from Middle Eastern nations since the oil crises in the 1970's, there is still a significant reliance by the U.S., western Europe and Japan on oil imports. Basic laws of supply and demand dictate that in the future, depletable natural resources will cost more world wide.

The development of alternative fuels and energy systems such as solar, wind, low head hydro, synthetic fuels, resource recovery, biomass, geothermal,

and other more exotic technologies are being explored. However, as Figure 3-1 indicates, this country will continue to rely heavily on conventional energy supply options. It is now widely recognized that no single technological "answer" to the energy problem will emerge in the near term; rather, an appropriate blend of predominantly conventional energy systems will continue to serve U.S. energy markets at least to the year 2000.

Energy Service Demand.

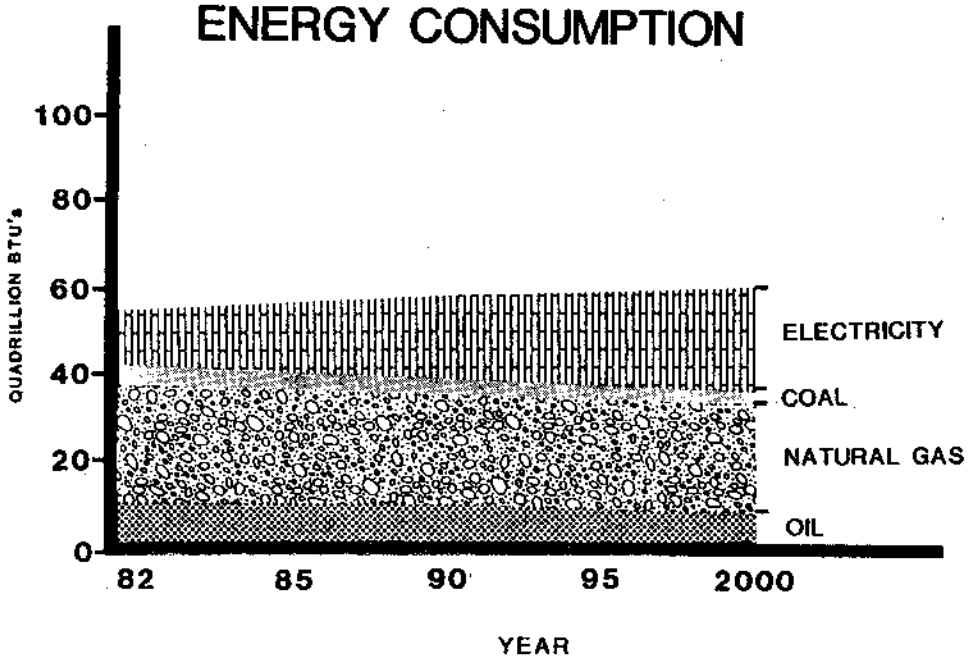
Delivering energy in the form of combustible fuel to be burned at the point of use requires that combustion and conversion equipment, and possibly fuel storage, must be owned and operated at the consumers' sites. Since these systems require substantial capital investment and maintenance, consumers may be willing to pay a higher price for energy which does not require this on-site equipment. Use of electricity resistance for space heating, for example, removes the energy conversion process to a large power plant typically located many miles away. In selecting an energy system the consumer must trade off the higher initial purchase price and maintenance expense of a gas furnace or boiler with the higher fuel cost of electric resistance heat. If, as DRI forecasts, the price of natural gas and oil rise faster than electricity, convention typically indicates that consumers will frequently switch to electric heating systems.

Energy Services Supply.

The conventional U.S. energy outlook just presented above shows that while individual consumers can make adjustments in energy demands, for the most part their choices of fuel are limited. We are, in effect, dependent in large measure on bulk energy supplies of oil, natural gas, coal, and electricity. These bulk energy supplies are typically manufactured at remote locations and shipped, piped, or sent over transmission lines long distances to demand centers for local distribution to consumers.

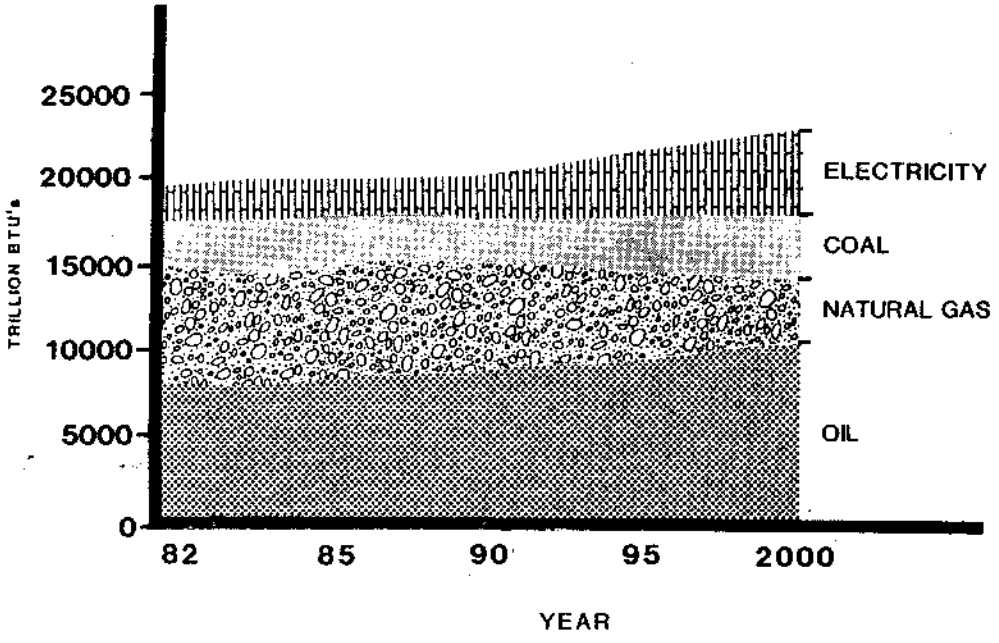
The consumer can make adjustments to capital stock and operating procedures in response to higher energy prices. However, he is still mainly dependent on large-scale energy networks. Graphs 4-2 and 4-3 show the expected energy demand forecasts for the residential-commercial and industrial sectors respectively. Significant improvements in these demand outlooks can only come from an examination of the efficiency with which energy is manufactured, delivered and utilized through U.S. energy networks to local consumers.

RESIDENTIAL AND COMMERCIAL ENERGY CONSUMPTION



Graph 4-2

INDUSTRIAL ENERGY CONSUMPTION



Graph 4-3

As previously indicated, the majority of the increased demand for primary energy inputs is accounted for by the electric utility industry. Figures 4-2 and 4-3 predict that electricity will play an increasingly important role in end-use energy systems. The only way to capture efficiencies under the predicted scenario is through cogeneration. Since electrical energy is 100% efficient at the consumers' homes or businesses in resistance heating, and more efficient through the consumers' use of heat pumps, the efficiency of fuel input can only be realized at the production station.

In the future as natural gas and oil prices continue to rise and levels of future supplies remain uncertain, DRI forecasts that the future growth in energy market shares belong to coal based-electricity. Utility coal consumption will almost double from 13.8 quads in 1984 to 25.9 quads in 2000. Electricity consumption is forecast to grow 7.8 quads in 1984 to 12.5 quads in 2000, an increase of 60%. Natural gas and oil shares of electric production are forecast to decline from 18.3% in 1984 to 12.2% by 2000.

Unfortunately, the shift to electricity does not come without cost. In order to meet the forecast demand, current electrical generation capacity is predicted to increase over 33% from 630,000 megawatts in 1984 to over 843,000 megawatts in 2000. In addition, each unit of energy delivered from electrical production requires an input of more than three units of primary fuel at the plant. Therefore, in increasing the electric share of the energy market, the efficiency design considerations of future U.S. electric networks must be improved.

The use of thermal energy networks, or "district heating systems", can contribute significantly to the goal of efficiency. Once installed, district heating systems have the advantages of being designed to use alternative and more abundant fuel sources, or energy that might otherwise be wasted. District

heating systems can efficiently supply a range of energy services often requiring simpler, less expansive consumer-owned and operated equipment than conventional fuels. In addition, a thermal network can be coupled with an electrical generation source to more than double the fuel efficiency of the system.

4.2 DISTRICT HEATING AND COOLING MARKET PENETRATION METHODOLOGY

District heating and cooling market potential is based on the projected ability of system developers to compete effectively in the end-use energy market. It has been established that district heating is a proven energy delivery concept that has acquired acceptance in certain market segments -- central business districts and older nearby industrial areas in U.S. cities with steam systems. However, the popularity of this energy technology and its market share of the total energy market has been declining in recent years for a variety of reasons. The principal causes for the decline are: the face of downtowns changed as a result of urban redevelopment programs and shifts in factory locations; utility change-outs from coal to oil and natural gas for steam production in order to meet environmental regulations while avoiding the installation of costly emission control equipment suitable for coal-fired systems; and the general absence of aggressive marketing programs designed to improve existing system economics on the part of investor-owned steam utilities.

The technologies of district heating and cooling systems are beginning to shift in the United States from steam to hot water, and system ownership appears to be moving away from the traditional ownership by investor-owned electric utilities to entrepreneur and public or not-for-profit ownerships. As a result

of these changes in the market place, district heating and cooling systems essentially are, and must be treated as, new energy technologies when evaluating their market potential. In order to evaluate these changes and resulting potential, a market acceptance function was developed by Argonne National Laboratory to project the market penetration of district heating.

Argonne National Laboratory's District Heating Market Penetration Model (ANL Model) is a predictive, econometric model that segments both the energy source technologies and the end-use market by energy production and use characteristics. Its primary purpose is to predict a technically available market; that is, how much of the national residential and commercial energy needs potentially could be supplied by district heating systems if the only considerations were the physical limitations of making connections. This initial calculation establishes a technical upper limit for district heating development. In subsequent stages of the calculations, economic variables applicable to each region of the country are introduced. They are based on the current cost of competing fuels, projected fuel prices, electric demand, current and projected financing costs, and population characteristics that will influence market growth. These variables establish an "economically attractive market" projection. This projection identifies the level of district heating activity that could be competitive with existing energy systems. In the final step of the ANL Model, a technology acceptance function is applied that predicts the amount of the market that can reasonably be expected to be served by district heating.

The ANL Model follows the methodology used to predict the market penetration of any new product. Thus, the total available market is projected; the segment of that market that can be competitively served is identified; and the market share is projected.

The following discussion was prepared by the developer of the Argonne National Laboratory Model. It explains the model in much greater detail.

4.2.1 Introduction

The objective of this model is to evaluate the impact of changing energy scenarios on the development and market potential of district heating and cooling (DHC) systems that deliver hot/cold water and/or steam, plus electricity, from a central source to users in residential, commercial, and industrial sectors. This section describes the model, estimating the impact of changing energy scenarios on DHC systems. A discussion is provided on (1) methodology, (2) updated DHC market penetration estimates under a base case, (3) alternative energy scenarios and associated DHC market penetration estimates, and (4) possible implications for development of DHC systems.

4.2.2 Methodology

The impact of changing energy scenarios on DHC systems is estimated by using the Argonne National Laboratory District Heating and Cooling market assessment model. This DHC market model is linked with DRI's U.S. Economy Model and U.S. Energy Model to obtain projections of approximately 100 exogenous variables under alternative macroeconomic and energy scenarios. In the first step, the base case (future projection of current situations) DHC markets are estimated between 1984 and 2005 under the recent DRI base case energy scenario (ENG/ECONTROL/1183). In the second step, DHC markets are estimated under the two DRI alternative energy scenarios: High Oil (price) Case (ENG/HIGHOIL/1183) and Low Oil (price) Case (ENG/LOWOIL/1183). These DRI simulations assume alternative trajectories of crude oil prices compared to the base case crude oil price. The impact of alternative energy scenarios is then measured by comparing the DHC markets under the high oil case and low oil case to that of the base case.

4.2.3 Estimating Market Penetration of District Heating and Cooling Systems

The methodology developed to estimate the penetration of selected DHC systems in residential and commercial energy market uses an econometric and probabilistic approach to analyze the technical and economic factors that influence possible market penetration. The methodology includes four steps:

- Segmentation of DHC systems and end-use markets.
- Estimation of DHC potential market.
- Estimation of DHC economic market.
- Estimation of DHC market penetration.

Segmentation of DHC Systems and End-Use Markets. For purposes of market segmentation only the primemover technologies of the diesel engine, gas turbine, and steam turbine are included in the following DHC cogeneration systems.

1. Combined Heat and Power Systems. These relatively large plants (150-750 MW) are assumed to be equipped with steam turbines and coal-fired boilers. Private electric utilities are assumed to own these facilities.
2. Selective Energy Systems. These medium-size plants (10-150 MW) are assumed to be owned by nonelectric utility companies. The plants are allowed to buy and sell electricity from and to the local electric utility. For the plants between 20 and 150 MW, steam turbines and coal-fired boilers are selected; for plants between 10 and 20 MW, gas turbines are selected.
3. Total Energy Systems. These systems are designed to meet all the energy demands of the customer and are assumed to be owned by nonelectric utility investors. The plants use diesel engine (1-10 MW), gas turbines (10-20 MW), or steam turbines (20-50-MW) as the prime mover.

The DHC national market is divided into four census regions (Map 4-1) to account for variations in the climate and fuel prices. Each of the regional markets was further divided into seven groups of communities to capture the variation in site-specific energy demand density (Table 4-1).

4.2.4 Estimation of DHC Systems Potential Market

The DHC potential market was defined to include all end-use energy demands within the selected segment of residential and commercial sectors. These end-use applications specifically include space heating, air conditioning, water heating, cooking, lighting, appliances, and other categories. The DHC potential market was first estimated for the base year of 1970 based on end-use fuel demand data for 1970 from the Project Independence Report prepared by Arthur D. Little, Inc., in 1974.

The 1970 DHC potential market for each of the 28 market segments (four regions and seven market groups) is estimated from the data below in three

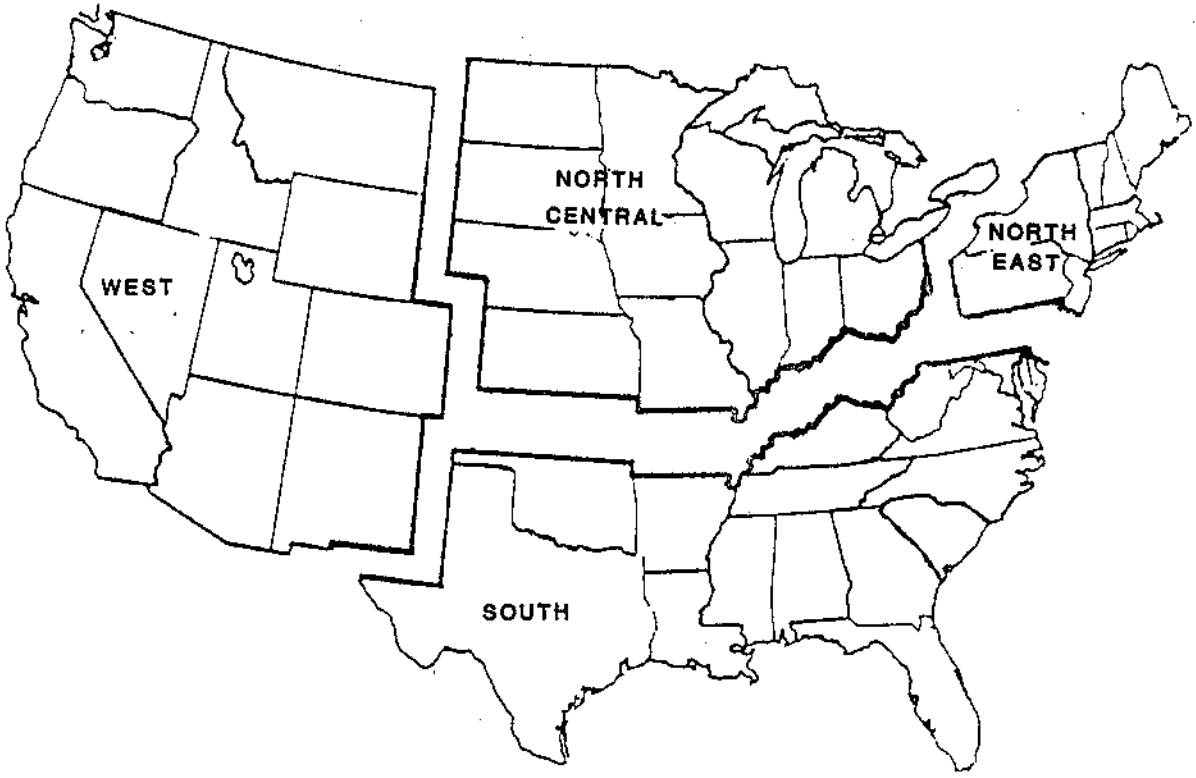
Table 4-1

DHC End-Use Market Segmentation into

Seven Groups within Each Census Region

End-Use Market	1970 Population	Market Group
Large Urbanized Area	More than 1,000,000	
Central Cities	____	1
Urban Fringe	____	2
Medium Urbanized Area	250,000 - 1,000,000	
Central Cities	____	3
Urban Fringe	____	4
Small Urbanized Area	50,000 - 250,000	
Central Cities	____	5
Urban Fringe	____	6
Other Urban Areas	2,500 - 50,000	7

MAJOR CENSUS REGIONS



Map 4-1

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steps. First, single-family fuel demand is excluded. Second, rural fuel demand is excluded. Third, fuel consumption data are multiplied with the assumed energy efficiency of the end-use equipment to estimate real demand of energy at the point of end-use.

The DHC potential market for each of the 28 market segments is projected for all the years between 1970 and 2005 using the historical (1970-1982) and projected (1983-2005) growth rates of the fuels demands in the residential and commercial sectors in that census region. The residential/commercial fuel demand projections are obtained from DRI's U.S. Energy Model.

