PB89165260

BUFFALO DISTRICT HEATING AND COOLING SYSTEM: TECHNICAL AND ECONOMIC ASSESSMENT

Final Report

Prepared for

NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

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657-FFES-84

NYSERDA Report 86-7

June 1985

First Printing: July 1986

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. NYSERDA 86-7	2.	3. Recipient's Accession No. PB89 165260/AS

4. Title and Subtitle	5. Report Date
Buffalo District Heating and Cooling System: Technical and Economic Assessment	June 1985
	6.
7. Author(s) Elliot Jennings	8. Performing Organization Rept. No.
9. Performing Organization Name and Address	10. Project/Task/Work Unit No.
Resource Development Associates, Inc. Colonel Glenn Highway Dayton, Ohio 45431	11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address	13. Type of Report & Period Covered
New York State Energy Research and Development Authority 2 Rockefeller Plaza Albany, New York 12223	14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The information in this report identifies and describes district heating and cooling opportunities for downtown Buffalo. It reviews technical and economic data necessary to building such a system, including a market study of how many buildings would use the system, energy price projections, regulations governing such systems, ownership options, expansion proposals and a plan of implementation. Certain buildings were selected for a survey to develop energy-use profiles. All evaluations were made within the context of the downtown energy-use patterns. This phase one project concludes that it is feasible to build a pilot-scale system for downtown Buffalo and to design it with expansion capability and that such a system would be both economical and energy efficient.

17. Document Analysis a. Descriptors

District Heating
Steam Heating
Central Energy System
District Heating and Cooling
Cogeneration
District Steam

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) unclassified	21. No. of Pages 128
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35)

ABSTRACT

The purpose of the work conducted under this contract was to identify and configure district heating and cooling system development opportunities in downtown Buffalo, New York. In order to accomplish this work, a four-part methodology was employed. In the first part, the block-by-block annual heating consumption in the downtown was identified and calculated. Selected buildings were surveyed, and typical energy use profiles were developed. In the second part, development opportunities and influences were identified. Development opportunities were evaluated within the context of the energy use patterns in the downtown. Early-start systems that could be economically developed to serve the loads in the development areas were identified in the third part. The fourth part involved developing interest for the early-start systems, and establishing long term strategy for system growth and expansion.

In Buffalo, two early-start systems with expansion capability were identified and recommended for development.

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SUMMARY

The broad purpose of this report is to identify, describe and quantify the opportunities for the development of district heating and cooling systems in Buffalo, New York. Specifically, this report assesses the preliminary feasibility of several systems in the downtown, the defined target area.

District heating and cooling (DHC) is a system of delivering energy to customers or end users. A central plant that produces thermal energy through a system of fuel combustion, a distribution system transporting steam, hot water, or chilled water, and an end use station at the customer's building comprise the components of a district heating and cooling system. District heating and cooling differs from a convential system supplying building space heating, in that heat in the form of usable thermal energy or chilled water is transported rather than a combustible fuel.

Since thermal energy - not fuel - is the commodity being distributed, the DHC system can use more than one fuel source for energy. Boilers, waste heat recovered from other processes, cogeneration (heat recovery from the generation of electricity), incineration of municipal solid waste, or any other method of production of thermal energy can be used at the central plant and provide energy to the distribution system. At the customer station, the energy is generally transferred from the distribution system to the customer's space conditioning system, using heat exchangers.

THE MARKET AREA

The City of Buffalo initially identified the Central Business District (CBD) and immediate environs as the preferred development area for district heating. This area consists of over 400 buildings. This area was selected based on the density of development. Buildings range in age from new structures to historic properties and in use from single family houses to enclosed shopping malls. Retail and office use are dominant.

From an energy use standpoint, the buildings are generally heated by natural gas-fired boiler systems. Many of these systems were originally designed to burn coal and have been converted, resulting in surplus boiler capacity due to the higher efficiency of natural gas.

Estimated energy consumption by city block based on building square footage and typical energy consumption for buildings was calculated. The result is a thermal density map of the downtown.

Based on the thermal densities and other factors, e.g., building ownership, the Ellicott Historic District and redevelopment efforts, the southwestern CBD was selected as the prime area for initial project development. An early-start project based on City Hall, City Courts and Fire Headquarters was selected as having the most potential and immediate benefit. The energy source is natural gas. The central heating plant is gas boilers in Fire Headquarters.

Other early-start projects include district heating projects based at new development. Specifically, a project at the proposed Buffalo Stadium would employ cogeneration technologies. Over time, the two early-start projects could grow together. In order to serve this customer base, a hot water system similar to those found in Scandanavia is the preferred type of district heating system. The selection of a hot water system is made based on the lower cost of piping systems and greater efficiencies of thermal transport.

ENERGY PRICE

Fuel prices are destined to increase in the future. The rate of the increase of energy is one determining factor in assessing the potential of district heating development. Currently, energy costs in Buffalo, after applying the conversion efficiency calculations of end use equipment, are as follows:

	Average Efficiency	Cost/MMBtu
Natural Gas (commercial)	70%	$ 8.47
Natural Gas (industrial)	70%	$ 8.01
Electricity	100%	$23.91
Oil #2	65%	$11.32
Coal	75%	$ 3.13

Predictions were made estimating the long-term costs of energy. These predictions are based on the review of a number of different forecasts, including local utilities. The projected costs of energy in year 2000, including the efficiency of the end use conversion, are the following:

	Cost/MMBtu
Natural Gas	$26.84
Electricity	$84.25
Oil #2	$40.41
Coal	$ 9.93

There is cost advantage of using coal as a fuel source. As the early-start systems grow, coal will rapidly become the fuel of preference. Gas offers the second best opportunity; it becomes less expensive as usage increases due to tariff structures. Gas will be used in both early-start systems.

REGULATION

A number of institutional and regulatory issues face the Buffalo district heating developer. These include regulations dealing with the use of various fuel sources particularly natural gas, environmental regulations on burning of fuels, and the sale of energy.

In Buffalo's case, these issues will become increasingly important as the system grows. In the initial years of the early-start systems, the central plants used will not be subject to extensive regulation due to their size. As the system grows, and fuel sources change, environmental regulation will be more of an issue to the developer.

Presently, New York State hot water district heating systems are not subject to regulation by the Public Service Commission.

OWNERSHIP

There are a number of viable ownership opportunities available in Buffalo. Five basic configurations are posssible:

- City of Buffalo-Public Works Department,
- Development Downtown Inc./established Non-Profit,
- Development Downtown Inc./established For-Profit,
- Third Party Component Ownership, and
- Cooperative.

EARLY-START SYSTEMS

Case analyses of the early-start options were developed. Cases 1, 2, 3a and 3b all include a system connecting City Hall, City Court and Fire Headquarters. Case 1 evaluates only these three buildings, while the Case 2 analysis includes the addition of a domestic hot water system to nearby apartments. Cases 3a and 3b evaluate adding the Old City Court building at 42 Delaware Avenue and the Buffalo Athletic Club building at 69 Delaware Avenue to the Case 1 system. All of these options are based on the addition of new boiler capacity at Fire Headquarters, providing steam to City Hall, and hot water service to the other buildings. The piping configurations vary in Cases 3a and 3b.

These configurations result in cost savings in three areas. First, by centralizing the heating plants for at least three buildings, the city will qualify for a lower rate for natural gas. The rate is based on annual consumption of gas and is approximately $1.00 per MMBtu lower than general commerical rate. Second, newer boilers will result in increased boiler efficiencies, hence lower operating cost. The City Court building is heated electrically; by shifting to gas-based heat, there will be a considerable savings in energy purchase price. Electric heat is approximately $17.40 per MMBtu, and gas cost, adjusted for boiler efficiency, is approximately $7.05 per MMBtu. This results in a savings of over $10.00 per MMBtu. In addition, the boilers in City Hall are in need of repair to keep them in operating condition.

Cases 2, 3a and 3b add private customers to the systems. The system offers savings potential in the mid-term from lower fuel-operating costs--elimination of boiler maintenance, insurance and operators. Over the long-term, these buildings systems will also operate more efficiently. In Cases 3a and 3b, the buildings will benefit from reduced energy use in converting from steam to hot water.

Two additional early-start projects were evaluated. Configurations were identified for the Majorka Village sub-division and a cogeneration system for the proposed Buffalo Stadium. The Majorka Village project, a private development proposed for the far east side of Buffalo, does not demonstrate sufficient savings to justify the initial investment based on a heat-only system.

Cases 4a and 4b are early systems designed for the Buffalo Stadium and Marine Midland Tower. In both cases, a 3000 kw diesel engine fired by natural gas serves as the central plant. Heat is recovered from the exhaust gases and is piped to the Stadium and Marine Midland for heating. Electricity is sold at $.06/kwh either to Niagara Mohawk or to an electric agency. In Case 4a only heating and electric power are provided. In Case 4b, a chiller-heater, which can simultaneously provide chilled water for cooling and hot water for heating, is added to the system. Chilled water is sold to Marine Midland and the Stadium with cooling. Heat is still provided to both, and electric is sold as in Case 4a. Case 4b offers a much better economic outlook and is recommended.

ACTION PLAN

In the evaluation of district heating and cooling in Buffalo, two small early-start projects have been identified as priorities for development. The early-start system based at City Hall, including the buildings at 42 and 69 Delaware Avenue (Case 3b) and the cogeneration project at the proposed Buffalo Stadium and Marine Midland Center (Case 4b), offer the best potential, technically and economically.

The City Hall district heating system will become the core of a development program that can be broadened to include other publicly and privately owned buildings in the southwestern CBD. In fact, expanding this initial system is the objective of the district heating developer. The early-start system at the stadium also offers expansion potential from the core system. Since district heating and cooling systems substitute capital for fuel, the system developer must be prepared to expand the early-start systems incrementally, and recognize that the early-start systems represent only the first increment of development. As hot water district heating becomes accepted in the market place by building owners, each additional increment will be easier to market.

Section 1

INTRODUCTION

The broad purpose of this report is to identify, describe and quantify the opportunities for the development of district heating and cooling systems in Buffalo, New York. Specifically, this report assesses the preliminary feasibility of several systems in the downtown, the defined target area.

BRIEF DESCRIPTION OF DISTRICT HEATING AND COOLING

District heating and cooling (DHC) is a system of delivering energy to customers or end users. A central plant that produces thermal energy through some system of fuel combustion, a distribution system transporting steam, hot water or chilled water, and an end use station at the customer's building comprise the components of a district heating and cooling system. DHC differs from a conventional system for supplying building space heating, in that heat inthe form of usable thermal energy or chilled water is transported rather than a combustible fuel.

Since thermal energy - not fuel - is the commodity being distributed, the DHC system can use more than one fuel source for energy. Boilers, waste heat recovered from other processes, cogeneration (heat recovery from the generation of electricity), incineration of municipal solid waste, or any other method of production of thermal energy can be used at the central plant and provide energy to the distribution system. Coal, oil, natural gas, wood, solar, geothermal and energy from heat pumps can all be used as system inputs. Some are more practical than others depending on availability, environmental considerations, cost of commodities, and cost of conversion to usable energy.

At the customer station, the energy is generally transferred from the distribution system to the customer's space conditioning system, using heat exchangers. Depending upon the customer's type of heating system, the conversion or retrofit to make use of the district heating may involve simply substituting a packaged heat exchanger for the customer's existing boiler, and starting the system. In other cases, the retrofit may be quite involved and costly. Each case of retrofit is unique and requires individual attention. In the case of new construction, building systems can be designed for district heating initially, facilitating the connection to a system.

Historically, district heating has been used since 1877. An inventor in Lockport, Niagara County, New York, designed and constructed the first known commercial district heating system. The system used steam made at a boiler in the inventor's home and transported the steam to a nearby neighbor. From this modest start, the use of district heating and cooling systems has expanded to include some city-wide systems in places such as Moscow, Helsinki, and other European capitals; large systems such as Consolidated Edison's in New York City, and downtown systems in Baltimore, Maryland, Rochester, New York, St. Paul, Minnesota, and numerous others.

Recently, there has been a renewed interest in district heating and cooling in cities in the United States. This is partially due to the increase in fuel costs over the last ten to twelve years, the positive experience of many European countries, and the use of modern insulating materials in the distribution piping systems. Most of the DHC systems being planned and installed are seriously investigating the use of hot water (200°-350°F) as opposed to steam for distribution. There are technical advantages associated with hot water in terms of reduced heat loss, lower maintenance, and better reliability that generally offset the reduced energy-carrying capacity of the media. Additionally, the piping distribution system for hot water is less costly, easier to install, and requires substantially less maintenance than steam piping systems.

Since World War II, the European countries, particularily in Scandanavia, have refined the use of hot water systems. It has only been in the last few years that utilities and engineers in the United States have begun to adopt these lower temperature systems and technologies. Previously, steam had been the standard in the United States.

Also during the past few years, the State of New York has been increasingly conscious of the potential of modern district heating and cooling systems. The State's interest had also encouraged the federal government and other states to develop programs to encourage DHC development. The assessment in Buffalo is being funded by the New York State Energy Research and Development Authority (NYSERDA) under its district heating/cooling development program.

BUFFALO'S INTEREST IN DISTRICT HEATING

Like many other cities that have become interested in district heating, Buffalo's interest evolved because of the economic development potential of district heating and cooling. District heating systems are less subject to price flucuations, because they are more efficient and can substitute less expensive fuel sources efficient and can substitute less expensive fuel sources over time. Effectively, district heating substitutes capital for fuel, which has a stabilizing effect on price. By stabilizing, if not reducing, energy prices, a city or an area within a city can secure a competitive advantage in attracting and retaining development.