4.2.5 Estimation of DHC Systems Economic Market

DHC systems will have to compete with conventional systems and fuels to capture residential and commercial energy demands. To estimate the economically attractive market for DHC systems, the following procedure is used:

1. Estimate Cost of Conventional Systems. The average delivered energy cost ($/million Btu) of the conventional fuel is measured by (1) weighting the regional costs of natural gas, oil, coal, and electricity in the residential and commercial sectors; and (2) adding the cost of end-use equipment.
2. Estimate Cost of DHC Systems. To estimate the DHC system delivered energy cost, a detailed engineering-economic analysis is done. The Electric Power Research Institute Revenue Requirement Methodology provided the basis for estimating the cost of delivered energy from DHC systems. Additionally, earlier research on costs of DHC facilities provided the necessary input data for engineering analysis. Using the energy demand patterns in the residential and commercial sectors, one or more feasible DHC systems are designed for each of the 28 market

segments. By dividing the estimated total annual cost by the useful district heating output, the average delivered energy cost ($/million Btu) is obtained.

3. Economic Comparison of DHC and Conventional Systems. Unlike that of conventional systems, the cost of DHC systems is expected to change significantly among the applications within any of the 28 market segments. A simulation is used to estimate the delivered energy cost of DHC systems and then compare the results with the conventional system cost. After sufficient simulation trials, the probability of DHC systems being the least-cost technology is estimated by multiplying the probability with the potential market:

$$\left\{\begin{matrix}\text{DHC}\\ \text{Economic}\\ \text{Market}\end{matrix}\right\}_{i,j,k} = \left\{\begin{matrix}\text{Probability of DHC}\\ \text{System Being}\\ \text{Least-Cost}\\ \text{Technology}\end{matrix}\right\}_{i,j,k} \times \left\{\begin{matrix}\text{DHC}\\ \text{Potential}\\ \text{Market}\end{matrix}\right\}_{j,k}$$

4. Estimation of DHC Systems Market Penetration. New DHC systems are not expected to capture the economic market immediately. As with other new products and technologies, they are assumed to follow a somewhat s-shaped growth pattern. To estimate the growth curve, the behavioral lag function approach developed by Stanford Research Institute (SRI) is adapted. The SRI behaviorial lag function is specified as follows:

$$Y_K = \frac{1}{1 + \left\{\frac{H}{K}\right\}^a}$$

where: Y = market penetration share,

H = half-life (years required for 50% of the market to respond to the entry of new technology),

K = number of years since introduction of the technology, and

a = response parameter.

In an earlier research work, the growth curve parameters of market penetration were estimated using data for the sales of new gas turbine systems in the electric utility peak-load market between 1959 and 1977. The response parameter (a) (which measures how quickly the user accepts the new technology) was estimated to be 3.2; half-life (number of years for 50% penetration) was estimated to be 11.3 years. The estimated equation had an R-2 of 0.95 (the equation explains 95% of the variation). The 3.2 estimated value of (a) for gas turbines compares close to the SRI assumed value of 4.0 for solar technology.

For medium-size DHC systems (the same capacity range as gas turbines), half-life is arbitrarily increased to 15 years to reflect the greater institutional problems of DHC systems compared to those of gas turbine systems. Moreover, difficulties are expected to increase with the increase in system size. Therefore, an adjustment is made to slow the rate of penetration for large systems, compared to that of medium systems, by arbitrarily increasing the half-life to 20 years. Conversely, for smaller systems the half-life is reduced to 10 years. The response parameter (a) is assumed to be 3.2 for all DHC systems. Yet another assumption is made that DHC systems penetration begins in 1984. The DHC annual market penetration is then determined by the equation:

$$\begin{pmatrix} \text{DHC} \\ \text{Market} \\ \text{Penetration} \end{pmatrix}_{i,j,k} = \begin{pmatrix} \text{DHC} \\ \text{Economic} \\ \text{Market} \end{pmatrix}_{i,j,k} \times \begin{pmatrix} \text{DHC} \\ \text{Pentration} \\ \text{Share} \end{pmatrix}_{i,k}$$

where: i = DHC option (<7),
j = end-use market (28), and
k = year (1984-2005).

The application of this methodology led to the development of the Argonne District Heating and Cooling Market Assessment Model. The model can be used to estimate DHC market, under a variety of scenarios.

4.2.6 DHC Base Case Market Penetration.

The base case represents the "as is" situation with no additional assistance provided for district heating development. The base case establishes the foundation for testing other options. The model is used to estimate DHC markets using the DRI base case energy scenario.

Table 4-2 summarizes the energy market assumptions under the DRI base case scenario. Graphs 4-4 and 4-5 indicate fuel prices projected for residential and industrial markets.

Table 4-2

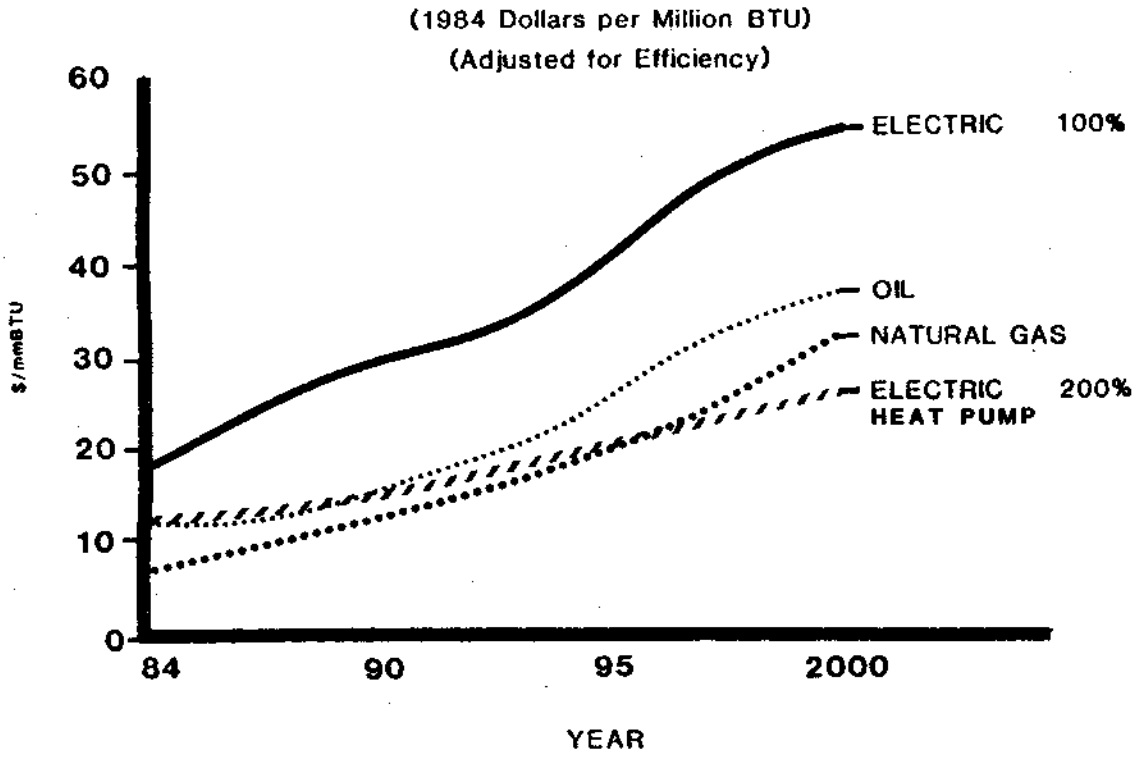
HIGHLIGHTS OF DRI BASE CASE ENERGY SCENARIO

Principal Indicators	1982	1983	1984	1985	1990	2005
Macroeconomic Indicators						
Real Gross National Product (%)	-1.9	3.4	5.5	3.0	3.0	2.4
Inflation rate (a) (%)	6.0	4.3	5.0	5.1	5.9	5.5
Unemployment rate (%)	9.7	9.7	8.2	8.0	7.2	7.5
Wholesale Price Index: fuels and power (c) (%)	-0.2	-3.6	3.3	5.4	8.8	7.2
AA Corporate Utility Bonds: Yield (%)	15.1	12.4	11.8	12.2	10.2	9.6
Energy Indicators						
Imported Crude Oil Price						
($/bbl)	33.6	29.3	29.3	30.4	45.1	161.7
(1982 $/bbl)	33.6	28.1	26.8	26.4	29.8	44.9
U.S. Primary Energy Consumption (Quad)	70.7	70.1	72.8	73.9	79.7	94.4
U.S. Residential Energy Consumption (d) (Quad)	8.8	8.6	8.8	8.9	8.7	8.3
U.S. Commercial Energy Consumption (d) (Quad)	5.8	5.5	5.8	5.9	6.3	8.8
Distillate Fuel Price (1982 $/10(6)Btu)	6.7	5.7	5.4	5.4	6.3	9.1
Natural Gas Price (1982 $/10(6) Btu)						
Average residential	5.1	5.8	5.7	5.7	6.8	9.7
Average commercial	4.8	5.5	5.4	5.4	6.4	9.1
Electricity Price (1982 $/10(6) Btu)						
Average residential	18.9	18.4	18.8	19.4	20.3	20.6
Average commercial	18.9	18.2	18.5	18.9	19.4	19.2

Source: Data Resources Inc. (ENG/ECONTROL/1183)

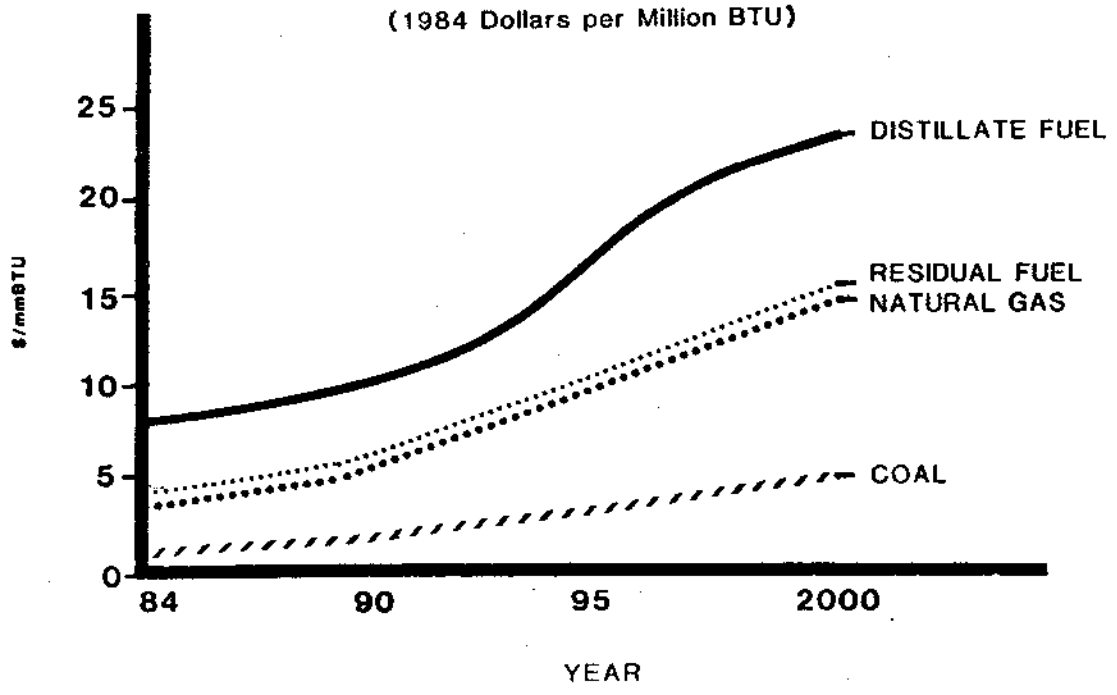
(a) Implicit price deflator (gross national product; index 1972 = 1.000).
(b) Unemployment rate as percentage of total labor force.
(c) 1967 = 1.000.
(d) Primary and secondary fuels (oil, gas, electricity and coal).

RESIDENTIAL FUEL PRICES



Graph 4-4

INDUSTRIAL FUEL PRICES

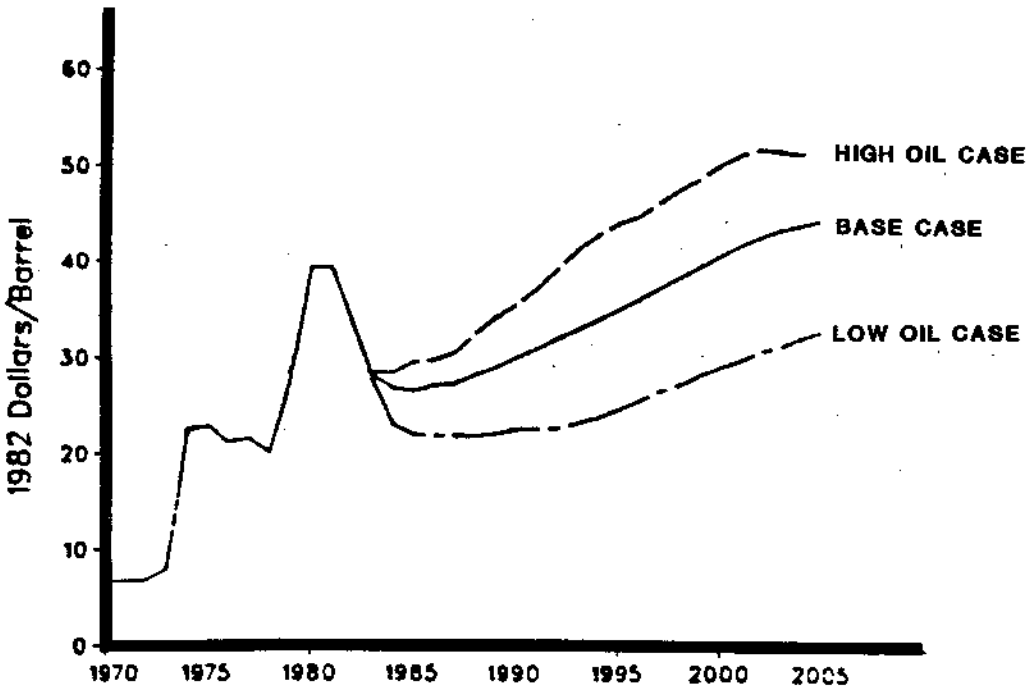


Graph 4-5

DRI Base Case Energy Scenario. In this scenario, the current economic recovery proceeds in an orderly manner, and real GNP increases by 3.4.% in 1983 after declining 1.9% in 1982. The economy picks up momentum as it rises 5.5% in 1984, but slows to 3.0%/yr in the mid-1980's. Over the long run, real GNP grows at an average annual rate of 2.4%. Inflation, as measured by the implicit price deflator of GNP, drops to 4.3%/yr in 1983, compared to 6.0% in 1982. Over the next 20 years, inflation worsens moderately, but remains below a 6.0% average annual rate. No major energy or other economic disruption is assumed under this scenario.

The price forecast for crude oil and other fuels is also shown in Table 4-2. Under this scenario, the price of imported crude oil declines to $29.35/bbl in 1983 because of the continued weak world oil demand. This is the second consecutive year in which the imported oil price declines, earlier the price declined from a peak of $37.07/bbl in 1981 to $33.59/bbl in 1982. However, the combined effect of a growing world economy and a continuing but smaller rate of decline in oil intensity is expected to lead to increased oil consumption in 1984, the first increase since 1979. As a result, the crude oil price holds to its level of $29/bbl in 1984. Over the intermediate term (1985-87) there are only modest adjustment-type inflation increases. Beyond this period, the Base Case price is premised on orderly real price increases in the range of 2% to 4% by OPEC. Under the these conditions, the nominal crude oil price reaches $45.13/bbl in 1990 and $71.30 in 1995. In real 1982 dollars (Graph 4-6), the price falls to a low of $26.38/bbl in 1985, compared to $33.59/bbl in 1982. The real price approaches $29.82/bbl in 1990 and $44.92/bb in 2005. The change in real imported oil price corresponds to an average annual decline of 7.7% between 1980 and 1985, and an annual increase rate of 2.5% between 1985 and 1990 and 2.7% between 1990 and 2005.

The total U.S. energy demand for 1984 is projected to increase to 72.8 quads, an increase over the 1983 level of 70.1 quads. Steady improvement continues over the forecast, and the total energy demand reaches 94.4 quads in 2005.



U.S. IMPORTED CRUDE OIL PRICE IN ALTERNATIVE CASES

Graph 4-6

BASE CASE PROJECTIONS

1. DHC Potential Market: The annual potential market was estimated to be 4.39 quads in 1982 for the base case. This market size is substantial by any standard, constituting 6.2% of the total U.S. primary energy consumption of 70.7 quads in 1982. After reaching a low of 4.26 quads in 1983, the DHC market potential bounces back to 4.41 quads in 1984. It is then projected to rise to 4.54 quads by 1990, 4.87 by 2000, and 5.16 by 2005. The average annual growth rate is 0.4% between 1982 and 1990 and 0.8% between 1990 and 2005.

2. DHC Economic Market: The relative economics of DHC systems are affected by changes in the cost of delivered energy from conventional systems and DHC systems. One exogenous policy that has an impact on cost of DHC systems is the 1982 federal legislation making DHC distribution and transmission system costs eligible for tax exempt industrial bond financing. This bill passed in 1982 but is due to expire in 1990.

   The DHC aggregate economic market is estimated to be 0.201 quad in 1980, or 4.4% of the DHC potential market. However, the economics of DHC systems deteriorated in 1981 due to sharp increases in interest rates (the average yield on new issues of AA rated corporate utility bonds increased from 10.24% in 1979 to 13.14% in 1980 and to 16.25% in 1981). The DHC economic market declined to only 0.089 quad in 1981. However, the interest rate declined moderately in 1982, increasing the DHC economic market to 0.221 quad. With some relief in interest rates (yield of AA bonds declined to 12.37%) in 1983 and with the passage of the 1982 legislation, DHC relative economics improve and the DHC economic market approaches 0.363 quad (8.2% of DHC potential market). As shown in Table 4-3, the DHC economic market improves marginally between 1984 and 1990 as interest cost continues to ease

(AA bond yield falls to 10.22% by 1990). However, with the expiration of the 1982 law, the economic market declines from 0.408 quad in 1990 to 0.298

Table 4-3

DHC Market and Energy Savings in the Base Case
(Trillion Btu/yr)

Year	Potential Market	Economically Attractive Market	Conditional Market Penetration	Fuel Savings
1980	4582	201	-	-
1985	4432	332	< 1	<1
1990	4536	408	10	11
1995	4667	298	43	47
2000	4867	419	150	163
2005	5159	523	298	324

in 1995. Thereafter, however, DHC relative economics improves steadily. By 2005, the economic market reaches 0.523 quad, or 10.13% of the DHC potential market.