The following is excerpted from the Industrial Energy Conservation Planning Final Report, prepared by the County of Erie, Division of Planning, Energy Office in May, 1983, and discusses district heating as one element of an overall approach to energy conservation.

> Potential Applications Locally
>
> After reviewing many possible applications for district heating systems three locations seem to warrant further attention. They are:

1. The Downtown CBD[1], specifically the area south of Division Street. This area is characterized by under-utilized commercial structures. Much of the commercial space is classified as B or C solely in need of capital investment to make it competitive with the newer class A office space. The second element making this area particularly attractive for further study is that lower Main Street is also being proposed for designation as the Joseph Ellicott Historic District. The third element is the proximity of the Seneca Street site, the chosen location for the proposed baseball stadium. Altogether the commercial space is in need of rehabilitation; a proposed historic district which under the Economic Recovery Act of 1981 makes all of the structures 30 years old or older eligible for considerable tax incentives for rehabilitation. In almost all cases this will include an updated heating system; and a large scale municipal project which will include a central thermal plant which might be possible to size as the source for an adjacent district heating system.

The plan describes two other areas of the county, specifically the Thruway Industrial Park under development by the City of Buffalo and the area around Niagara Mohawk's Huntley Station in Tonawanda. The discussion of district heating offers the following conclusion.

> In conclusion, District Heating is being investigated in cities all over this country and is presently in wide use throughout Europe. Its proven worth in Europe and apparent feasibility in this country, as attested to by systems currently being installed in Trenton, N.J., and St. Paul, Minn., combined with demonstrated reliability, cost effectiveness and ability to improve air quality all recommend the formation of central heating districts. In addition, as a recent article in the New York Times indicated, district heating systems are being promoted by the United States Conference of Mayors as a means of redeveloping the central city which has the building and population density to support district heating. The same New York Times article, citing an Urban Land Institute study, estimated that $70 billion plus will be spent on district heating in the next two decades. To date, the Department of Housing and Urban Development has given grants to 28 cities to study the feasibility of district heating.
>
> The time seems right for Erie County in conjunction with the City of Buffalo to seriously consider a detailed analysis of the feasibility and applicability of a local District Heating System.

In August, 1983, the Malcolm Pirnie Company submitted a study commissioned by the Erie County Industrial Development Agency (ECIDA) titled Resource Recovery/Low-Cost Energy Project For the City of Buffalo. The report evaluated three site options for developing resource recovery systems, co-sited with large industries in Buffalo. The analysis concentrated on steam applications and

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[1] CBD: Control Business District

evaluated cogeneration potentials. The report recommended proceeding with a resource recovery project on the city-owned Squaw Island that would produce electricity for sale to Niagara Mohawk.

Although the study did not recommend a resource recovery/district heating application, it furthered the interest in resource recovery and district heating as an energy supply option.

When the New York State Energy Research and Development Authority announced its round of the assessment funding on August 30, 1983, Buffalo was encouraged by the State of New York's commitment to district heating and submitted its application for analysis of district heating potential, primarily in the central business district.

OTHER ACTIVITY IN BUFFALO

The City of Buffalo has undertaken an aggressive program of development and redevelopment in its downtown area. The projects that comprise the program have involved both public and private actions designed to support, reinforce and revitalize downtown Buffalo. To accomplish this, the City of Buffalo has established development corporations that act on the city's behalf and that are chartered, funded and staffed to operate in both functional and geographic areas. The lead corporation for projects in the central business district is Development Downtown, Inc. (DDI). DDI is responsible for the district heating assessment.

The major activities that are occurring in the downtown are the Main Street transit Mall, Joseph Ellicott Historic District, Buffalo Stadium, and private/public rehabilitation of buildings. In areas near the downtown, several mall subdivisions of single-family homes are being planned and developed on in-fill parcels.

Main Street Transit Mall

Niagara Frontier Transit Authority (NFTA) is finishing the development of a light-rail mass transit system that will serve downtown Buffalo. From downtown, the system extends north along Main Street and then goes underground, operating as a subway. Main Street has been closed to traffic, and NFTA is constructing a pedestrian mall. As a result of the train system and the mall, substantial investment in building renovation, new construction and rehabilitation has occurred. This includes two new major bank buildings, a new hotel and a storefront improvement program.

Joseph Ellicott Historic Preservation District

Buffalo has designated the Joseph Ellicott District as a local preservation district. The investment tax credits can be up to 25% of the cost of renovation of National Register-qualified buildings. In addition, the renovations may be fully depreciated. For non-qualified buildings over forty years old, an investment tax credit of 20% is allowed, and the owner may depreciate the remaining amount. This can significantly aid in the financing of end use equipment. The map shown in Figure 1-1 identifies the boundaries of the historic preservation district.

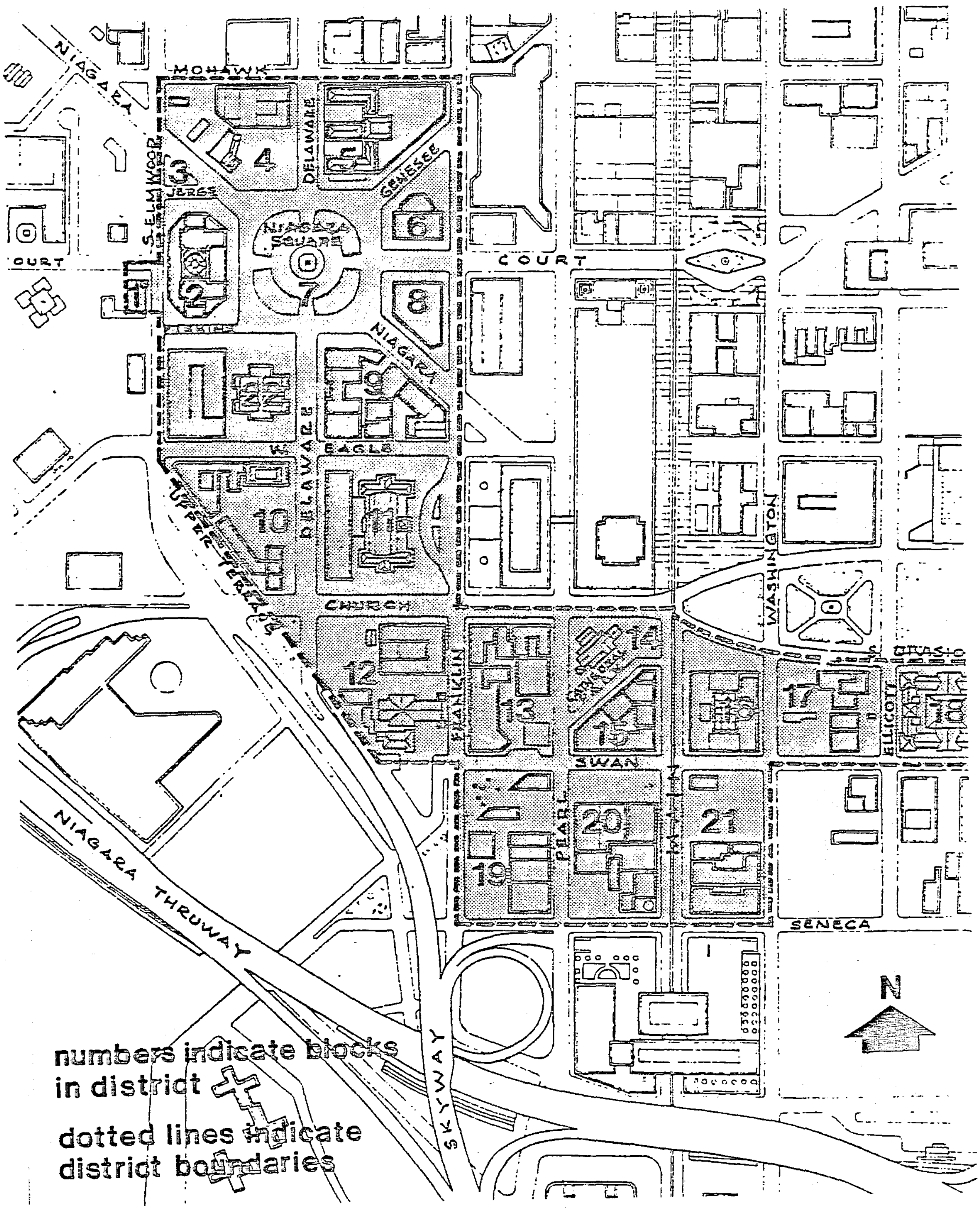


Figure 1-1. Joseph Ellicott Preservation District

Buffalo Stadium

The proposed baseball stadium will initially seat 20,000. It is designed to be expanded to seat 40,000 and possibly be domed to accommodate a major league franchise. Commitments are now in place for a AAA team to use the facility when it is constructed. The stadium is to be located in the area defined by Swan, Oak, Washington and Exchange Streets. The sports facility will provide another anchor at the southern end of the Central Business District (CDB). Construction of the stadium could begin in 1985, opening in 1987. The principal financing for the project is in place.

Private/Public Rehabilitation of Buildings

Over the past few years, Buffalo has experienced an upswing in building activity in the downtown, both in new construction and more significantly in building rehabilitation. This has been the result of several things - most notably the city's support of private development and the advent of major tax advantages for older buildings. In addition, the market in Buffalo appears to have been ripe for new development. As in any city, office development tends to occur in cycles, Buffalo appears to be on the up cycle for the past few years. This building transformation is also partially caused by a shifting in the local economy. Like other cities in the Northeast-Midwest, Buffalo is moving to more service sector employment.

This building surge and the shift in the local economy have resulted from cooperation and leadership in both the private and public sectors. There is an attitude on the part of local leadership that has allowed Buffalo to form partnerships and move forward. For example, recent housing development within the city is an interesting phenomena. In most urban centers one finds a few in-fill single family homes built each year, and a greater number of multifamily rental units being developed. Buffalo, however, has developed new single family subdivisions, and has more planned. These developments have been assisted by creative use of federal Community

Development Block Grant and Urban Development Action Grant funds that help the developers hold prices in the affordable ranges. The units that have been built have been sold without difficulty, to the benefit of neighborhoods and the city as a whole.

WHY BUFFALO'S INTEREST AND ACTIVITIES ARE RELATED

As previously stated, DHC offers the potential to provide reliable and safe energy at potentially more stable prices. Buffalo's development efforts in and around the downtown have been designed to make the CBD a more competitive and desirable place to work, shop and visit. Virtually anything the city can do to make the downtown more desirable and competitive is in its best interest. An energy system that will save building owners and tenants money, while offering quality service, will benefit the downtown. Obviously, the city benefits through increased economic activity, while businesses can benefit from a more cost effective energy system that is less sensitive to price fluctuations.

The NYSERDA program offered Buffalo the opportunity to undertake an assessment to determine existing opportunities and how these opportunities could be approached. As a result of this program the City of Buffalo can move to undertake appropriate actions that will support the downtown through district heating development and expansion.

DANISH INVESTIGATION

During the week beginning September 22, 1984, representatives from Buffalo, Rochester,and Jamestown, New York, Baltimore, Maryland, and Provo, Utah, attended a one week study tour of district heating systems in Denmark. The purpose of the tour was to review low-temperature district heating system development, observe operating systems, meet with development officials, and observe European system components. The tour was sponsored by the Danish District Heating Association and coordinated through NYSERDA. Mayor James Griffin, Commissioner John Friedline, Charles Rosenow and Susan Aldrich from Development Downtown, Inc. represented the City of Buffalo. During the tour, the group visited municipalities, private systems, the Danish Minister of Energy, equipment manufacturers and system customers.

The discussions centered on how and why district heating systems were developed in Denmark on and how the Danish method could be applied in the United States. The Danes are aggressively pursuing system expansion and consolidation using operating parameters that are unique. The Danes operate the majority of their systems at low temperatures, generally under 210°F. This allows direct customer use of energy and limits the use of heat exchangers at residences and small businesses. Since the Danish heating standard is a hydronic system, this has been readily accepted in the marketplace by customers and has facilitated retrofits of units.

In Buffalo, particularly in the neighborhoods near the downtown, hydronic systems are frequently found. Central air conditioning is not extensively used, nor is it apparently required. This presents a similarity to the conditions found in Denmark. The climates in Buffalo and Denmark also are similar. In the long term, as the systems in Buffalo grow, the opportunity to move into residential neighborhoods is present. The Danish experience and methodology support the ability to serve single family housing with district heating.

One of the points that was continually emphasized during the Danish tour was the need to start small and phase system growth to match plant capacity with energy demand in the marketplace. In the United States, electric power plants are built in anticipation of electric demand growth and are, therefore, oversized to meet a projected future demand. In Denmark, the trend has been to build small (by U.S. standards) plants that cogenerate and have more plants to capture both the thermal and electric markets. The cogeneration plant, however, is the culmination of the district heating/electric system, and is built when an existing district heating system justifies the investment. Prior to building such a power plant, heat-only stations, municipal solid waste incinerators, waste heat reclamation from industry and existing power plants are used. Only when these sources are unavailable or uneconomical are power plants built, and then the plants are sized to meet thermal demand.