3. DHC Conditional Market Penetration: DHC market penetration, assumed to begin in 1984, is estimated to be 0.043 in 1995, 0.150 in 2000, and 0.298 in 2005. This market penetration is subject to certain conditions, as presented by Table 4-2 and the model methodology.

In terms of market share under these "base case" assumptions, DHC systems capture only about 1% of the potential residential/commercial market by 1995. However, as penetration accelerates, the market share reaches 3.1% by 2000 and 5.8% by 2005.

4. DHC Energy Savings: The efficiency of DHC systems (as measured by the useful Btu output/primary fuel Btu input) is expected to be higher than that of conventional systems. A DHC plant could achieve an efficiency up to 0.70

or even higher depending on end load characteristics, compared to a value to about 0.33 for a typical conventional power plant. Table 4-3 shows estimated DHC energy savings that approach 0.01 quad/year by 1990, 0.05 by 1995, 0.16 by 2000, and 0.32 by 2005. Because most of the market is captured by coal-based DHC systems, oil and gas (scarce fuels) savings are also quite significant in that DHC systems primarily displace these scarce fuels Oil and gas savings are estimated to approach 0.23 quad/year by 2005.

Impact of Alternative Energy Scenarios on DHC Markets. As can be seen from the price trajectory of imported crude oil in Graph 4-6, the world oil markets have been very volatile during the last 10 years. Because of the tremendous influence of OPEC on world oil markets, one can never be sure of the future course of world oil prices. Because other energy prices in the U.S. economy are driven by changes in the price of imported crude oil, all energy projections are subject to this uncertainty. The degree of commercialization of new energy technologies and systems such as DHC is expected to be controlled strongly by the future course of energy prices. Market penetration of DHC systems is expected to be less if energy prices follow lower trajectories. To measure the sensitivity of DHC market penetration, two alternative DRI energy scenarios were selected with higher/lower oil prices than those in the DRI base case.

The low oil price scenario assumes a longer and more severe glut that is followed by a much slower oil price recovery. Real oil prices decline until 1986, approaching $21.68/bbl in constant 1982 dollars. In this case, the average annual increase in real oil prices amounts to 0.4% between 1985 and 1990 and 2.7% between 1990 and 2005. By 2005, real oil price reaches $33.13/bbl.

In contrast, in the high oil price scenario the real oil price begins to rise in 1985 and accelerates thereafter until 1990. The average annual increase in real oil prices amount to 3.8% between 1985 and 1990 and 2.7% between 1990

and 2005. The price of imported crude oil reaches $52.64/barrel in constant 1982 dollars by 2005.

DHC Market Under Alternative Oil Price Scenarios. Lower oil prices are more favorable to economic growth, while higher oil prices tend to dampen economic activity. However, long-term growth rates are not too far from those in the base case. Real GNP grows at an average annual rate of 2.9% in the low price case between 1983 and 2005, 2.8% in the base case, and 2.7% in the high price case. The other effect of changes in oil prices are on energy demands. Residential and commercial energy demand is expected to be moderately higher in the low oil price case than in the base case. As expected, the Base Case DHC potential market is higher in the low oil case (and lower in the high oil case) than in the base case. The 2005 DHC potential market is estimated at 5.33 quad in the low oil case, 5.16 quad in the base case, and 5.07 quad in the high oil case.

The economic market reflects similiar changes. In the low oil case, the prices of conventional fuels (electricity, oil, gas, and LPG) delivered to residential and commercial sectors are expected to have lower trajectories than those in the base case. Because these are the fuels against which DHC must compete, the lower fuel prices result in deterioration of the relative economics of DHC systems vis-a-vis conventional systems. However, this is expected to be partially offset by (1) the lower cost of primary fuels (coal, oil, gas) delivered to DHC plants, and (2) the lower cost of capital. The DHC economic market is 0.38 quad in the low oil case, compared to 0.52 quad in the base case; approximately 27% lower. The reverse is true in the high oil case; here, DHC economic market in the low oil case remains lower than that of the base case throughout 1983-2005. The 2005 DHC economic market in the high oil case is estimated to be 0.64quad, compared to 0.52 quad in the base case. This is equivalent to a 23% higher economic market.

The DHC market penetration trend follows the track of the economic market. By 2005, DHC systems could capture 0.37 quad of market in the high oil case, 0.30 quad in the base case, and 0.22 quad in the low oil case. These market penetration estimates are not forecasts, but only projections based on the assumption that DHC systems are able to penetrate the market on the basis of their economic viability. Historically, many institutional and environmentally related barriers have inhibited the growth of DHC systems in U.S. markets.

4.3 BASE CASE MARKET PENETRATION RESULTS

Any model is dependent on data sources in order to accomplish the purpose of the model, in this case, predicting district heating market penetration. This model uses commercial/residential development density as a predictor of potentially servicable thermal loads. The density factors are generated from population statistics. Since these land uses form a significant share of the district heating end-use market, it is a valid method of proxying development. However, the model overlooks the potential of the industrial market for energy for lack of a valid proxy for thermal density.

The ANL Model is heavily influenced by the demand for electricity; and in the selection of energy sources, employs cogenerating energy systems as the basis for all heat delivery. These factors input the model, and to a certain extent, the model and the market is established by the demand for, and price, of electricity. Since electric statistics are readily available, and cogeneration should be one goal of a district heating system developer, the model on cogeneration is valid. However, the model does not recognize that, in numerous cases, the value of the thermal market can exceed the value of the electric market. It also does not evaluate resource recovery as a heat source technology, and the motivation of communities to offset some of the rapidly rising cost of solid waste disposal by developing thermal markets.

The ANL Model is developed as a "macro" model, in that, it is designed to evaluate the whole of the continental United States, and not specific areas or communities. Experience in developing new district heating systems indicates that lower thermal load densities can be overcome by careful planning, and that each system must be approached uniquely and independently. Specific or "micro" experience indicates that district heating systems are being developed under circumstances that the macro parameters of the model would identify as insufficient to support development.

Experience gained from the 28 Cities program, other district heating support programs, and the experience of district heating utilities indicate that industrial markets and municipal solid waste through resource recovery can significantly contribute to the market for and development of district heating systems. For example, of the ten projects proceeding from the 28 Cities program, four serve primarily industrial markets, and four use solid waste as the basic fuel. Galax, Virginia and Lawrence, Massachusetts have both elements. District heating utility members of the International District Heating Association indicate that historically, roughly one-third of their total sales have been to industrial customers. Recent small-scale cogeneration systems have been almost exclusively developed by and for industrial concerns. This emphasizes the importance of industrial markets and resource recovery in district heating and cooling development.

For the above reasons, and others less influential, adjustments were made in the design of the model output to include markets that the model was forced to exclude or overlook for data availability reasons. These adjustments in no way are meant to say that the model is not fundamentally valid, but only that model limits are imposed by available data sources. Tables 4-4 and 4-5, and Graph 4-7 present the revised Base Case.

Table 4-4

Market Parameters
(trillion Btu's)

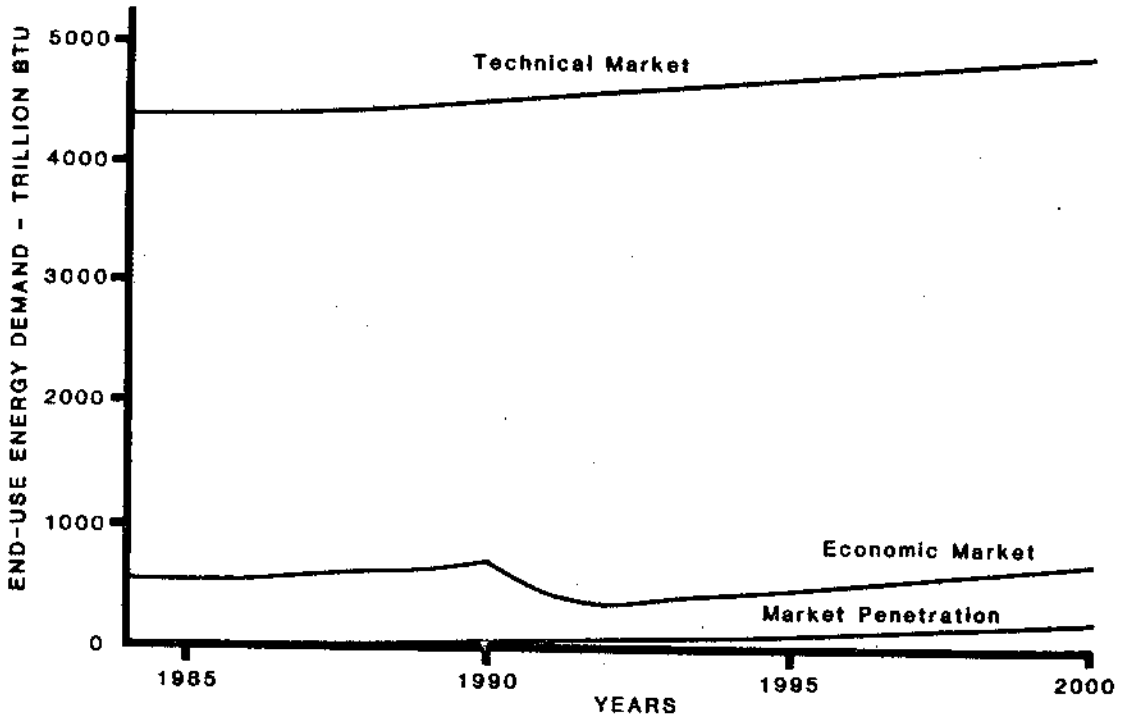
Year	Residential and Commercial Technical Market	Residential and Commercial Economic Market	Industrial Economic Market	Total Economic Market
1985	4432	332	166	498
1986	4432	331	166	497
1987	4436	351	176	527
1988	4461	381	191	572
1989	4499	387	194	581
1990	4536	408	204	612
1991	4569	298	149	447
1992	4579	267	134	401
1993	4601	281	141	422
1994	4630	298	149	447
1995	4667	300	150	450
1996	4703	342	171	513
1997	4738	339	170	509
1998	4777	359	180	539
1999	4818	404	202	606
2000	4867	419	210	629

Table 4-5

Base Case
Conditional Market Penetration
(trillion Btu/Yr)

Year	Residential/ Commercial	Industrial	Total Base Case
1985	.02	.01	.03
1986	.23	.115	.345
1987	.92	.46	1.38
1988	2.6	1.3	4.
1989	5.4	2.6	8.
1990	9.8	5.	15.
1991	11.	6.	17.
1992	16.	8.	24.
1993	24.	12.	36.
1994	33.	17.	50.
1995	43.	23.	65.
1996	63.	32.	95.
1997	75.	38.	113.
1998	96.	48.	144.
1999	126.	63.	189.
2000	150.	75.	225.

*Totals may not equal due to rounding



DISTRICT HEATING PENETRATION

Graph 4-7

Chapter 5
FEDERAL POLICY OPTIONS

5.1 POLICY OPTIONS IDENTIFICATION

Thus far, this report on district heating and cooling has reviewed the advantages of DHC systems, the market conditions which have historically affected its development in the United States, and the problems which have inhibited the realization of the market potential of DHC systems. This chapter considers alternative forms of Federal government support that might enhance district heating and cooling development in the future.

The role of the Federal government in helping to develop the market for district heating and cooling could range from construction subsidies to the systems to a more subtle presence in the form of regulatory policy changes to encourage private investment. A number of European countries provide some financial assistance in the construction of DHC systems which would, to some extent, explain the fact that European countries have progressed more quickly than the United States in implementing district heating and cooling. Swedish government participation in the development of DHC systems, for example, involves either complete ownership or joint-venture partnerships with private enterprise.

The preceeding discussion of district heating systems also demonstrates that there are numerous Federal actions that would be helpful in aggregating a market in which this proven technology could compete against other systems for providing space heating and hot water to commercial, residential, industrial, and institutional customers. A number of different types of Federal assistance could be undertaken in order to promote the commercialization of DHC systems. Several of the options that are presented in this chapter can be

combined in a number of ways to form a consistent framework of federal encouragement. Certainly, a combination of actions selected from among the following options could be chosen if the Federal Government decides to accelerate the commercialization of DHC systems.

For over ten years, beginning in the Nixon Administration, the Federal Government has taken an active interest in supporting a variety of district heating and cooling/cogeneration programs. The federal support has included participation running the gamut from feasibility assessments to technology demonstrations to project development loans and grants. The Department of Housing and Urban Development sponsored programs to improve energy efficiency and the urban environment. The programs included the Modular Integrated Utility Systems (MIUS) in the 1970's, the "28 Cities" program both Phase I, and Phase II in the early 1980's, and Urban Development Action Grant availability for eligible project financing.

The Department of Energy and its predecessor agencies, including the nuclear programs have sponsored a variety of programs to encourage energy-efficient development. These programs have ranged from technology demonstration projects to assessments of new technology to project feasibility assessments. DOE programs have generally concentrated on energy sources and their roles in project development. Although with DOE's recent announcement of new grants for district heating and cooling feasibility assessments, their emphasis may be shifting to the role the thermal energy distribution networks play in allowing different heat source technologies to service in thermal systems. It would be extremely difficult to catalogue all of DOE's program efforts that have DHC components since these have generally been divided along functional lines. For example, industrial waste heat recovery, nuclear, resource recovery, and community systems office have all investigated district heating.

Other federal agencies have also been involved in district energy programs. The Environmental Protection Agency has sponsored numerous resource recovery projects and project assessments until when their program emphasis was recently changed. In addition, the Department of Defense has been, and continues to be, a major user of district energy systems at military installations throughout the world.

In fact, the federal government is, in all likelihood, probably the single largest producer and consumer of thermal energy in the free world. In spite of this, there has never been a truly coordinated approach to district heating and cooling within individual agencies, let alone the federal government as a whole. This is due to the programmatic division of the effort in structure of agencies other than the Department of Housing and Urban Development. The "28 Cities" program most directly addressed the true nature of district heating and cooling, in that, this program was the least restrictive functionally and technically making it possible for local governments to enter creative and productive arrangements with the private sector.

Based on the history of federal participation in district heating and cooling described above, the federal government has pursued a policy, albeit fragmented, of encouraging district energy system development from the Executive Branch. The Congress through tax laws and committee action has also encouraged the development and expansion of systems. Although these activities have clearly stimulated a renewed private sector interest in DHC development, they have not had the leverage that a more consciously consistant set of activities would have had.

Therefore, the balance of this chapter sets forth the basic policy options that are available to the federal government, particularly the Executive Branch and its agencies. Since the energy delivery system in the

United States is not controlled by the federal government, but rather by individual energy companies, both privately and publicly owned with regulation of local energy delivery systems not being a federal issue, the role that the federal government can play is limited to encouraging or discouraging project development. The encouragement can basically come by giving technical support to those interested in system development, by providing front-end risk reduction to those interested in project development, and/or by clarifying the Administration's position on district heating and cooling thereby facilitating other regulatory changes in support of national objectives at the state and local levels.

Since there is an opportunity for a more consistent Administration posture to enhance DHC development, this report has attempted to construct a set of options which represent a reasonable array of actions. In order to test the impact of the basic federal policy options, five scenarios were developed that offer policy makers the opportunity to observe market impacts of a range of federal actions. These options were then tested for their potential influence on the market for district energy systems.

It is well documented that district energy systems can improve the efficiency of energy supply, and make better use of indigenous energy resources, such as coal, solid waste and natural gas. District heating also offers the potential to deliver energy in an urban setting in a more environmentally sound manner by reducing the number of individual point sources and concentrating energy production at a single point source which is more readily controlled.

The following are the five policy options that are felt most representative of the myriad of permutations and combinations available.

Option 1 - Base Case

- Continue "as is" closing out HUD/DOE effort-no new program opportunities at the federal level
- Industrial Development Bond financing continues
- Community Development Block Grant & Urban Development Action Grant eligible
- Stable economic outlook

Option 2 - Technical Assistance

- Continue Feasibility Assessment Planning Grants
  - ° 50-75 Additional Communities
- State Planning Assistance Program
  - ° Develop and provide implementation assistance to state programs
  - ° Develop favorable regulatory/legislative environment
  - ° Develop model legislation
  - ° Develop model state utility commission policies
- Improve Technology Transfer Activities
  - ° Training sessions, conferences, workshops
  - ° Peer to peer interchange
- Develop Model Codes for State and Local Adoption

Option 3 - Project Packaging Assistance

- Provide Phase II assistance to an additional 15 communities for DHC packaging
- Promote public-private partnership in project packaging
- Only pre-development cost--no project capital participation--cost-sharing required

Option 4 - Financial Incentives

- Clarification of Tax Codes to place DHC on the same basis as other energy saving technologies
- 10% Retrofit Investment Tax Credit available to consumers for five (5) years
- Continuation of 10% Investment Tax Credit
- Utility eligibility for 10% ITC

Option 5 - Capital Support (listed only to show full range of options)

- DHC specific program
  - Loans, grants, price supports
  - Contract authority $100,000,000 over 5-7 year period

Options 1 through 4 are considered to be realistic policy considerations and market potentials for each are developed and presented. Option 5 is considered to be unnecessary and unrealistic given the unlikelihood of it receiving support from the administration or Congress in the face of other national needs in the 1980's. Therefore, no market penetration scenario was developed for Option 5, but it was listed to provide a full range of options. It can be assumed that if such a program were to be put in place, the market penetration of that action alone would approach the economically attractive market in the mid and long term.

5.2 POLICY OPTIONS ANALYSIS

The analysis is built upon the market penetration model developed by Argonne National Laboratory, with extrapolated conclusions based on market knowledge from the 28 Cities program, professional judgement, and insights from others closely associated with the district heating and cooling industry particularily as reflected in the study recently completed by the National Academy of Science/National Academy of Engineering.

The model is most useful in assessing Options 1 and 4. Option 1 -Base Case established the "as is" scenario. Option 4 -Financial Incentives adds direct financing support through investment tax credits and accelerated cost recovery for system components. Option 5 -Capital Support is dismissed as unrealistic. Option 2 -Technical Assistance and Option 3 -Project Packaging Assistance are programmatic as opposed to financing options. The ANL model is not designed to directly test these latter two types of assistance. For this reason, the impacts of these options are predicted using other methods and data sources. These methods are based on applying adjustment factors using professional knowledge of the district heating and cooling marketplace gained in designing and building hot water and steam systems in Provo, Piqua, Baltimore and other cities. This methodology is consistent with the evaluation techniques used in previous analysis of the market potential of district heating and cooling systems.