Phasing is certainly appropriate in Buffalo. The approach of meeting load with existing heat sources, developing a distribution system, and expanding until the capacity of the heat source is approached is the Danish method. By developing in this manner, capital investment is matched to the revenue-producing load. The early-start systems proposed for Buffalo will follow this method.

The Danes have attempted to simplify district heating and limit their reliance on imported fuels. Since their indigenous fuel resources are limited to recent North Sea natural gas wells, they have moved to resource recovery (municipal solid waste) as a fuel source. Denmark is a small country with a fairly dense population. Landfills are limited, and environmental concerns about the quality of landfills are growing. Resource recovery reduces solid waste mass, extends the life of landfills, and produces energy from a fuel source that has heretofore been a cost item. Mass burn technology with curb side source separation is widely used. In fact, many systems regulate the flow of trash by rationing trash bags; trash bags over the alloted number must be purchased. This system works quite well in controlling volume, and establishing a recycling program for non-burnables (Denmark, like New York, has container deposit laws).

Buffalo is currently supplying trash to a resource recovery operation, but is not involved in the energy production. As the district heating system grows, modular incineration with heat recovery may become a viable option in Buffalo.

The Danes are committed to district heating. The commitment is enthusiastic. They believe that district heating is a simple concept that makes energy and economic sense. To support that belief, an industry has grown up in Denmark that supplies product and technical skills to the industry. The industry realizes that for district heating to work technically and economically, cost must be held down and high quality standards maintained. This was obvious in their presentations and factory visits.

The tour indicated that district heating works, does not need to be overly complex, does not require high temperatures and pressures, and should be designed for phasing. The enthusiatic attitude, along with real working systems helped to convince those on the tour of the practical applications of district heating, and how it can work in each of the cities that participated.

Section 2

THE MARKET AREA

SUMMARY

The City of Buffalo initially identified the Central Business District and immediate environs as the preferred development area for district heating. This area consists of over 325 acres with over 400 buildings. This area was selected based on the density of development. Buildings range in age from new structures to historic properties built in the mid 1800s and in use from single family houses to enclosed shopping malls. Retail and office uses are dominant.

From an energy use standpoint, the buildings are generally heated by natural gas-fired boiler systems. Many of these systems were originally designed to burn coal and have been converted, resulting in surplus boiler capacity due to the higher efficiency of natural gas. This has been supplemented by significant investment in energy conservation.

A computer model was used to estimate the energy consumption in the downtown. The model estimates energy consumption by building use. Energy consumption is based on building energy engineering design standards. Square footage estimates for each downtown block were made and input to the model. The result is a thermal density calculation for the downtown.

Based on the thermal densities, and other factors, e.g., building ownership, the Ellicott Historic District, and redevelopment efforts, the southwestern CBD was selected as the prime area for initial project development. An early-start project based on City Hall, City Courts and Fire Headquarters was selected as having the most potential and immediate benefit.

Other early-start projects include district heating projects based on new development, specifically, the proposed Buffalo Stadium. This project would be based on cogeneration technologies. Over time, the two early-start projects could grow together. In order to serve this customer base, a hot water system similar to those found in Scandanavia, and recently installed in nearby Jamestown, Chautauqua County, New York, is the preferred type of district heating system. This selection is made based on lower cost of piping systems and greater efficiencies of thermal transport. Hot water district heating systems are not currently regulated in New York State.

Energy Characteristics

In terms of energy systems, virturally all the buildings in the study area are heated. As one would suspect from the various ages of the buildings, different types of heating systems prevail. Much of the differences are predictable based on the age of the building and the prevailing engineering practice of the day.

In the older buildings built before the 1940s, most were originally fitted with coal boilers. Massive, constructed in-place, cast iron boilers are found in Buffalo's buildings. Often sizable, multiple boiler installations are found. As oil and natural gas became available, the coal burners were converted to use the liquid fuels at a tremendous benefit to the environment and labor saving to the building owner. Due to greater burner efficiency, many of the buildings that once required three coal boilers on cold winter days, now can be heated quite effectively with one or two boilers.

Along with the changes in fuels, many building owners have undertaken energy conservation projects that have reduced energy consumption. Newer window systems, air mixing equipment, boiler controls and set-back programs have dramatically improved energy efficiencies of buildings.

One good example of the effects of fuel switching and conservation is found at the New York Telephone Company Building on Erie Street. This sixteen-story building was originally built in 1913, expanded in 1930 and modified again in 1950. It required three coal boilers to carry the initial load. These boilers were refitted for natural gas, and two boilers were able to provide sufficient energy for heating. Over the past several years, New York Telephone has undertaken a building conservation program that allows the building to operate, except for the coldest days, on one boiler. In the near future, window system improvements are planned that should reduce energy requirements by 15% and allow the building to operate exclusively on one boiler. Similar examples occur throughout the downtown.

As buildings are modernized/rehabilitated, energy systems are improved and, in some cases, completely changed to modern, more efficient systems. This generally means that older, low-pressure, in-building steam systems are being gradually converted to low-temperature hot water systems. Because hot water systems are more efficient than steam, building owners are seeing a savings from fuel costs and reduced system maintenance. In St. Paul, Minnesota, which converted from a steam district heating system to a modern, low-temperature hot water system, some buildings on the new system are using approximately 70% of the energy they previously used.

LOAD ANALYSIS

To evaluate the potential for district heating in Buffalo, it was necessary to understand how much energy is consumed for space heating and domestic water heating. These two forms of building energy use are the most adaptable to district heating.

Initial Assessment-Area Identification

In identifying and characterizing prospective district heating and cooling projects within the downtown and adjacent areas, Resource Development Associates, Inc. configured potential service areas based on considerations of thermal load estimates, potential thermal suppliers, future development plans, and physical barriers or constraints to a potential system. The load estimates for potential service areas were based on professional judgment regarding land use and density in various areas of the downtown. Physical barriers or constraints to potential district heating service areas such as major rivers and other topographical considerations do not appear to be a problem in Buffalo.

Data Analysis and Synthesis Methodology

Once the initial service area (Figure 2-1), or "heat island," was identified, the next task was to delineate the smallest reasonable units of observation or evaluation. The basic concerns in delineating these thermal zones were homogeneity of land use, building type, and availability of relevant data. The city block was selected as the basic unit of observation for the downtown assessment (Figure 2-2). Originally configured to define similar land uses and socioeconomic characteristics, the small size of the thermal zone aids in identifying problems and potential solutions. Also, these small thermal zones allow ready identification by residents and those working in the downtown. Detailed maps of the downtown and aerial photographs, which allowed identification of individual buildings, were used to evaluate the individual thermal zones.

The methodology used in assembling this data was intentionally configured to input RDA's proprietary, computerized energy load models.

Figure 2-1. District Heating Study Area

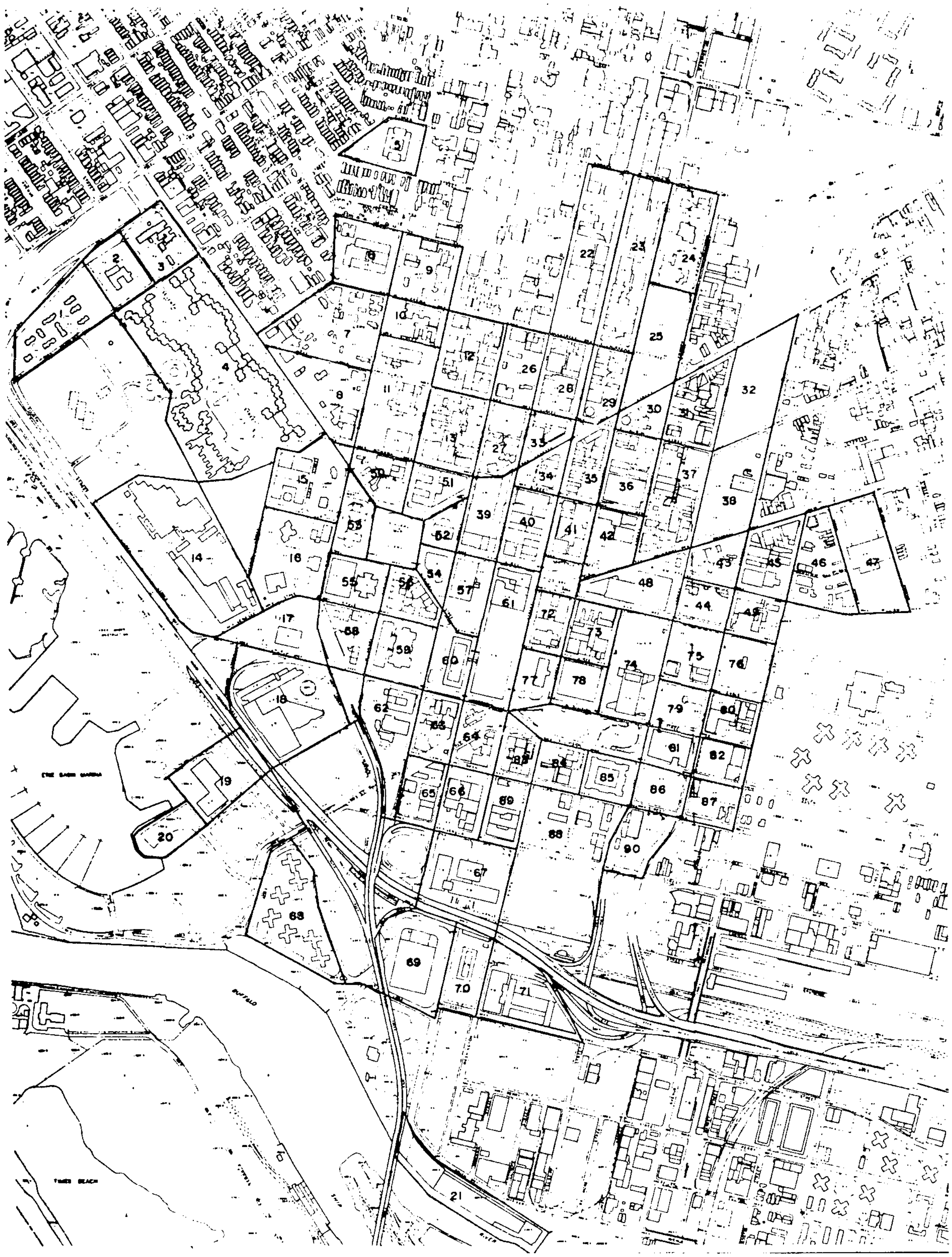


Figure 2-2. Thermal Zones

Data Base

With this information in hand, the team calculated building square footages from the aerial photographs for each thermal zone. Once building square footages were determined for all buildings, including residential, individual buildings were identified by building type, and counted and averaged for each thermal study zone (Table 2-1). The assessment team also determined acreage figures for each of the thermal zones, so that thermal loads calculated from building number and square footage data could be compared in terms of thermal or Btu demand density.

The Central Business District

The Central Business District (CBD) received detailed attention in terms of basic data collection. Because the CBD has such high density, and building heights vary so radically, it was determined that taking square footage figures directly off aerial photographs was less than desirable. As a result, the study team secured actual square footage figures from other sources and surveys when possible. These square footages were available for most major buildings in the downtown.

Thermal Load Analysis

In previous work with district heating and cooling systems evaluation and planning, RDA has identified a need to organize and estimate heating, cooling, and process thermal energy requirements on a community basis. For that purpose a model was developed that utilizes sample input data to estimate energy requirements on a community scale. The model is organized in two sections. The first section estimates thermal loads for the individual zones; the second section sums the individual zones for purposes of simulating system arrangements.