Policy Options and Working Assumptions

The following represents the current assumptions for testing each case.

5.2.1 Policy Option 1 - Base Case

The Base Case represents the market for district heating and cooling with no new federal action, and the discontinuance of existing HUD and DOE programmatic action. (This option does not include any predicted results from the September, 1984 DHC assessment program announced by the Department of Energy). This case is presented to define the market potential of district heating and cooling under a free market scenario assuming existing levels of state and federal regulation. This scenario establishes the basis for determining the market potential resulting from alternative federal actions' support of DHC development.

The previous chapter details the assumptions and workings of the model. The principal federal policy actions and working assumptions of this case are the following:

- There are no new federal initiatives put in place to promote the development of district heating/cogeneration systems. Existing programs are closed out as current commitments are completed. Tax codes remain unchanged. The three states with program efforts may continue them, but the federal government will not directly participate or financially encourage these endeavors.
- Industrial Development Bond financing continues under the regulations defined by the Tax Reform Act of 1984. The per capita limit of $150 is assumed to have limited, if any, impact on system development due to the small-system nature and ownership configurations of the projects predicted by the model. It is assumed that the cap is liberal enough to permit project financing of eligible components.
- The 10% Investment Tax Credit for eligible components continues under existing tax law.
- Essentially all district heating system components are classified as fifteen year property for cost recovery purposes.
- Projects continue to be eligible for Community Development Block Grant and compete for Urban Development Action Grant funding assuming that the project can satisfy eligibility requirements.
- The economic outlook is stable.

Based on the above assumptions, the following are predicted outcomes.

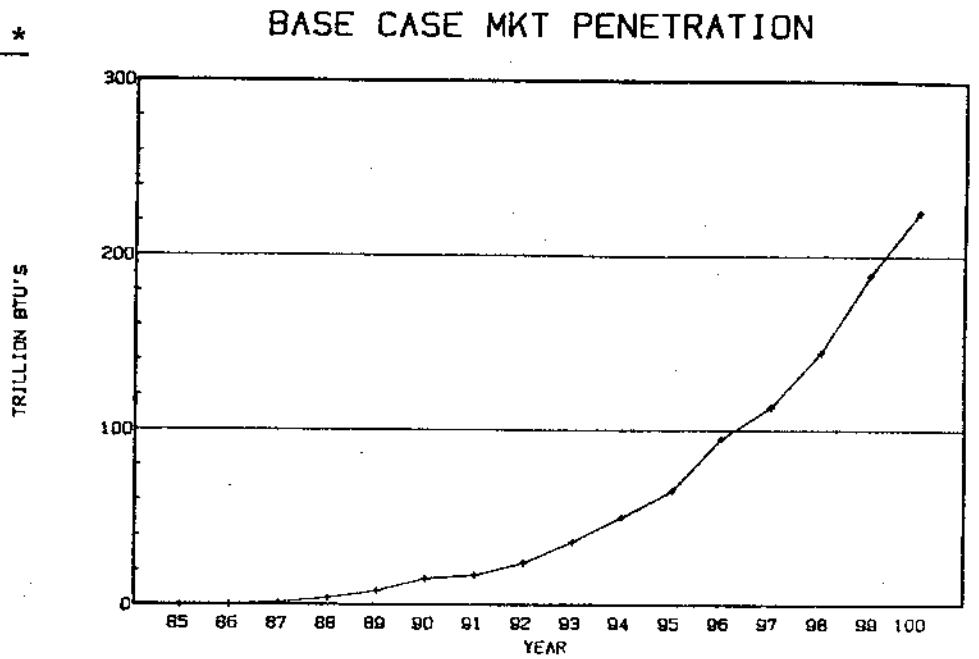
Table 5-1

BASE CASE (Trillion Btu's)

Year	Conditional Market Penetration *
1985	.03
1986	.345
1987	1.38
1988	4
1989	8
1990	15
1991	17
1992	24
1993	36
1994	50
1995	65
1996	95
1997	113
1998	144
1999	189
2000	225

*Adjusted

Graph 5-1



5.2.2 Policy Option 2 - Technical Assistance

In this option, the federal government through the Department of Housing and Urban Development and the Department of Energy continues to take an active role in developing interest for district heating and cooling system development. Programmatically, the government offers funding for preliminary project feasibility assessments similar to those under programs structured like the "28 Cities Program" and DOE's announced Phase I program.

The federal government also promotes project development by encouraging states to take a more active role in system identification and development. State district heating assessment programs like those in New York and Minnesota, and state programs for cogeneration like Pennsylvania's or indigenous fuel use like Illnois' program, would receive federal encouragement and

cooperation. The federal government would also work to encourage more uniformity in regulation at the state level thus facilitating consistency for system developers and planners.

Further, the federal government also continues to support technology transfer activities including such activities as:

° Communication Strategies

- Conferences that accelerate the exchange of experience among systems designers and developers.
- Workshops on financing ownership structures, marketing and rate marketing.
- Training sessions on technical design issues such as, piping, customer retrofits, metering and new technologies.

Communication strategies would also include periodic workshops and regional conferences, having two target goals. Workshops with a limited number of attendees would promote free, informal discussions and cross-fertilization of ideas among the participants. These would be held periodically with groups such as state energy agencies, utilities, equipment manufacturers, financial institutions, regulators (such as the Economic Regulatory Administration, the Federal Energy Regulatory Commission and state public utility commissions), and administrators of site-specific projects.

Regional conferences would provide a forum for discussions among state and municipal governments, state public service commissions, and utility officials within a specific region of the country. The format would include aspects of both the national conferences and the workshops, i.e., some formal presentations, but sufficient time would be allotted for informal discussions. Several conferences would be held each year independently or in coordination with regional conferences of governors and/or mayors.

° Associations

- Associations concerned with furthering district heating/cogeneration/-resource recovery development.

Organizations such as the International District Heating Association (IDHA), North American District Heating and Cooling Institute (NADHCI), National Resource Recovery Association, and International Cogeneration Society are all organized to support all or portions of district energy system development. These organizations offer the federal government opportunities to reach those involved in project development and operations. These associations of private firms can be a useful sounding board for ideas, project needs, and for disseminating information. Federal program activity should be coordinated with these and other groups as appropriate to insure maximum support and exposure.

° Technical Support

- This would consist of technical support teams of experts that would be made available to communities for specific problem solving purposes.

This would continue the HUD support of technical assistance to communities. Previously this type of support has been provided to a number of cities involved in the "28 Cities" program, and to certain communities through the U.S. Conference of Mayors. These teams would be assembled at the specific request of communities for specific problem solving purposes.

° Model Code and Standards Development

Standards and codes are an important part of any system and affect system design, cost, performance, reliability, and safety. Although DHC began in the United States about 100 years ago, existing U.S. standards, codes, and practices for steam DHC systems may not be applicable to modern hot-water systems. European standards for DHC piping differ significantly from U.S.

standards. Therefore, a review should be made of pertinent U.S. and foreign codes and standards. New and/or modified U.S. standards should be proposed as deemed necessary. This activity will be carried out with the close cooperation of equipment manufacturers and users, the National Bureau of Standards, and technical and professional associations such as the American Society of Heating, Refregeration and Air Conditioning Engineers, International District Heating Association, American Society of Mechanical Engineers, and American National Standards Institute.

The major cost and reliability factors for DHC systems are associated with energy transmission and distribution; therefore, improvements in this area should be given high priority in DOE's research program. Examples include the need to develop and test low-cost, non-metallic materials for piping systems and the need to improve trenching and installation techniques. A reduction in the total installed cost of piping would expand the market potential of DHC systems to serve lower-density heat-load areas. One approach that could be considered in carrying out this work is the establishment of a piping technology R & D center. Coordination and joint support of this center with private industry and European countries would be stressed. The center would conduct analyses, experimentation, testing, and demonstration of new technology. It should be noted that district heating technologies have been extensively demonstrated in Europe and elsewhere. To the extent of availability, therefore, district heating technology will be transferred into the U.S. to prevent duplication of technology development efforts.

It is important to note that although continuing support of technology transfer through devices such as workshops and conferences can sound trivial, the cumulative effect of such activities when thoughtfully orchestrated and coordinated, on a multi-year basis can have a strong effect in the creation

and solidification of an industry. These activities can aid the industry in becoming entirely self-sustaining in a five to ten year period.

The key to the effectiveness of this option is the continued participation of the federal government in providing assistance to communities in project assessments. This option assumes 50 to 75 additional Phase I feasibility assessments grants at approximately $50,000 per project, or a total program commitment of three to four million dollars over five years.

The conditional market penetrations are developed from those generated by the ANL Model (Base Case). The penetrations include market impacts of industrial and heat-only loads. Discussions with officials of the International District Heating Associations and IDHA member utilities indicate that industrial loads constitute approximately one third of system loads with those loads included by extrapolation.

The results of the "28 Cities" program and earlier DOE sponsored programs indicate that project feasibility assessments can directly lead to project development and construction. From the "28 Cities" program it is likely that district heating development will be built in at least five communities with no further planning assistance from the program. It is also felt if similiar support were made available in the future, the percentage of projects moving forward through planning and development phases into construction would increase due to better applicant selections; i.e., project selection criteria would establish thresholds that improve program success. This action will increase market penetration by helping to identify more projects (Technical Support Effort), and by indirectly demonstrating technologies in the marketplace (Resource Recovery), thus building city investor confidence in system development.

Table 5-2 and Graph 5-2 present the project impact for DHC through implementing Policy Option 2.

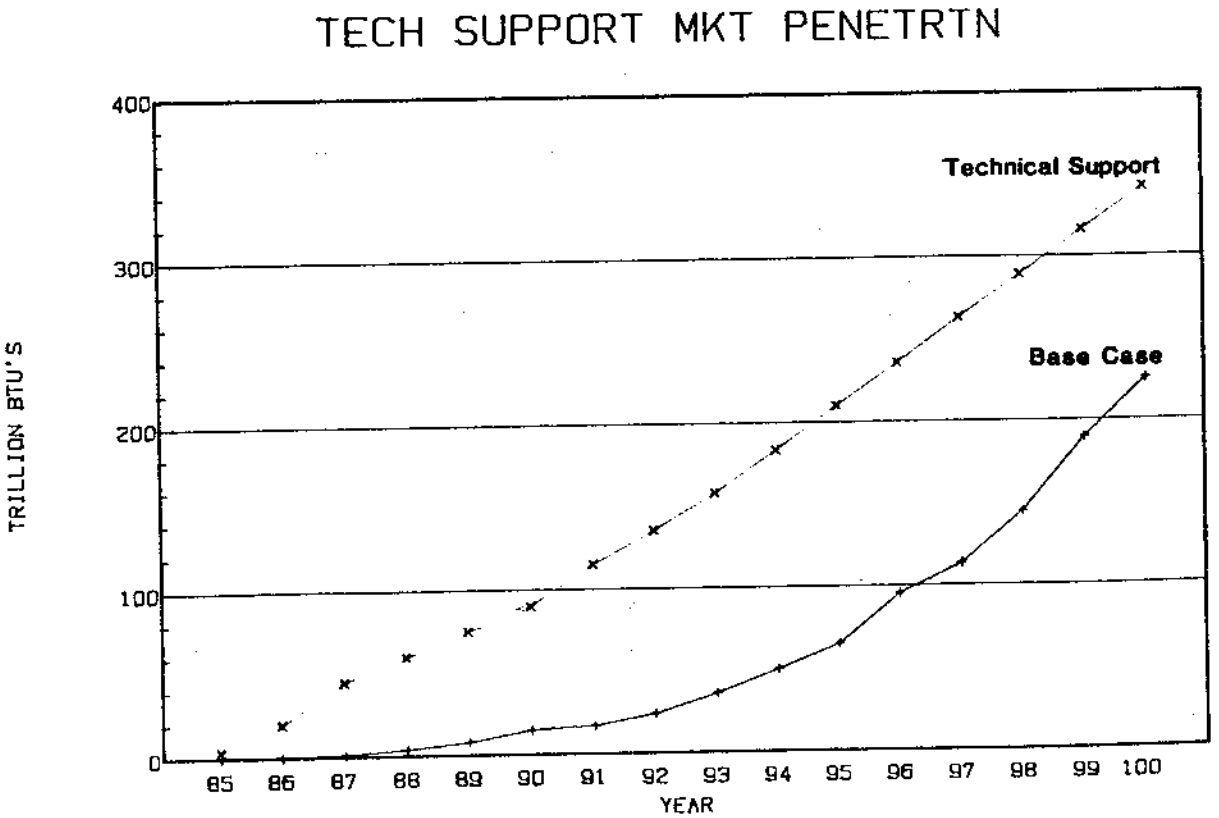
Table 5-2

TECHNICAL SUPPORT MARKET PENETRATION
(Trillion Btu's)

Year	Base Case	Technical Support Effect	Resource Recovery *	Total Market Penetration
1985	.03	3.9	.2	4
1986	.345	12	7.7	20
1987	1.38	24	19.6	45
1988	4	30	26	60
1989	8	36	33	75
1990	15	38	37	90
1991	17	44	54	115
1992	24	48	63	135
1993	36	52	69	157
1994	50	55	78	183
1995	65	57	88	210
1996	95	55	88	238
1997	113	55	95	263
1998	144	50	95	289
1999	189	37	90	316
2000	225	27	90	342

*and other technologies

Graph 5-2



Inclusions are also made for resource recovery and other alternative energy sources (not including experimental technologies). These technologies and systems are motivated by factors not included in the ANL Model.

5.2.3 Policy Option 3 - Project Packaging Assistance

Structuring a district heating project which can be financed is not a simple task. Barriers, real and perceived, abound causing delays, false starts and general project difficulties in many projects that present initial feasiblity. Feasible projects often require detailed work which is beyond the scope of phase I assessments. This was demonstrated in the "28 Cities" program.

Of the twenty-eight, only four cities were able to move directly to system design and ultimate constructions. Special conditions and project elements permitted this in Devil's Lake, North Dakota; Lawrence, Massachusetts; Richmond, Indiana; and Galax, Virginia. Other cities needed additional time and "staying power" to complete design and make final arrangements that allowed or will allow project development. Construction is highly probable in eight other cities that participated in the program. Of the twenty-eight, Baltimore, Maryland; Lawrence, Massachusetts; Provo, Utah; Lewiston, Maine; Springfield, Massachusetts; and New York City received Phase II awards to finalize project arrangements. Holland, Michigan is proceeding with locally generated funding.

The most recent HUD Phase II solicitation attracted a number of proposals, most of which were from cities not involved in the "28 Cities" program. This continues to demonstrate the usefulness of support in packaging projects. All of these communities had accomplished Phase I assessments.

One of the most encouraging elements of the Phase II assistance program is the project cost-sharing participation. Based on the confidence the Phase I feasibility assessments give local private and public decision-makers, it has proven possible to obtain two-thirds of Phase II funds locally. Cost sharing indicates a high degree of local project commitment. Where the local match comes from is almost immaterial, as long as a fair percentage of project cost is paid from local monies, and the locality demonstrates that it is committed to project development.

This concept of public-private partnership has permitted both the federal government and communities to leverage their resources, and complete difficult projects that benefit both the public and private sectors. Community district heating system development is certainly a complex process and one with which most communities have little, if any, experience. Even such limited Phase II assistance, can greatly help the communities in packaging projects that, for lack of such support, would be dropped from the community agenda.

In this option, the federal government would make available cost-sharing to 15 communities in addition to those already funded to enable them to "package" their project for financing. These communities would be required to demonstrate that they have undertaken an initial feasibility assessment and are committed to the development of an apparently feasible project. The communities will be required to produce matching funds at a 2:1 local to federal ratio, and demonstrates that there is a high likelihood of project development. Federal assistance would be limited to pre-development costs, and could not be used for off-setting any project capital requirements. This program would have a three to five year duration in order to give private industry the sense of continuity they require as a basis for investment.

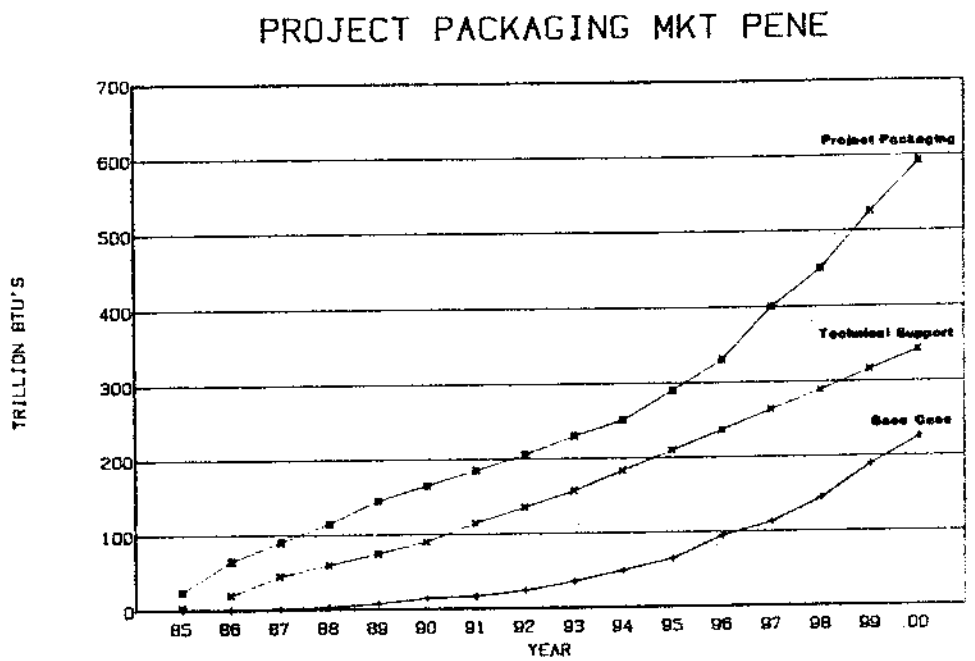
The following market penetrations are based on the above assumption and the additional effect of providing Phase II assistance to projects that have accomplished Phase I assessments. They also assume that the activities from the previous option are in effect.