Table 2-1

BUFFALO LOAD DATA

ZONE	PRINCIPAL BUILDING	ACREAGE	BLDGS	SINGLE FAMILY SFR	SINGLE FAMILY SFR SF	LOW RISE MULTIFAMILY LRR	LOW RISE MULTIFAMILY LRR SF	HIGH RISE MULTIFAMILY HRR	HIGH RISE MULTIFAMILY HRR SF	SMALL OFFICE SMO	SMALL OFFICE SMO SF	LARGE OFFICE LGO	LARGE OFFICE LGO SF	SCHOOL SCH	SCHOOL SCH SF	RETAIL STORE STO	RETAIL STORE STO SF	WAREHOUSE WRH	WAREHOUSE WRH SF	INDUSTRIAL IND	INDUSTRIAL IND SF	PROCESS PRO	PROCESS PROCESS	COMMENTS:
1	SUBSIDIZED HOUSING	5.4	9			9	4500																	HOUSING
2	NURSING HOME	2.8	1			1	37000																	
3	COLUMBUS HOSP.	2.9	1			1	60600																	SMALL FACILITY
4	SHORELINE APTS.	29.4	4			900	900																	UDC HOUSING, ELEC BASEBRD
5	SCHOOL	2.4	1											1	64000									
6	HUTCH TECH	3.7	2											1	180000									
7	HOUSING/COMMERCIAL	6.6	17	7	1500	2	27600			8	7000													
8	OFFICE	4.8	6							5	7500	1	90000											
9	250 DELAWARE CT.	3.20	6									6	30025											
10	ELDERLY	2	2					2	168300															TWO HIGH RISES
11	FED/FRB	6	3																					FEDERAL OFFICE & FED RES BANK
12	ROOT BLDG.	4.1	13							5	9490	8	43950											OLDER 1ST FLOOR STORES
13	135 DELAWARE/CROSBY	4.1	15							3	10815	10	29900			2	2800							
14	WATERFRONT SCHOOL	17.9	1																					ELEMENTARY
15	CITY GARAGE	4.9	1													2	3425							CITY GARAGE/FIRE
16	CHURCH	5.7	5							5	12430													
17	TV STATION	2.4	1									1	40800											HEAT FROM PEOPLE&MACHINARY
18	HILTON	8.3	1																					MOTEL/OFFICES/RACQUETBALL
19	PIONEER PYRAMID	7.5	2									2	67985											TWIN OFFICE BLDG. 3RD PLANNED
20	MARKETPLACE	2.3	1							1	5000													PROPOSED
21	NFTA GARAGE	5.5	1															1	210000					SUBWAY GARAGE
22	SHEA'S BUFFALO	7.3	13									7	40200			5	22950	1	120000					THEATER DISTRICT
23	MCDONALDS	5.5	23													1	2450	22	19100					
24	POST OFFICE	4.3	8							6	8800	1	20000					1	36000					
25	PARKING	3.9	0																					
26	COMMERCIAL	2.9	4									4	31700											
27	COMMERCIAL	2.7	6									6	21550											
28	NEW BANK	3.1	1									1	242000											
29	GOLD DOME	2.5	2									2	252200											
30	NIAGARA MOHAWK	.7	1									1	142175											
31	COMMERCIAL	3.7	20															20	9675					
32	NEW DEV	6.1	0																					HIGH TECH BLDGS
33	HYATT	1.7	1																					REHAB+NEW
34	COMMERCIAL	1.1	6													6	20850							
35	STOREFRONT REHAB	1.8	15													15	17500							NEW FRONTS PLANNED
36	COMMERCIAL	3	9													9	16100							
37	COMMERCIAL/WH	5.1	11													6	25625	5	40550					
38	HIGH TECH	5.1	1									1	40500											
39	CONVENTION CENTER	3	1																					
40	BANK NY/KEY BANK	2.8	9									9	68100											
41	TISHMAN/RAND	2.1	10									10	74420											
42	COMMERCIAL/PARKING	2.2	4									4	29975											
43	OFFICE/RESIDENTIAL	1.6	4	2	1100					2	10500													
44	PARKING/OFFICE	1.7	4													4	375							
45	INDUSTRIAL	3.5	12																	12	13000			
46	RESIDENTIAL/IND	4.1	11	4	1500															7	11200			
47	CITY GARAGE	4.5	1																					
48	ERIE CO. LIBRARY	3	2							1	3300	1												COUNTY
49	OFFICE	1.8	3							3	23300													
50	120 DELAWARE	1.9	4									1	115200			3	3500							

Table 2-1 cont.

BUFFALO LOAD DATA

ZONE	PRINCIPAL BUILDING	ACREAGE	BLDGS	SINGLE FAMILY SFR	SINGLE FAMILY SFR SF	LOW RISE MULTIFAMILY LRR	LOW RISE MULTIFAMILY LRR SF	HIGH RISE MULTIFAMILY HRR	HIGH RISE MULTIFAMILY HRR SF	SMALL OFFICE SMO	SMALL OFFICE SMO SF	LARGE OFFICE LGO	LARGE OFFICE LGO SF	SCHOOL SCH	SCHOOL SCH SF	RETAIL STORE STO	RETAIL STORE STO SF	WAREHOUSE WRH	WAREHOUSE WRH SF	INDUSTRIAL IND	INDUSTRIAL IND SF	PROCESS PRO	PROCESS PROCESS	COMMENTS:
51	STATLER BLDG.	1.9	1									1	750000											REHAB/OFFICE CONVERSION
52	STATE COURTS	.5	1																					
53	CITY HALL	1.6	1																					
54	FEDERAL COURTS/P.O.	1.6	1																					
55	CITY COURTS/PARKING	2.5	1																					
56	BUFFALO ATH. CLUB	1.9	10							9	13350	1	150000											
57	PARKING	2.7																						
58	COUNTY JAIL/42 DELA	2.2	4																					
59	OLD COUNTY BLDG.	3.3	2																					
60	RATH BLDG.(COUNTY)	2	1																					
61	LIBERTY BNK./MAIN PL	5.6	3									2	398000			1								
62	POLICE/CHURCH	2.9	5							1	12000	3	34800					1	60000					
63	NY TEL/GUARANTY	2.7	2									2	122000											
64	BLUE CROSS/NFTA	2.6	7																					
65	OFFICE	2.3	6									6	56350											
66	268 MAIN/MERCH. MUT.	2.4	4									4	75600											
67	MARINE MIDLAND	6.4	1									1	1165000											
68	MARINE DR. APTS.	5.2	7					7																
69	MEMORIAL AUDITORIUM	5.5	1																					
70	DONAVAN BUILDING	2.3	1																					
71	BUFFALO NEWS	4	1																					
72	BRISBANE BUILDING	2.1	2									2	216500											
73	OFFICE	2.6	4									4	99950											NIAG/MOHAWK SUBSTATION
74	NFTA BUS STATION	4.8	1																					
75	OFFICE/VACANT	2.6	1																					
76	NI-MO SUBSTATION	2.5	0																					
77	M & T PLAZA	2.6	1									1	316326											
78	PARKING GARAGE	1.7	0																					
79	PARKING	1.9	0																					
80	OFFICE	2.1	8							7	7500	1	100200											
81	OFFICE	1.3	1									1	168000											
82	OFFICE	2	1									1	103500											
83	ELLICOTT SQUARE	2.1	1									1	408000											
84	OFFICE	2.1	3							1	7500	2	42900											
85	ERIE CO COMM COLLEGE	2	1																					
86	PARKING	2																						
87	OFFICE	2.2	2									2	22170											
88	STADIUM SITE																							20000 SEAT OPEN-DOMABLE
89	MAIN-SENECA BLDG	2.1	3							1	6400	2	217825											
90	OFFICE	2.3	2							1	3750	1	124000											
		327.7	370	13	4100	913	130600	9	160300	59	140635	114	5953401	2	244000	54	115575	51	495325	19	24200	0	0	

Thermal Load Model

The model is comprised of three segments designed to permit the user to understand the energy use density of an area, to predict areas of acceptable density for district heating development and to project load growth or system acceptance in the area.

The model requires the user to input annual energy consumption estimates by square footage for up to twelve building categories. In Buffalo, single family residential, multifamily low rise, multifamily high rise, small office, large office, schools, retail stores, warehouses, and industrial buildings were the categories used. Actual energy use can also be included when known. The next input is the total acreage of each zone; in Buffalo, city blocks were generally used. The total number and average gross building square footage for each type building is then entered for an initial year. A final year (twenty years in the future) building count and gross square footage can be entered to project building activity in the future. This can be used to simulate growth or demolition in an area. The final input is a market penetration factor of 0% to 100% for a twenty-year period and can be entered to simulate system acceptance. The model then calculates total space and water heating requirements and an energy density in Btu's per acre for each thermal zone.