Table 5-3

PROJECT PACKAGING
(Trillion Btu's)

Year	Conditional Market Penetration
1985	25
1986	65
1987	90
1988	115
1989	145
1990	165
1991	185
1992	205
1993	230
1994	250
1995	290
1996	330
1997	400
1998	450
1999	525
2000	592

Graph 5-3



5.2.4 Policy Option 4 - Financial Incentives

Option 4 continues financial incentives, such as the 10% Basic Investment Tax Credit and Accelerated Cost Recovery found in Option 1, as well as the technical assistance in Options 2 and 3. In Option 4, additional investment incentives are offered to qualifying investors in DHC systems. These incentives either reduce capital requirements by offering investment tax credits or by accelerating the depreciation of the system components. In both cases, the incentives are designed to encourage private investment in district heating and cooling systems. They would be particularly useful over the first five to ten years in the development of this industry and may prove

unnecessary after a critical mass is attained. This option has seven basic elements primarily designed to attract private sector interest in project development and expansion. Most of these elements will require legislative action to implement.

° Clarification of Tax Codes

The current tax codes relating to property classes and depreciable life for district heating systems and component equipment are confusing, and do not offer the across-the-board support that would encourage project developers. Private sector developers have been required to request rulings from the Internal Revenue Service on questions of tax treatment and tax credit eligibility that are central to project financing. These rulings add time and cost to the project. If the codes were modified to recognize that there is not any inherent difference between steam and hot water systems, the open loop or closed loop systems, and between regulated or non-regulated system as far as district energy systems are concerned, developers would be encouraged.

° 10% Energy Investment Tax Credit

This would revive the energy investment tax credit for district heating system components for private developers. Investment tax credits are a strong, incentive that are quite favorably viewed by investors. Experience has demonstrated that tax credits spur investment in emerging technologies by reducing investor risk. The tax credits would have a sunset provision of between five and seven years. This would be sufficient time to plan and develop systems.

° Investor owned utility eligibility for tax credits

This is a clarification of tax codes that would insure that the investor owned utility industry would be encouraged to develop or expand district heating systems. As it now stands, electric utilities are somewhat reluctant

to forge ahead with cogenerating systems and/or steam system expansion. By insuring their eligibility for investment tax credits, the industry would more seriously evaluate these alternatives.

° 10% Investment Tax Credit eligibility for steam systems

As the tax law is written, there are qualifying requirements placed on steam systems vis-a-vis state regulation and closed loop (condensate returning systems)/open (no condensate return) systems. These qualifying requirements basically are used to establish "property classes" under the IRS Code. Different property classes receive different treatment for investment tax credits and depreciation. Often the private system developer faces uncertainty in assessing the tax treatment his proposed system will receive, and he must request rulings from IRS which causes delays in establishing project feasibility and arranging financing.

Again, this is a clarification and statement of eligibility targetted primarily at investor owned utilities. This would solve the open loop/closed loop distribution system property questions. It would also encourage existing systems to expand in central cities.

° Five Year Accelerated Cost Recovery for All Piping Systems

Generally, 50% or more of the capital costs of district heating and cooling systems are in the energy transmission and distribution piping. This change in depreciation schedules would set a property life standard that would encourage private-sector ownership of piping systems. Like the tax credits, there should be program limits on when construction must occur; a five to seven-year period should sufficiently stimulate development.

° $150 per capita limit on Industrial Development Bond Financing

This reflects the Tax Reform Act of 1984 and the financing limits imposed in each state. It is assumed that this will have limited impact on the

ability of system developers to arrange tax-exempt financing for systems. The per capita limit is sufficient, if the project is a local priority, to permit IDB financing of eligible systems.

° Planning Support Funding

Unlike the previous option, this option does not consider the additive effects of continued federal support of system development. That is, Phase I and Phase II program support are not included in the market penetration estimate.

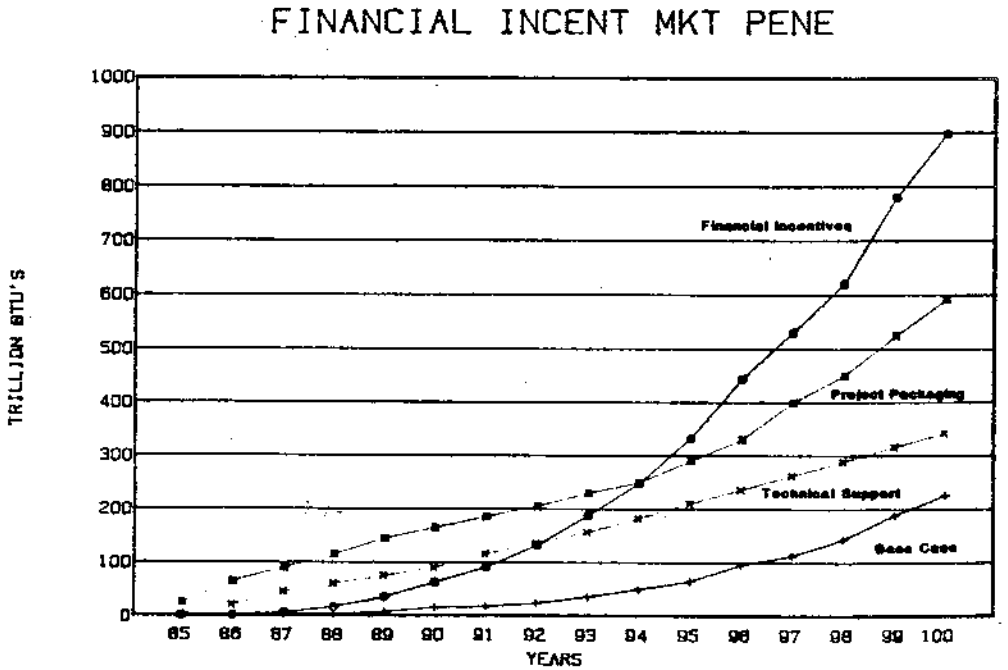
The financial incentives provided in this option are designed to reduce the preconstruction cost of systems and to increase the probable number of system developers. These incentives will focus the support of the federal government in a cohesive and clearly stated manner; that is, essentially all district heating and cooling systems would be encouraged, not just entrepreneurially owned hot water, cogeneration systems.

Table 5-4

FINANCIAL INCENTIVES
(Trillion Btu's)

Year	Conditional Market Penetration
1985	.135
1986	1.41
1987	6
1988	17
1989	35
1990	63
1991	90
1992	131
1993	188
1994	248
1995	332
1996	444
1997	531
1998	620
1999	780
2000	897

Graph 5-4



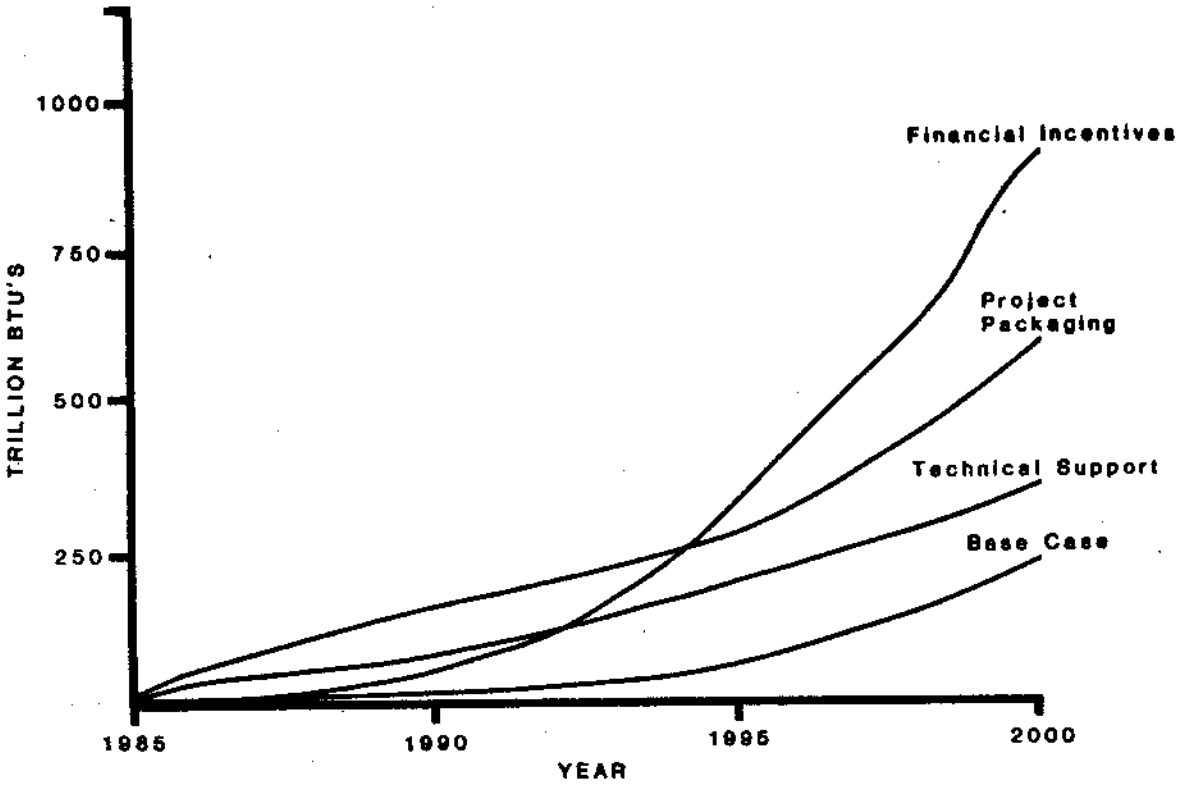
5.2.5 Policy Option 5 - Capital Support Program

This option is a full federal commitment scenario. Under this option, the federal government would commit funding to the construction of district heating and cooling systems. The capital support could include loans, grants, price supports or other method for infusing capital into projects. Obviously a program of this scale would require Congressional approval. The program duration would be sufficiently long enough to allow projects to develop, but would have sunset provisions in the legislation to allow the federal government to cease support once DHC is fully accepted. Five to seven year duration is assumed, with total federal investment of $100,000,000.

This program would establish support for district heating system development similar to that found in the Scandanavian countries of Sweden, Denmark and Finland where district heating and cogeneration system development are national energy goals. It would also establish thermal energy networks as part of the urban infrastructure system in areas where projects are technically and economically feasible.

This option was not tested by the ANL model due to limitations of the model, resource constraints, and the determination that this option is highly unlikely to receive the support of the administration and Congress in the face of other pressing national needs. It is projected that the market penetration that would result from such support would approach the economically attractive market for district heating; however, any further discussion of this option would be irrelevant since it is unlikely to be considered.

Graph 5-5



DISTRICT HEATING MARKET PENETRATION

By defining, characterizing and calculating market penetrations of these options, we are able to convey an understanding of the significance of accelerating the development of DHC nationally. The following chapter describes the benefits that can accrue from the increased use of district heating and cooling market penetration. Technical support and Project Packaging have the most near-term impact. As stated in the preceding discussion district heating and cooling can achieve substantial greater market penetrations with rather modest federal support.

Chapter 6

BENEFITS OF DISTRICT HEATING AND COOLING

6.1 INTRODUCTION

Widespread development and operation of district heating and cooling systems will result in the accrual of substantial benefits both locally and nationally to the public and private sector. Analysis and evaluation to this point has quantified selected, direct benefits resulting from district heating development in the core areas of the nation's larger urban communities. The benefit calculations are accomplished through models which use the ANL market penetration forecasts as the basis for forming the required calculations. The benefits calculated and presented later in this chapter are:

1. Energy Savings
2. Scarce Fuel Savings
3. Total End User Heating Cost
4. Employment
5. Retention of Dollars
6. Taxes

Site-specific analysis, planning and actual project development clearly conclude that other benefits accrue. However, to date these have not been quantified for the nation. Consequently these will only be discussed briefly. Among these other identified benefits are:

- improved air quality
- industrial and economic development/revitalization
- expanded manufacturing markets
- new business opportunity
- balance of payments (U.S. imported oil bill)
- national security

6.2 WHERE BENEFITS ACCRUE

In order for the benefit analysis to be meaningful, a brief general discussion of beneficiaries is required. Benefits derived from district heating and cooling system development and operation will accrue to the nation, cities, consumers and utilities. At this time, the benefits identified and quantified are mutually supportive. Each benefit accrues in varying ways, with levels of importance accruing to different parties. However, some benefits, such as energy savings and employment opportunities, significantly contribute to the well-being of all elements of the American economy.

6.2.1 The Nation

One of the most direct results of DHC market penetration is that the nation will benefit from district heating energy savings both in terms of net energy and scarce fuel savings. As fuel prices increase and require an increasingly larger share of the national income, fewer dollars will be available for investment in other sectors of the national economy. District heating and cooling can displace scarce and imported fuels with coal, wood and other energy resources that are less expensive and indigenous to the United States. When used to provide fuel for district heating systems, these resources permit oil and natural gas to be saved for processes which require higher quality energy than do space and water heating. This will also help reduce the U.S. dependence on foreign sources of oil and gas. When oil or gas must be used for environmental or other reasons, district heating coupled with cogeneration can use these fuels more efficiently, thereby further conserving dwindling resources.

Today, West Germany is undertaking the most ambitious district heating program of any non-communist country. The West Germans import oil from OPEC

countries and natural gas from the Soviet Union. One of their primary reasons for undertaking district heating is to displace these imported fuels, and to replace them with German natural resources, primarily coal. The West Germans believe that district heating will allow them to become less energy dependent, thereby furthering the national security goals of West Germany. Energy independence is a national security issue for the United States; district heating can contribute to energy independence and the national security through the reduced dependence on foreign fuel sources.

As is often the case, most benefits found at other levels and sectors apply in the aggregate to the nation. While unemployment, particularly of minority workers, is most critical in cities, it is a national issue. While district heating will not return the United States to full employment levels, sustained construction of district heating and cooling systems has the potential to reduce sectoral unemployment rates, and provide jobs for workers with unemployment levels higher than the national averages. Increased employment opportunities will return unemployed workers to taxpayer status, positively impacting national goals as well as the Treasury.

Beyond the impact on construction jobs, all industrial and commercial operations can benefit from the opportunity to invest relatively less in energy and more in productivity. By taking advantage of this opportunity to invest in production capacity, American industry will be able to reassert its position in the world economy.

There is another national impact and benefit from district heating that will in the long run surpass the benefits from direct employment and reduced oil imports. District heating and cooling systems are investments in the productive capacity of American cities. Government, industry, business and consumers are continually spending an increasingly larger share of revenue for

energy. These are monies that are being diverted from new investments. District heating and cooling can help to stabilize energy costs over the long term due to the relatively stable prices of fuel used in district heating and cooling systems. This stability will allow the nation to not only face a more certain energy picture, but also to budget less for energy and more for other more productive and long term investments.

6.2.2 The Consumer

The primary direct benefit to the consumer will be the availability of stably priced energy. Consumers are not only individual households but also businesses ranging from corner stores to the auto industry. Over the past ten years, most consumers experienced heating costs that were escalating due to increases in world oil market prices and deregulated natural gas prices. While these price increases have subsided temporarily, consumers still have limited choice in fuel selection, and little control over price. In the long term, real prices will increase. With district heating and cogeneration plant technology, which is not fuel-specific, economies of scale and price stability benefits will be passed on to the consumer, insuring a more stably priced energy supply for consumers.

Like the other beneficiaries of district heating and cooling, consumers will be able to adjust their consumption patterns to account for the relative lower expenditures for fuel. This will allow the consumer more budget freedom for discretionary purchases, consumer durables, housing rehabilitation and maintenance, investments and savings. Increased spending not targetted to oil and gas will spread the economic impact more evenly throughout the economy.

Price stability in energy will ultimately trigger a realignment in consumers' expenditure patterns. Realigned consumer expenditures will help support the spending and reinvestment necessary to insure a stable economy.

6.2.3 The Utilites

As district heating and cooling becomes more economically feasible and marketable due to price increases of competing fuels and wider customer acceptance, utilities will increasingly become more interested in this energy supply system. As the costs of oil and gas continue to rise, consumer pressure will encourage utilities to seek alternative fuels and technologies that will stabilize energy costs while concurrently permitting utilities to make an acceptable return on investment. Utilities will also seek additional profit centers through diversification to insure their long-term profit ability. Well-designed, planned and marketed district heating and cooling systems will offer utilities the opportunity to satisfy the concerns of both the customer and the stockholder in terms of price and profit.

The utility industry is rapidly approaching a decision point on long-term investments strategy. Many of their electric generating plants are getting older and less efficient. The very large nuclear power stations are proving to be financially draining for many of them. The continued pressure on utilities to replace older, urban-located plants with remote, efficient and expensive new facilities (particularly nuclear) is a difficult one for financially strapped utilities. District heating and cooling with cogeneration offers the utilities the opportunity to reinvest in the efficiency and the productivity of existing generating facilities, while at the same time creating new revenue streams and new profit centers.

District heating and cooling systems offer two additional benefits to utilities. First, they have long economic lives as evidenced by fifty to seventy-five year old steam systems found in a New York and several other cities. This allows utilities long-term returns on invested capital. Second, district heating and cooling systems will allow utilities to introduce

unconventional energy sources into their energy supply options. Currently it is difficult for a utility to take advantage of resource recovery, solar energy and other lower grade energy resources due to the technical requirements of electric generation, a utility's primary business. Since hot water and chilled water systems do not require high quality energy requirements, other currently unusable energy inputs are made available.

6.2.4 The Cities

Cities stand to benefit substantially from the development of district heating and cooling systems. In fact, cities will capture meaningful proportions of the full range of benefits including long-term price stability, savings from the use of cheaper fuels, and increased employment. The word "cities" is used in this discussion to mean the complete set of participants in urban settings and is not limited to the "body, corporate and politic," but includes industries, institutions, consumers and other interest groups.

The main benefits will be economic. District heating and cooling basically replaces fuel with capital equipment. Capital equipment consists of central plant heat generating equipment, a buried distribution and storage component, and end-user equipment that are financed and costs are recovered in the long-term. The development of a district heating system is a major infrastructure under-taking, similar to sewer and water systems in cities. Due to the density requirements of district heating and cooling, it is also obvious that all this investment will occur in urban areas; more specifically, it will often occur in the urban core of central cities or in industrial/-commercial areas of central cities.

The development of these systems is a very labor intensive activity. Central cities generally face higher levels of unemployment and declining tax

revenues. District heating development can impact both of these areas by employing unemployed persons and, hence, returning some of the unemployed to tax payer status.

District heating and cooling systems, as stated previously, offer investment opporturnites to utilities in urban plants and equipment. Remote plants have limited employment and investment impacts for cities. Urban plants offer much higher economic potential to cities. This investment pattern for utilities also holds true for consumers; that is, with district heating and cooling, the consumer dollar will be spent in the city on other consumerable goods, thereby assisting in the growth of the immediate local economy.

Environmentally, district heating and cooling can help cities to improve air quality. Fewer air pollution point sources are necessary to heat or cool buildings since the need for individual building boilers will be significantly reduced. The air pollution load will be transferred to a single, more efficiently controlled air pollution point source.

Most importantly, cities with district heating and cooling systems can offer business and industry an energy competitive advantage. Stable energy supplies and life-cycle cost advantages will play an increasingly larger role in business location decision making. Those cities with district heating and cooling systems will be in a better position to attract and retain commerce in their city. The future economic base and financial condition of virtually any city depends on business and industry located there.

6.3 DIRECT BENEFIT EVALUATION

The analysis and evaluation of direct benefits of district heating and cooling focus on the areas cited above. In order to quantify these benefits, several models were developed and applied. Both the dollar savings and

savings in (imported) oil and gas have been calculated using the Argonne National Laboratory Market Penetration Model. The four additional direct benefits of district heating that are quantified are total end-user heating cost, employment, retention of dollars and taxes.

The models used to calculate the benefits were developed to assess the impact of district heating and cooling system development. Since the ANL model was used only to project market penetrations in the Base Case and Financial Incentives options, model-generated data was not available for every calculation associated with each option. It has been assumed that benefits for the Technical Support and Project Packaging options are proportional to the estimated market penetrations and benefits as in the case of the calculated options.

6.3.1 Energy Savings

The ANL market penetration model evaluates the net energy savings as a result of projected levels of market penetration. The energy savings is a result of the reduced total fuel consumption resulting from conversion to cogenerating energy systems. The ANL model predicts in the Base Case that net energy savings in the year 2000 will be 163 trillion Btu's which is equivalent to 28.1 million barrels of oil having an estimated current dollar value of over three billion dollars. In the Financial Incentives Case, the net energy savings is estimated to be 520 trillion Btu's in 2000, which is equivalent to 89.65 million barrels of oil, with a current dollar value in excess of 9.6 billion dollars. These values only calculate the savings potential in the residential and commercial markets. The potential would dramatically increase if industrial markets were introduced into the ANL model.

The national impact and benefit as a result of this net energy savings can be translated into other categories, not the least of which is national

security. As stated previously, the West Germans are undertaking an ambitious district heating development program based on the issue of national security. They expect to achieve improved security by substituting indigenous energy resources for imported ones, thus becoming more resistant to supply or price disruptions. It also affects "balance of trade", where fewer dollars will be required for importing foreign fuels.

For utilities, energy savings is also a critical issue. Currently, utilities use approximately one-third of the total energy input from natural resources in electric generation. Cogenerated district heating and cooling has the potential to allow utilities to capture up to 80% of the energy from the natural resource inputs. This will allow utilities to operate at higher levels of efficiency and to "get more for their money" from their natural resource purchases. The energy savings can then be passed on to the consumers through more stable, long-term energy prices.

6.3.2 Scarce Fuel Savings

The ANL market penetration model also predicts scarce fuel (oil and natural gas) savings for the options tested. Since the ANL model is based on central plant cogenerating systems and urban core markets, district heating will be replacing oil and gas-fired systems with solid fuel systems. These central plants will generally use coal as the primary fuel, resulting in both a net energy savings and a scarce fuel savings.

In the Base Case the projected savings is 109 trillion Btu's, an equivalent of 18.79 million barrels of oil with an estimated value of over two billion dollars in 2004. The projected savings in 2004 in the Financial Incentives Case are 296 trillion Btu's, or an equivalent of 51.03 million barrels of oil worth almost 5.5 billion dollars.

Compared with the net energy savings, it is quickly seen that the scarce fuel savings is less than the net energy savings. This is the result of the equipment mix in the generating equipment used. If industrial markets, other energy sources, and district cooling are introduced, it is not unrealistic to assume that scarce fuel savings would be doubled.

Nationally the impacts on security and balance of trade are obvious, and increase as the commitment to district heating and cooling increase. What is less obvious is how the scarce fuel saved can be used.

District heating and cooling can be used for space conditioning, water heating and low temperature processes which are now being supplied by high quality fuels such as natural gas and oil. These high quality fuels can then be transferred for use in high quality processes, achieving a more appropriate use of these fuels. By appropriate fuel usage, the nation can make more economic use of its least costly indigenous natural resources-coal and solid waste, as well as its, oil, natural gas, and renewable energy sources.

The consumer that elects to convert to district heating and cooling will be capitalizing on the opportunity to shift from oil or gas to coal or cogeneration, thus insuring energy price stability. For those consumers who currently have "interruptible" natural gas service, they will be able to avoid supply uncertainties during the heating season. Consumers with oil systems will be able to eliminate storage and handling as well as boiler operations and maintenance costs.

Like other benefits, net energy and scarce fuel savings mean different benefits to different parties over the projects' life cycle. The following tables present the annual market penetration, net energy savings and scarce fuel savings for the Base Case and Financial Incentives policy option in detail.

Table 6-1

BASE CASE
TRILLION Btu's

YEAR	MARKET PENETRATION	ENERGY SAVINGS	SCARCE FUEL SAVINGS
1985	.02	.02	.02
1986	.23	.26	.27
1987	.92	1.00	1.00
1988	2.60	2.80	2.50
1989	5.40	5.70	5.00
1990	9.80	11.00	9.10
1991	11.00	12.00	10.00
1992	16.00	17.00	13.00
1993	24.00	25.00	18.00
1994	33.00	36.00	26.00
1995	43.00	47.00	33.00
1996	63.00	68.00	46.00
1997	75.00	82.00	57.00
1998	96.00	105.00	69.00
1999	126.00	137.00	92.00
2000	150.00	163.00	109.00

Source: "Argonne District Heating Market Penetration Model"

Table 6-2

FINANCIAL INCENTIVES
(TRILLION Btu's)

YEAR	MARKET PENETRATION	ENERGY SAVINGS	SCARCE FUEL SAVINGS
1985	.09	.09	.08
1986	.94	.83	.66
1987	4.00	3.40	2.50
1988	11.00	9.40	5.80
1989	23.00	19.00	11.00
1990	42.00	35.00	20.00
1991	60.00	51.00	27.00
1992	87.00	73.00	37.00
1993	125.00	105.00	51.00
1994	165.00	141.00	64.00
1995	221.00	188.00	90.00
1996	296.00	250.00	121.00
1997	354.00	303.00	151.00
1998	413.00	358.00	190.00
1999	520.00	449.00	254.00
2000	598.00	520.00	296.00

Source: "Argonne District Heating Market Penetration Model"

6.3.3 End User Heating Costs

Heating and energy costs are becoming an increasing larger concern to energy users. Continuing upward price pressure on oil and natural gas prices affect every economic sector and individual in the United States. By implementing district heating and cooling, and by substituting coal and other plentiful resources for scarce fuels, some of the pressure on energy costs to consumers can be alleviated.

The following three graphs present analysis on total cost of different energy systems in Baltimore, Maryland and Provo, Utah. These cities have been selected due to differing characteristics of energy systems, geographic

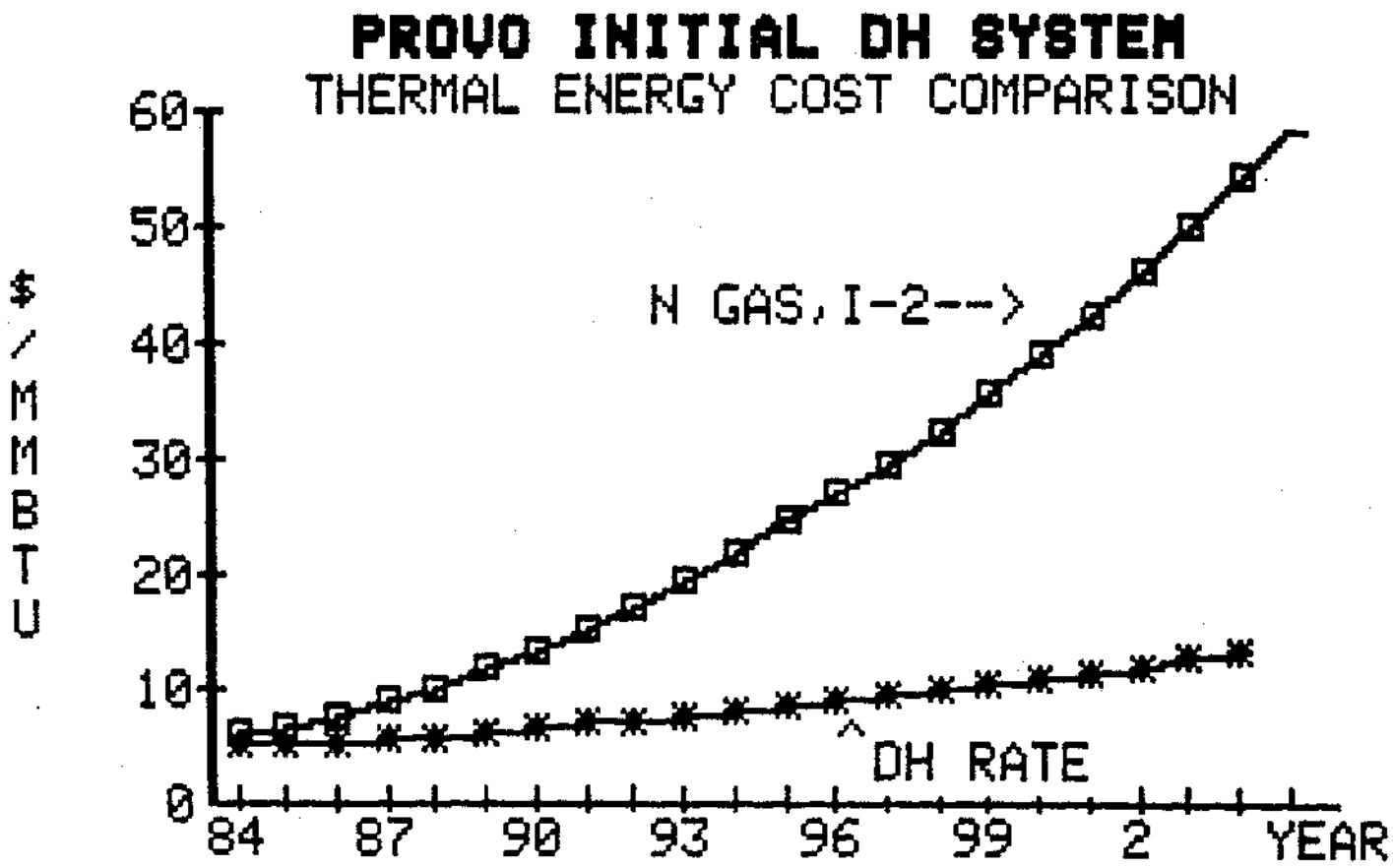
locations, and district heating applications. In both cities district heating costs display lower price increases than the existing heating system currently in use in the individual cities.

Baltimore has the type of dense development and climatic conditions which favor the introduction of district heating. While Provo does not have the density of Baltimore, it does have similar climatic conditions; and, Provo does have the advantage of municipal ownership of the power system.

Baltimore's energy relies on scarce fuels, Provo uses coal and United States' natural gas for primary fuels. Based on fuel mixes in the cities and cost estimates for proposed district heating systems, it is possible to project end-user costs for district heating versus conventional energy systems. The following three graphs indicate the projected costs, price stabilities, and competitive advantages that district heating can offer in the two cities.

The Provo Energy Cost Comparison indicates the future prices expected of oil, natural gas to industrial customers (I-2 rate), and coal assessing typical industrial boiler efficiency. Clearly, coal is and will continue to be the least expensive fuel. The initial Provo DH System will be based on coal, and the indicated prices demonstrate the potential savings a district heating customer could expect to receive. The Cherry Hill System in Baltimore also demonstrates the potential for substantial future savings.

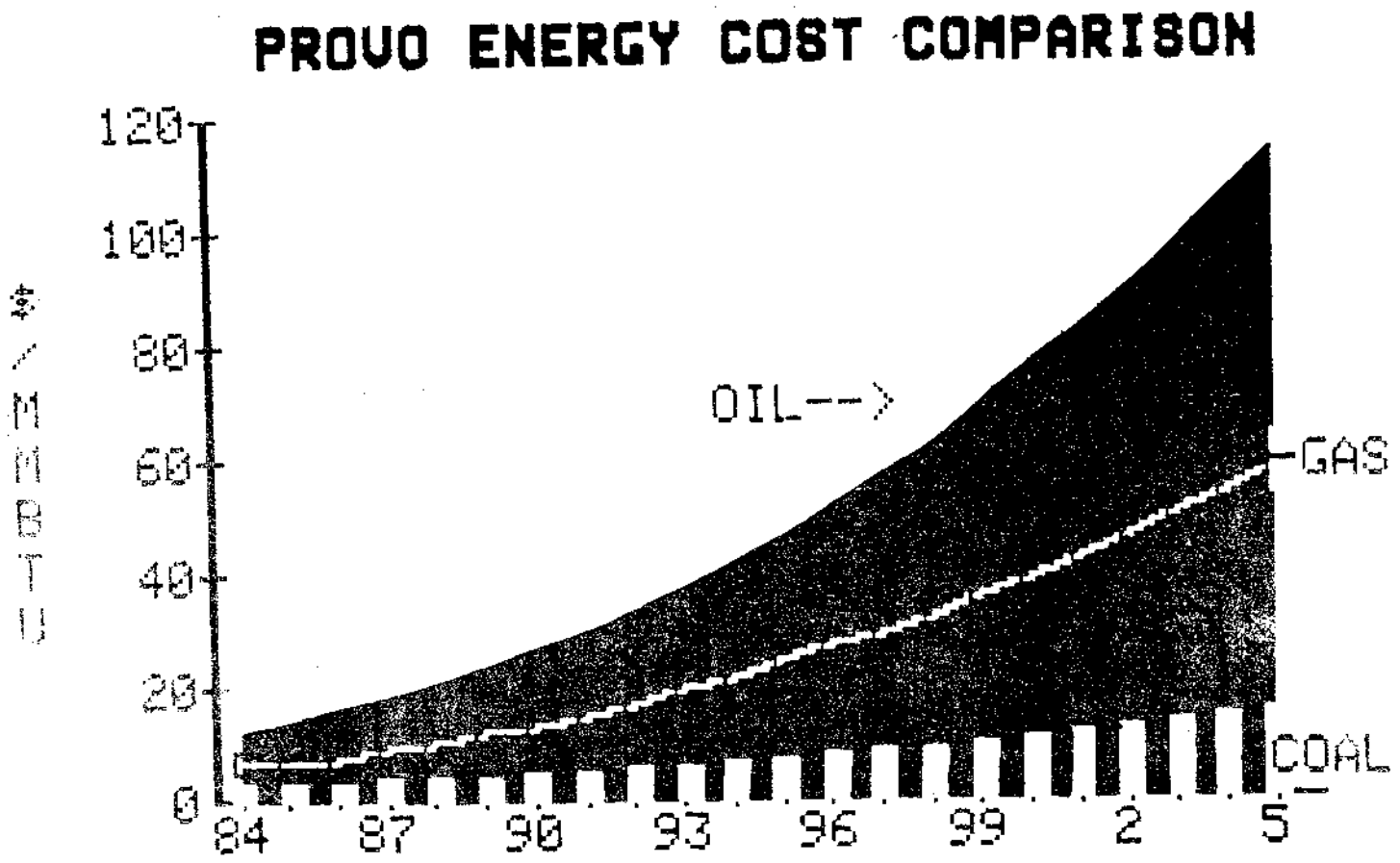
Graph 6-1



INCLUDES ALL END USER RETROFITS
REFLECTS RELATIVE END USE EFFICIENCY

0001W

Graph 6-2



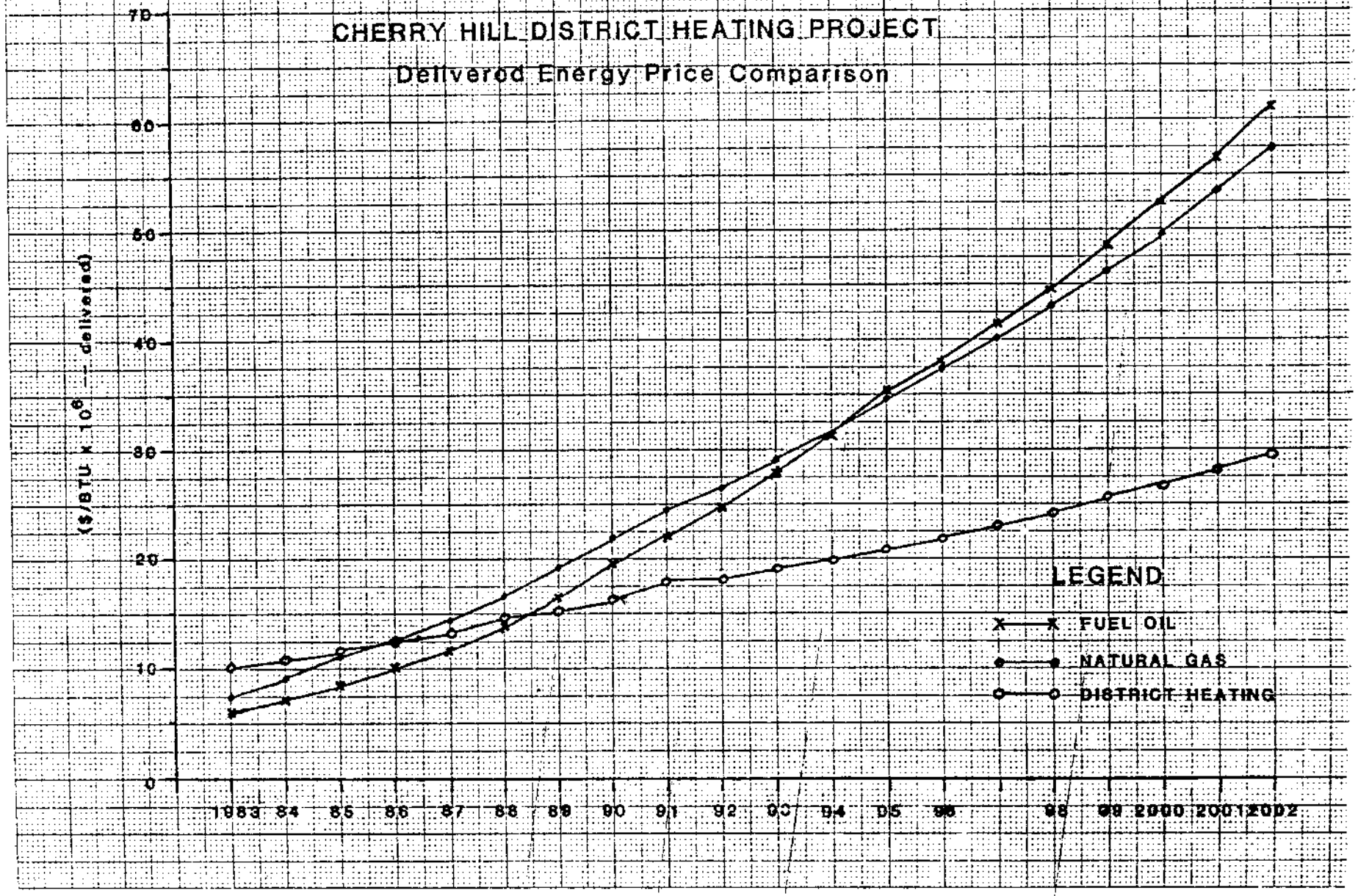
RDA MID-RANGE FEBRUARY, 1984
END USE EFFICIENCY ADJUSTED
N GAS = I-2 RATE

M1000

Graph 6-3

CHERRY HILL DISTRICT HEATING PROJECT

Delivered Energy Price Comparison



The end-user cost examples presented for each city indicate differences in system size. Since district heating and cooling systems are capital intensive, a larger and more cost intensive system will have higher end-user costs than a smaller system. The key is how the end-user cost matches against the alternatives. The divergence of these cost lines indicates the level of life cycle savings that can be expected.

6.3.4 Employment

District heating and cooling system development will have a positive, long-term impact on national and urban employment. Cities will directly benefit from the jobs generated as a result of the construction of district heating and cooling systems. District heating and cooling system construction is labor intensive; it will require heavy equipment operators, welders, and laborers. These job skills are readily available in the labor market in urban areas. While district heating will not solve unemployment, sustained construction activity will help alleviate labor surpluses in these skill areas in urban America.

The Department of Labor Bureau of Labor Statistics provides job year estimates for various types of contruction projects. While BLS does not estimate job years for district heating construction, it does estimate jobs for sewer line and plant construction which is quite similar to district heating construction methods in skill requirements.

BLS estimates that for every one billion dollars of sewer line construction, 23,400 job years will be required. 9,400 of these job years will be in the construction industry. The estimated gross investment in the Base Case, through 2005, will be almost $2 billion. This results in 46,800 job years, of which 18,800 will be in the construction industry. When the Financial

Incentive option is considered with its gross investment is $23.75 billion, the job-years increase to 555,750 of which 223,250 will be in the construction industry.

Cities will directly benefit from this employment, not only from the buying power generated, but by reductions in unemployment. ANL estimated employment effects for simulated district heating systems in nine Northeastern and Midwestern cities and found that the average reduction in male unemployment rates would be almost 23%, and almost 26% for black males. This is based on 1970 unemployment rates. With appropriate hiring practices and training programs, more of the jobs in district heating construction could be directed to minorities which experience higher than average unemployment levels. The benefit to cities of this unemployment reduction will go beyond the resulting increase in purchasing power. The benefit will include a more productive urban labor force.

Baltimore and Provo were tested in order to determine the impact on employment from site-specific district heating and cooling project development. Based on the initial system construction cost estimates for the two cities and by using the Bureau of Labor Statistic job year methodology, one finds that this construction will positively impact the employment levels in these cities.

Table 6-3

JOBS IN DISTRICT HEATING CONSTRTUCTION

City	Contruction Expenditure	All Job Years	Construction Job Years
Baltimore	$13m	304	122
Provo	$ 2m	47	19

In each case, district heating construction could be likened to adding a new employer in each city. These jobs are also the kinds of jobs that will

have impact in the unemployed sectors in each of these cities. As the projects continue, jobs will be added with each system expansion.

District heating and cooling system development can also have a positive impact on many important, national industries. The steel industry is a case in point. Since district heating and cooling is a "capital intensive" technology, it may be inferred that development of DHC will benefit those industries which supply components or put into place our cities' infrastructures and buildings. Steel used for piping systems, heat exchangers, turbines, boilers, etc. will be a major raw material component needed for DHC development. A detailed economic and market assessment would be required to quantify all the steel product uses throughout a district heating and cooling system and to quantify the impact of those demands on the steel industry. But preliminary market estimates for steel pipe use in underground DHC distribution systems have been prepared. These estimates and the associated total capital cost estimates are based on Argonne National Laboratory DHC market penetration studies, D.O.E. and Argonne Capital Cost Estimates and engineering experience in DHC system design and construction.

Experience shows that roughly sixty percent (60%) of the capital cost of a DHC system is invested in the energy distribution system. Of this, sixty percent (60%) of the distribution system cost is the cost of the pipe. Approximately twenty percent (20%) of the total installed cost of a distribution network is allocated to straight runs of preinsulated pipe, not including fittings, valves or supports. According to several preinsulated piping system manufacturers, forty percent (40%) of the delivered cost of preinsulated piping is attributable to the carrier pipe used. By applying these component costs to the market estimates for district heating and cooling systems, a sizable market for components is found.

Table 6-4

Component Cost
(million dollars)

Market Option	Total Estimated System Investment	Part Attributable to Distribution System	Part of Distribution System Allocated to Steel Pipe
Base Case (2000)	$ 5,625	$ 3,375	$ 810
Financial (2000) Incentives	22,425	13,455	3,229
Baltimore (1986)	13	7.8	1.9
Provo (1985)	2	1.2	.29

It should be emphasized that these component cost projections are preliminary estimates, they do not reflect any of the other demands for steel products associated with DHC development or any steel piping demand for in-building systems. The markets for these other items are also quite significant.

6.3.5 Retention

There are additional economic effects resulting from district heating and cooling system development that will have direct impacts on the economy of cities. The following model was developed to review local benefits from district heating and cooling systems. The prinicipal upon which the methodology is based is local retention of money spent for energy.

In district heating and cooling systems, there are three primary cost components: capital equipment, operations and maintenance, and fuel. The delivered price of energy is a function of the mix of these three components. The uniqueness of each system will determine the mix or percentage of each cost component that is in the delivered cost. The basic cost components are: capital-60%, operations and maintenance-15%, and fuel-25%. The basic methodo-

logy for evaluating the funds that will be retained in the community involves assessing the amount of the cost of each component that will be imported by the community.

The following discussions of the component charges indicate the retention of expenditures an urban area could expect, and the impact of the retention on the local economy.

Fuel -Few urban areas actually have the natural resources to provide local fuel for a district heating system except for municipal trash. Coal, oil and natural gas are all imported fuels. The money spent for fuels in virtually all cases leaves the local economy. The local economy will retain approximately 10% of the fuel commodity charges for local handling, storage, mark-up or transportation.

Operation and Maintenance -This component is primarily in labor charges. In urban areas, labor is readily available. Therefore, all expenditures on operation and maintenance will be retained in the local economy.

Capital Equipment - Including Installation -This cost is made up of two components -labor and equipment. Labor is estimated to constitute approximately 60% of the total installed cost of a district heating system. Again labor will be locally available. Equipment will be partially available through local suppliers and manufacturers. Estimates for local equipment availability indicate that in large urban areas approximately 50% of the equipment will be supplied by local equipment suppliers. Overall for urban areas it is estimated that 85% of total capital equipment expenditures will be in the local economy.

The following tables, apply the retention model to the two options as described by the ANL market penetration model for national district heating markets using $20.00 as the average delivered energy price in year 2000.

Table 6-5

UNITED STATES - BASE CASE (2000)

$/MMBTU	CAPITAL	$RETAINED	O&M	$RETAINED	FUEL	$RETAINED	TOTAL $/MMBTU RETAINED
20.00	12.00	10.20	3.00	3.00	5.00	.50	13.70

MMBTU'S SOLD	225,000,000
x $/MMBTU RETAINED	x 13.70
TOTAL $ RETAINED	3,082,500,000
LOCAL MULTIPLIER	3
TOTAL BENEFIT	9,247,500,000

RETENTION FACTORS

CAPITAL	0.85
O&M	1.0
FUEL	0.1

Table 6-6

UNITED STATES - FINANCIAL INCENTIVES CASE (2000)

$/MMBTU	CAPITAL	$RETAINED	O&M	$RETAINED	FUEL	$RETAINED	TOTAL $/MMBTU RETAINED
20.00	12.00	10.20	3.00	3.00	5.00	.50	13.70

MMBTU'S SOLD	897,000,000
X $/MMBTU RETAINED	x 13.70
TOTAL $ RETAINED	12,288,900,000
LOCAL MULTIPLIER	3
TOTAL BENEFIT	36,866,700,000

RETENTION FACTORS

CAPITAL	0.85
O&M	1.0
FUEL	0.1

The funds retained in urban areas will be respent in the local economy. The income multiplier effect, or the number of times a dollar will be respent locally, is estimated by the Department of Commerce to be three (3) for large urban areas. Therefore, the amount retained locally will increase threefold. In the Base Case, the local economies will experience retained spending of $9.25 billion; and in the Financial Incentives Case, the local effect will be $36.87 billion. This is a rather significant amount of spending in cities as

a result of district heating expenditure in the year 2000. The cumulative retention from 1985 through 2000 is shown below using the same methodology.

Table 6-7

BASE CASE

Year	Thermal Price	$ Retained per MMBtu	MMBtu's Sold	Local $ Retained	Local Benefit
1985	6.66	4.56	30000	136863	410589
1986	7.55	5.17	345000	1784254	5352761
1987	8.44	5.78	1380000	7978332	23934996
1988	9.33	6.39	4000000	25564200	76692600
1989	10.22	7.00	8000000	56005600	168016800
1990	11.11	7.61	15000000	114155250	342465750
1991	12.00	8.22	17000000	139740000	419220000
1992	12.89	8.83	24000000	211911600	635734800
1993	13.77	9.43	36000000	339568200	1018704600
1994	14.66	10.04	50000000	502105000	1506315000
1995	15.55	10.65	65000000	692363750	2077091250
1996	16.44	11.26	95000000	1069833000	3209499000
1997	17.33	11.87	113000000	1341428650	4024285950
1998	18.22	12.48	144000000	1797220800	5391662400
1999	19.11	13.09	189000000	2474076150	7422228450
2000	20.00	13.70	225000000	3082500000	9247500000
				$11,856,371,648	$35,569,114,946

Table 6-8

FINANCIAL INCENTIVES

Year	Thermal Price	$ Retained per MMBtu	MMBtu's Sold	Local $ Retained	Local Benefit
1985	6.66	4.56	135000	615884	1847651
1986	7.55	5.17	1410000	7292168	21876503
1987	8.44	5.78	6000000	34688400	104065200
1988	9.33	6.39	17000000	108647850	325943550
1989	10.22	7.00	35000000	245024500	735073500
1990	11.11	7.61	63000000	479452050	1438356150
1991	12.00	8.22	90000000	739800000	2219400000
1992	12.89	8.83	131000000	1156684150	3470052450
1993	13.77	9.43	188000000	1773300600	5319901800
1994	14.66	10.04	248000000	2490440800	7471322400
1995	15.55	10.65	332000000	3536381000	10609143000
1996	16.44	11.26	444000000	5000061600	15000184800
1997	17.33	11.87	531000000	6303527550	18910582650
1998	18.22	12.48	620000000	7738034000	23214102000
1999	19.11	13.09	780000000	10210473000	30631419000
2000	20.00	13.70	897000000	12288900000	36866700000
				$52,113,323,551	$156,339,970,653

The magnitude of the system size will vary in the individual city, as will the end-user cost for thermal energy. These variables will determine the value to the local economy from district heating and cooling system development. In the above examples, $20.00/mmBtu was used as an estimate of delivered cost and was based on supplying thermal energy at approximately 90% of the natural gas price. The actual cost will vary, and consequently so will the benefits.

6.3.6 Taxes

Analysis to date has focused on the taxes generated locally, particularly local and state income taxes.

Cost estimates for district heating systems indicated that approximately sixty percent (60%) of the total installed cost of the system will be in labor charges. Since many cities have municipal income taxes generally ranging from 1% to 2.5% of gross income (in some cases state taxes replace local taxes), income tax on the system installers' payroll is the first economic benefit to the coffers of the city. For example, a system with a total construction cost of $20 million will have a 60% labor component; hence, $12 million would be spent on labor and 1%, $120,000 would immediately flow into the city's general fund during the construction period.

The Base Case and Financial Incentives Options illustrate the range of local income tax impact nationally. Under these two cases cities will be able to collect taxes on the 131,625 to 200,070 job years respectively anticipated to result from district heating construction. Estimating the wages for one job year to average $18,000, and city income taxes to average 1.5%, result in income tax receipts between $35.5 (Base Case) and $54 (Financial Incentives Option) million. This does not consider taxes from other employment generated by district heating through the multiplier effects of income and employment. Tax receipts added by accounting for the income multiplier effects and

additional employment, coupled with the tax receipts from the construction necessary to serve the industrial markets, could easily double the the taxes collected by cities. Other taxes such as gross receipts tax, franchise taxes, and property taxes will also contribute to the state and local economic bases. Since these taxes vary dramatically from state to state and city to city, it would be inappropriate to speculate on their impacts.

The benefits that district heating and cooling system development can offer are widespread throughout the economy. They range from the obvious national implications of energy security to jobs in construction to energy cost savings for businesses and residences. The key to reaping these benefits is investing in long-term capital rather than scarce fuel resources. By making the capital investment, one invests in productivity (as opposed to natural resources) which has a much greater impact on the broader segments of the economy, with the majority occurring in urban areas.

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

7.1.1 The Market

Previous chapters of this report have shown in great detail how and why Europe is far ahead of the U.S. in the development of multiple-customer, community-scale DHC systems. Publicly stated national policy objectives, commitment to planning and organization at the local and provincial levels, and partnerships with industry provide European nations the foundation for successful community energy system development. These elements along with reasonable initial financial assistance generally characterize the European DHC strategy. This approach, coupled with a driving desire to extract every bit of energy from limited resources, explains why these countries have progressed more quickly than the United States in implementing district heating and cooling.

Unlike European countries, the U.S. district heating and cooling organizational framework has been historically diverse, loose and relatively unorganized. To a large extent, this diversity and modest organizational cohesiveness is attributable to the transition in the U.S. energy supply economy and DHC which began in the 1970's. This transition continues today and is characterized by the expanding role of non-traditional suppliers in the energy supply system. The table below summarizes DHC market potential related to the several federal policy options identified, analyzed and discussed in Chapter 5.

Table 7-1

NEW DHC SYSTEM IMPACT IN THE U.S. ENERGY MARKET

1985

OPTION	MARKET PENETRATION (BTU'S)	INCREASE OVER BASE CASE	DEVELOPMENT DOLLARS INVESTED	RESULTANT EMPLOYMENT JOB YEARS
Base Case	30,000,000,000		750,000	18
Technical Assistance	4,000,000,000,000	13233%	100,000,000	2,340
Project Packaging	25,000,000,000,000	83233%	625,000,000	14,625
Financial Incentives	135,000,000,000	350%	3,375,000	80

Table 7-2

NEW DHC SYSTEM IMPACT IN THE U.S. ENERGY MARKET

2000

OPTION	MARKET PENETRATION (BTU'S)	INCREASE OVER BASE CASE	DEVELOPMENT DOLLARS INVESTED	RESULTANT EMPLOYMENT JOB YEARS
Base Case	225,000,000,000,000		5,625,000,000	131,625
Technical Assistance	342,000,000,000,000	52%	8,550,000,000	200,070
Project Packaging	592,000,000,000,000	163%	14,800,000,000	346,320
Financial Incentives	897,000,000,000,000	299%	22,425,000,000	524,745

The analysis indicates that without federal and state intervention DHC will continue to capture a small share of the urban energy market until the late 1990's. During the 1990's a combination of factors including forecasted energy price increases, projects' ability to endure front-end or predevelopment obstacles, emerging coal and MSW technologies, and the accelerating pace of municipal solid waste development may contribute to an increased penetration of DHC in the energy market.

The district heating and cooling market potential is based on the projected ability of system developers to compete effectively in the end-use energy market. Two things that have helped this effort are: 1) the technology of DHC systems is beginning to shift in this country from steam to hot water, and 2) system ownership appears to be shifting from the traditional, exclusive ownership by investor-owned electric utilities to entrepreneur, authority, cooperative, municipal and not-for-profit ownerships.

There are basically seven primary forces which motivate development in this area:

- energy efficiency
- energy prices
- indigenous resources
- entrepreneural opportunity
- environmental quality
- security
- city and state community and economic development

However, these seven forces do not, standing alone, account for the current market status of DHC in the U.S. Clearly, the cornerstone of the current U.S. market penetration has been the combined efforts of the Department of Housing and Urban Development and the Department of Energy through the "28 Cities Program". With the departments' assistance limited to predevelopment support in identifying and determining the project feasibility, cities are showing that local partnerships can be formed which lead to private system development

and private investment leveraged over 10:1 (i.e. Provo, Utah) against the early HUD funding. Although many of these systems are initially small in service area, all have potential for orderly system growth. Given the current underlying economic and regulatory climate and energy price uncertainty, incremental system development may be the only way to initiate DHC systems in the foreseeable future.

7.1.2 Technology

District Heating and Cooling, though not widely recognized and understood in this country, is a technology that is sound and proven, both in the U.S. and Europe. District Heating and Cooling is an urban energy delivery technology, unlike solar which is more applicable to suburban and rural areas.

DHC systems conserve scarce fuels and help cities use energy more efficiently by:

1. Substituting energy normally wasted or alternative forms of energy for oil and natural gas that are currently used in individual buildings; and

2. Utilizing energy resources more efficiently through the use of cogenerating power plants.

Cogeneration, the simultaneous production of electricity and thermal energy, can be a valuable input to the growing district heating and cooling system. By using the waste energy of electric production, cogeneration squeezes more energy out of each unit of fuel, and can raise the efficiency of central plants from about 30 percent to 80 percent. The increase in overall system efficiency results in accrued benefit to both thermal and electric customers.

Importantly, improved efficiency of cities' energy supply systems through DHC development directly contributes to reduction of the nation's balance-of-payment deficit and is necessary for U.S. business to remain competitive with Japan and Europe.

Just as with cogeneration and DHC systems, municipal solid waste (MSW) and DHC systems are now becoming mutually supportive and economically linked in the U.S. Solid waste disposal will become one of the largest municipal headaches of the 1990's in cities throughout the country as suitable landfills become harder to find, the costs of landfilling continue to escalate, and environmental rules become more strictly enforced. As the problem becomes more acute, more cities will find it necessary to allocate CDBG funds and management capabilities to its amelioration. MSW-burning plants producing energy are increasingly attractive investments and can reduce urban costs in the mid- and long-term. Consequently, developers of MSW plants are becoming cognizant of the advantages derived from system configurations which include revenue from valuable thermal markets, as well as electrical and tipping fee revenues.

Due to the proven nature of DHC technology today, further research and development need focus only upon cutting equipment costs while maintaining reliability. Research and development efforts directed at reducing the cost of building retrofits and thermal meters will directly contribute to the growth of district heating and cooling. Improved technology for identifying, locating and estimating the cost of underground interference will assist in lowering the cost of piping network installation.

Thin wall piping systems (European standard) are now moving into U.S. markets in modern hot water systems. This is primarily due to cost advantages of lower temperature systems as found in the lower cost European piping

products. The U.S. standard as defined by the Department of Defense standards is at a substantial price disadvantage in the low temperature ranges. This competition is causing the U.S. manufacturers to become more competitive and expand their product lines to include thin wall piping systems. The prices bid on recent projects confirms the competitive market, to the benefit of system purchasers and the energy consumer.

7.1.3 Barriers

In order to attract a larger share of the potential market, DHC system developers will encounter and must overcome four categories of barriers:

- Market Entry
- Financing
- Legal/Regulatory
- Air Quality

Market Entry

Notwithstanding the calculable advantage and efficiencies of DHC and cogeneration, these systems, which essentially deliver energy as opposed to fuels, require that energy suppliers, as well as, customers change their energy consumption patterns and equipment. Achieving systematic changes within the context of a free market economy can be an ordeal during the early years until such time as both consumer preferences and supply approaches have changed and are widely recognized. This could be characterized as the "new product syndrome."

Another impediment to increased market penetration is the predevelopment complexity that one encounters in the marketplace. Elevating district heating and cooling to a major role in U.S. energy delivery schemes raises complex issues of ownership, operation, finance, and regulation for the purpose of investor and customer protection. The complexity of this public/private negotiation process may quickly dampen enthusiasm for a district heating and

cooling project even though substantial benefits to the community can be demonstrated, unless it becomes an accepted element in a larger community development/economic development process which provides the assurance of stability and continued availability that customers and investors both require.

Without a doubt, one of the strongest barriers to market penetration is that risk capital is required for initial identification and feasibility analysis of DHC projects. The economic viability of DHC systems varies considerably according to site, prevailing local fuel types and prices, and the availability of electric generation equipment suitable for conversion to cogeneration. Therefore, in order to determine the economic viability of an individual DHC project, detailed analysis is usually necessary. This work must be undertaken with the possibility that some barriers will be discovered which will preclude proceeding with the project. Few other investment opportunities place such extensive technical (in addition to financial and legal) analytic demands on the developer.

In order for a district heating system to be economically viable, there must be a high enough density of energy demand within the service area. Achieving this economic "demand density" in a large enough area to make the construction of the system viable and obtaining the contractual commitments are necessary to financial development.

A final market entry barrier confronting the private development of DHC is the present limited level of knowledge of district heating as an alternative energy concept. There is a clear "learning curve" phenomena at work. As new systems are successfully developed and financed, marketplace acceptance, knowledge and financial support for future district heating

projects will become easier to obtain. Convincing customers to connect to the DHC system will require less effort and be accomplished in a much quicker manner.

Financing

The four financing issues which represent barriers to the rapid development of DHC in this country are:

- High Capital Cost with Long Construction Lead Time
- Risk of Unknown Future Energy Prices
- Customer Hook-up Cost
- Uncertain/Unequal Tax Treatment

First, DHC systems require large capital investment to construct most of the system before any revenue can be generated from sales. Since these systems usually have no established customer base, it is impossible to transfer the risk to the customers of the system as do existing electric and gas utilities. Second, long construction lead times force district heating developers to project energy prices and demands for 10-30 years in the future in order to project system revenue. The problems inherent in this undertaking are self-evident.

Third, DHC systems require an investment by the customer in on-site equipment, principally heat exchangers and their associated piping and controls. However, the potential DHC customer does not receive any of the normal tax credit incentives because DHC was relatively unknown in congressional circles and largely ignored at the time the incentives for energy conservation were passed.

Finally, the 1984 changes in the limitations on IDB financing that were outlined in greater detail previously in this report, both in terms of the limitations and the trade-off between tax-exempt financing and ACRS, all create uncertainty, and at a minimum, will add to the predevelopment complexity and related costs.

Legal/Regulatory

Treatment of major new energy investment efforts such as cogeneration and district heating and cooling, is still diverse, inconsistent and uncertain. The uncertainty surrounding regulatory treatment of these issues constrains promotion of district heating and cooling.

Where the Federal Government is concerned, the regulatory changes are relatively few and minor; for example, exempting DHC systems from application of the Fuel Use Act, particularly in infant stages of system development, would be extremely beneficial. More important in terms of federal regulatory changes, is that it would send a signal to state and local governments that the federal government was behind DHC and wants to clear away the barriers. Such a move would undoubtedly have a positive impact upon local regulation.

This is very important, for it is in the area of state and local regulation that DHC system development becomes most hampered. For example, DHC has substantial initial capital costs and must have some way to amortize this investment to the satisfaction of its creditors. Uncertainty about regulation drives up predevelopment cost. DHC sponsors cannot attract customers unless their prices are competitive. Since DHC simply does not, cannot, and will not result in a monopoly (as explained in an earlier chapter), there is no reason to regulate DHC services.

Air Quality

The hurdles and barriers in this area were dealt with very extensively in Chapter 3. The main conclusions to be drawn from this can be stated quite simply. First, air quality regulation has a more restrictive effect upon the use of coal. Second, and more importantly, regulation does not recognize the efficiencies of cogeneration. This is because the current regulations simply

evaluate units of emission. They do not evaluate units of emission per unit of useful energy, thereby penalizing DHC for its far more efficient use of our energy resources.

After reviewing all four areas of barriers to DHC market penetration, it is quite easy to understand that the sheer number of obstacles and the length of the course have, in fact, deterred all but totally resolute entrepreneurs and developers. Yet it is unlikely that sweeping institutional change will occur which removes these uncertainties or breaks down most barriers. This would require coordinated action by both federal and state government. Therefore, any near- and mid-term efforts to encourage district heating and cooling will have to be targetted to the ability of developers, cities and financiers to negotiate the obstacle course.

7.1.4 Benefits

Now that we have discussed the technology involved, the current and potential market, and the issues faced in attempting to increase the market share, it is appropriate at this point to turn to the benefits at stake. The following paragraphs merely summarize the detailed presentation found in Chapter 6.

The benefits derived from district heating and cooling system development and operation will accrue to the nation, cities, consumers and utilities.

Clearly, one of the first benefits is energy savings, both in terms of net energy use and in scarce fuel savings. This in turn will help to reduce U.S. dependence on foreign sources of fuel. The latter will impact two additional ways; it will help improve our national security and lower our trade deficits.

DHC will further benefit the country by reducing unemployment, which will also increase income tax revenue. Unemployment will be reduced both by the additional jobs in construction and supplier industries, and also through the fact that industry and commercial businesses will have more money to spend because of less expensive and more stable energy prices.

The primary benefit to consumers is the availability of more stably priced energy. Consumers will benefit from DHC's fuel flexibility, in that the system will be able to burn the most economical fuel available, and in turn, pass those savings on to the customers of the system.

Utilities will profit from their renewed ability to satisfy customer demands by the use of alternative fuels to stabilize prices. DHC systems will further benefit utilities by having long economic lives that will allow for return on investment several times over.

Cities will be able to reap most of the advantages mentioned above, such as long-term price stability, increased employment, additional tax revenue and the like. Most importantly, a DHC system will add to the major infrastructure of the city, thereby increasing the city's ability to attract and encourage economic development and carry out an effective community development program. At the same time, the city will benefit from improved air quality due to the reduction of a multitude of point sources of pollution down to one, more efficiently controlled point source. The remaining benefit to cities will be their increased ability to profitably operate resource recovery plants and reduce the increasing amounts of community development block grant funds that will otherwise be allocated to this growing urban problem.

It is easy to see that the benefits that district heating and cooling system development can offer are widespread throughout the economy. They range from the obvious national implications of energy security, to jobs in

construction, to positive impacts on national industries such as steel, to energy cost savings for businesses and residences and retention of dollars.

These are concerns that affect many areas of the federal government interest in addition to the urban development responsibilities of HUD. The key to reaping these benefits is investing in long-term capital, rather than scarce fuel resources. By making the capital investment, one invests in productivity (as opposed to natural resources) which has a much greater impact on the broader segments of the economy, with the majority of the impact occurring in urban areas.

7.1.5 Federal Policy

The technology of district heating is proven and sound. The market is very large and mostly untapped. The obstacles have been identified, as have the extensive benefits that will accrue, once those obstacles are overcome. Knowing all this, what should the federal policy be regarding district heating and cooling?

The federal government is, in all likelihood, the single largest producer and consumer of thermal energy in the free world. In spite of this, there has never been a truly coordinated approach to district heating and cooling within individual agencies' programs, such as HUD-sponsored housing, let alone, the federal government, as a whole.

The individual, specific items of federal policy and action are outlined in the recommendations below. Basically, incentive for DHC development can be provided by giving technical support to those interested in system development, by providing front-end risk reduction to those interested in project development, and by clarifying the federal position on district heating and cooling, which will facilitate other regulatory changes in support of national objectives at the state and local levels.

By defining, characterizing and calculating market penetration of these options (as was done in previous chapters of this report) we are able to convey an understanding of the significance of accelerating the development of DHC nationally. Front-end, predevelopment support clearly has the most near-term impact. As stated in the preceding discussion, district heating and cooling can achieve substantial and dramatically greater market penetration with relatively modest federal support.

In the longer view, the stimulation of public-private investment in this country's infrastructure will assure continued and improved competitiveness in the future.

7.2 RECOMMENDATIONS

The following recommendations are made by the Department of Housing and Urban Development (and where appropriate allied agencies). These recommendations are based upon exhaustive analysis conducted to date by the office of the Assistant Secretary for Community Planning and Development. Each of the following recommendations is consistent with, and enlarges upon, the recent report of the National Academy of Sciences on District Heating and Cooling and the American Public Power Association's DHC White Paper.

The recommendations are structured and guided by the following principles:

- DHC should receive an equal chance with other energy technologies and should enjoy equitable tax and regulatory treatment.
- The Federal government through its appropriate Departments and Agencies should encourage DHC development.
- Federal policy and specific programmatic actions should recognize that DHC does not represent a short-term, quick solution to any of the nation's problems but rather represents a mid- and long-term contribution to productivity, energy independence and urban development.

- Unrealistic and unsustainable capital grant programs which directly fund DHC infrastructure should be avoided.
- Administration policy statements (through appropriate agencies such as Treasury, DOD, GSA, HUD and DOE) should establish that the Federal DHC programmatic effort will be consistent, stable and dependable.

The following recommendations should be adopted by the federal government. Implementation of these recommendations will result in a effective, appropriately scaled, consistent policy framework for encouraging the implementation of DHC in American cities. Each recommendation will have a number of direct effects and encourage DHC market penetration. In addition, upon adoption and implementation, the recommendations will increase the ability of private investors, bankers, underwriters, developers, engineers, and other parties who are important members of the DHC project partnership.

Recommendation No. 1 -- HUD/DOE Policy Statement and Inter-Agency Cooperation

HUD and DOE should immediately develop a DHC policy statement which clearly indicates both agencies' support of DHC as an appropriate urban energy technology; reinforces private and public efforts at the state and local level; pledges inter-agency cooperation toward the development of DHC; and provides for joint program development where appropriate.

Although HUD and DOE should cooperate in the preparation of the basic policy statement, each agency should modify and detail its statement as needed to fit their role in the DHC strategy. Within the context of cooperation between two agencies each should release their DHC policy statements independently.

Recommendation No. 2 -- System Development Support

The department should continue the DHC Assessment Program in collaboration with DOE. Specifically, the department should provide additional feasibility and project packaging technical assistance to support local and

state efforts in developing DHC projects. This technical assistance program should encompass the provisions outlined in Options 2 and 3 of this report (Technical Assistance and Project Packaging Assistance). The Technical Assistance phase of system development support should include provisions for continued but limited feasibility assessment planning grants for an additional 50 to 75 communities. Emphasis should be placed on DHC linkages to other HUD programs and priorities. In addition, the department should provide planning assistance to formally organized state DHC programs.

Project packaging assistance (Phase 2) should provide support to an additional 15 to 25 communities for packaging the necessary local DHC private/public partnership. Project packaging should be limited to support for predevelopment costs on a cost-sharing basis.

Recommendation No. 3 -- DHC System Financing

The Federal (HUD and DOE) role in DHC system financing (other than that already provided through UDAG or CDBG programs) should be limited to support to local projects on a cost-sharing basis as indicated in Recommendation No. 2 above, until such time that there emerges a clearer picture of competitive fuels prices later in this decade; until the federal deficit is sufficiently in control; and until such time that the department can clearly evaluate the results of other program activities recommended herein.

Recommendation No. 4 -- UDAG and CDBG

Currently, DHC is an eligible activity within both the UDAG and CDBG programs; however, the regulations governing these programs need to be clarified and strengthened as they apply to energy activities and DHC. Specifically, the UDAG regulations award "energy points" for energy related activities. Liberal interpretations of this provision often result in projects with an insignificant energy component being awarded the same points

as a full-fledged DHC or community energy system development project. If the UDAG program is continued, awarding of energy points should be limited to projects which have a substantial DHC or community energy system component.

Current UDAG regulations prohibit municipal utilities from being the recipient of UDAG funds (in the form of loans) while investor held utilities are eligible UDAG recipients. This inconsistency and inequity should be corrected in that; a) many cities are served by municipal utilities as opposed to investor owned utilities; and b) the source of DHC financing is the same in both cases, i.e., the bond market; and c) the source of loan repayment is the same in both cases - rate payers.

Similarly, DHC is an eligible CDBG activity. However, the current regulations place little emphasis upon community energy systems resulting in significant DHC projects competing against multiple, subcritically funded, conventional CDBG activities which have developed and established local constituencies over the program's historical life. CDBG regulations should be amended, not to mandate, but to encourage the inclusion of DHC or community energy systems as a preferred energy activity in a community's block grant program and signal grantees that the department recognizes DHC as an important city activity.

Recommendation No. 5 -- Regulation

The department should implement program efforts directed at reducing regulatory uncertainty facing DHC system developers. Generally, HUD's program in this area should focus upon creation of a favorable regulatory and legislative environment for the development and orderly growth of DHC systems. Specifically, the department should:

- Develop model DHC legislation and regulatory approaches for discussion with appropriate state and local legislators and regulators (see pp. 2-98 - 2-104; 3-28 - 3-29)

- Convene a series of seminars to discuss DHC legislative and regulatory missions with appropriate state and local officials

- Work with EPA and DOE to review and revise the "bubble policy" to allow emission source substitutes conducive to DHC development (see p. 3-33)

- Discuss with EPA and DOE the revising of air-quality regulations to consider allowable emissions as a function of overall fuel efficiency as opposed to the current provisions which provide for allowable emissions as a function of basic fuel input. (see pp. 3-30 - 3-33)

- Collaborate with DOE in a review and evaluation of the Fuel Use Act to determine reasonable modifications which will facilitate DHC development

Recommendation No. 6 -- Taxation

The department, with the assistance of DOE, should monitor and review proposed 1985 tax law changes and advise the Treasury Department on ways to ensure that district heating and cooling receives even-handed treatment with other energy and urban development investments, as recommended also by the National Academy of Sciences. Specifically, emphasis should be placed upon tax considerations related to section 103 B4, Investment Tax Credits (ITC) and Accelerated Cost Recovery Schedules (ACRS). Both DHC and resource recovery should be exempt from small issues provisions under any tax law or IRS ruling. DHC and resource recovery are clearly public purpose investments not private purpose investments such as hotels or private industrial parks.

Both HUD and DOE should further consider and evaluate the need for and appropriateness of end-user retrofit tax credits which would assist building owners in connecting to DHC systems.

Recommendation No. 7 -- Technology Transfer

The department should conduct a thorough evaluation of current DHC projects (both HUD assisted and others) in order to glean data, knowledge and information relevant to cities undertaking new DHC projects. The results of this analysis and evaluation should be presented in a series of workshops and

training seminars for cities that participate in the department's Technical/ Project Packaging Assistance program outlined in Recommendation No. 2 above.

The department should develop guidelines for assisting cities through the very early identification of DHC interest. Importantly, the Department's program should assist cities during the early stages of resource recovery system project development as they evaluate the advantages and disadvantages of waste-to-energy systems.

The department should collaborate with DOE in the preparation and maintenance of an up-to-date DHC data base.

Recommendation No. 8 -- Research and Development

DOE should continue to lead the federal district heating and cooling R&D effort. This R&D effort should be targetted toward product development which will lower DHC component hardware costs while enhancing reliability and ease of maintenance. HUD should coordinate with DOE as the R&D program is conceived, developed, and implemented. HUD's primary R&D responsibility will involve distribution of findings through the technology transfer efforts outlined in Recommendation No. 7 above.