The remaining elements of the model are an option that allows the user to set minimum energy densities for district heating acceptance in the form of a set number of annual Btu consumptions per acre, and a summary table that identifies each thermal zone and the year the established minimum is satisfied.

The district heating industry survey used in this project sought detailed energy, system, and usage data, as well as physical building descriptions and availability of waste heat. Many of the major industries, institutions, and other entities supplied necessary data; however, not all were willing to do so at this time. In Buffalo's case, this assessment was conducted using a 100% penetration factor.

The factors used to estimate annual thermal energy consumption for each building in a thermal zone were determined through local experience, typical metered consumption data, or through estimates available from other sources. In Buffalo, the assessment team used base line energy building consumption estimates developed by the U. S. Department of Energy in their program to determine "building energy performance standards" (BEPS). While it is unlikely that BEPS estimates are appropriate for determining any single building's energy consumption probability, it was felt that they were reasonable in light of considering that the objective of the load assessment is to identify zone-wide energy consumption patterns.

A review of typical buildings' energy consumption patterns in the Buffalo area reveals a wide range of consumption statistics both higher and lower than the averages used. The consumption numbers used are conservative, in light of actual building consumption statistics reviewed. The use of conservative figures is appropriate because, during district heating system connection, building owners would likely revamp control systems and modernize heating and cooling systems to lower overall energy consumption during building retrofit. Likewise, escalating fuel prices should continue to result in lower unit energy consumption for most classifications of buildings. Table 2-2 presents the building types and estimated Btu per square foot thermal energy requirement for the building categories used in this assessment. Numbers are given for space heating energy consumption and domestic hot water heating energy consumption. It should be kept in mind that these are site energy consumption estimates at 100% efficient use of district heating system energy. Any comparisons made to fuel-burning systems or heat pump systems must take into account combustion efficiency and the coefficient of performance.

Table 2-2

Estimated Thermal Energy Requirements
for Buffalo Building Categories

Building Type	Estimated Btu/sq. ft.
Single-Family Residential	85,000
Low-Rise Residential	45,500
High-Rise Residential	71,000
Small Office	49,250
Large Office	33,000
Schools	68,000
Retail	49,000
Warehouse	55,000
Industrial	55,000
Industrial Process	actual Btu usage

Results of the Thermal Load Assessment

The use of the Resource Development Associates', Inc. Thermal Load Assessment program resulted in individual thermal load estimates for the 90 thermal zones within the Assessment Area boundaries.

Once areawide heating estimates were available, the assessment team configured initial service areas based on thermal load densities. These service areas were configured for a heating-only service. Zones with low thermal requirements were excluded from further consideration, given the cost of implementing a district heating system. Figure 2-3 indicates the thermal densities of the zones in the assessment area.

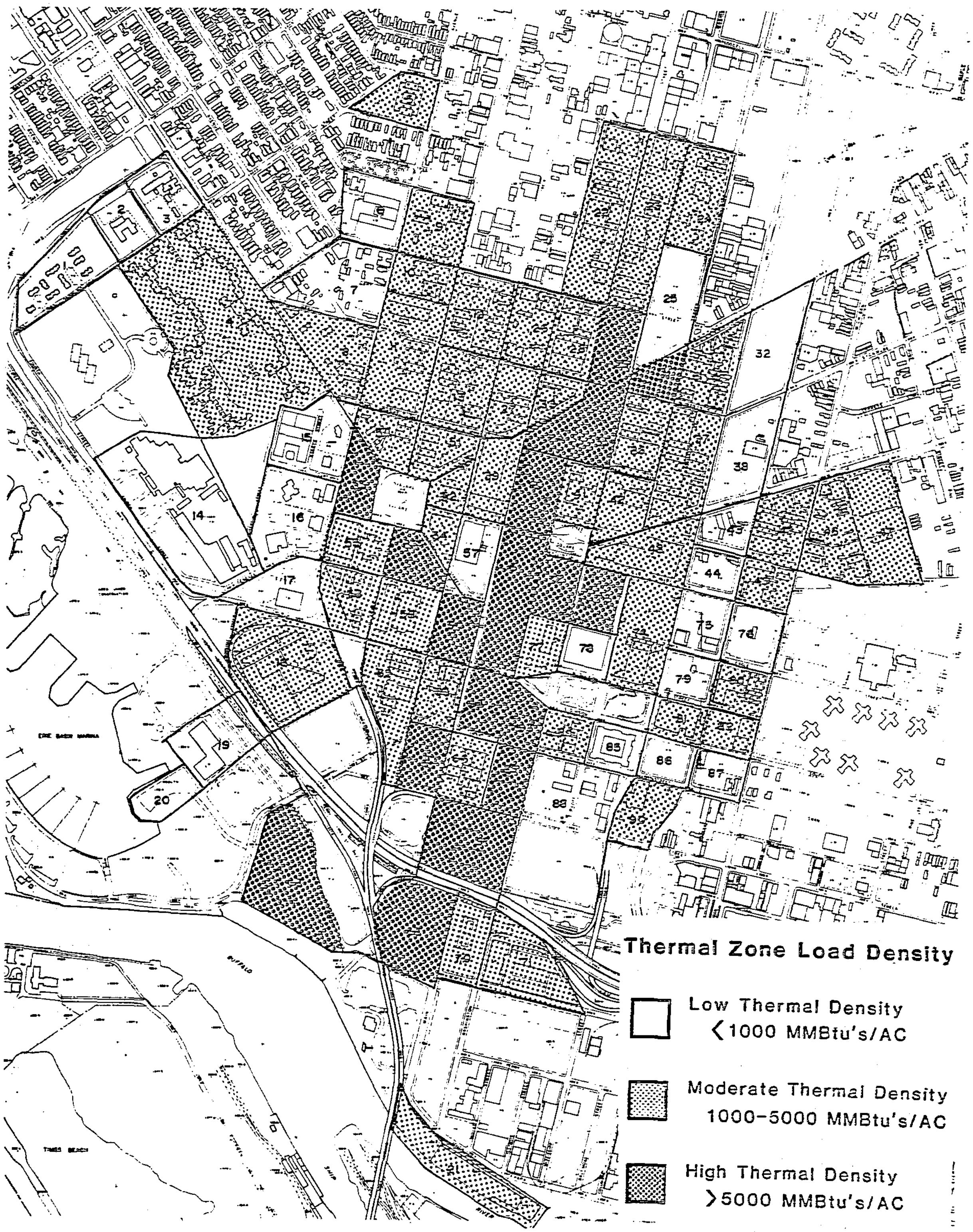


Figure 2-3. Thermal Zone Load Density

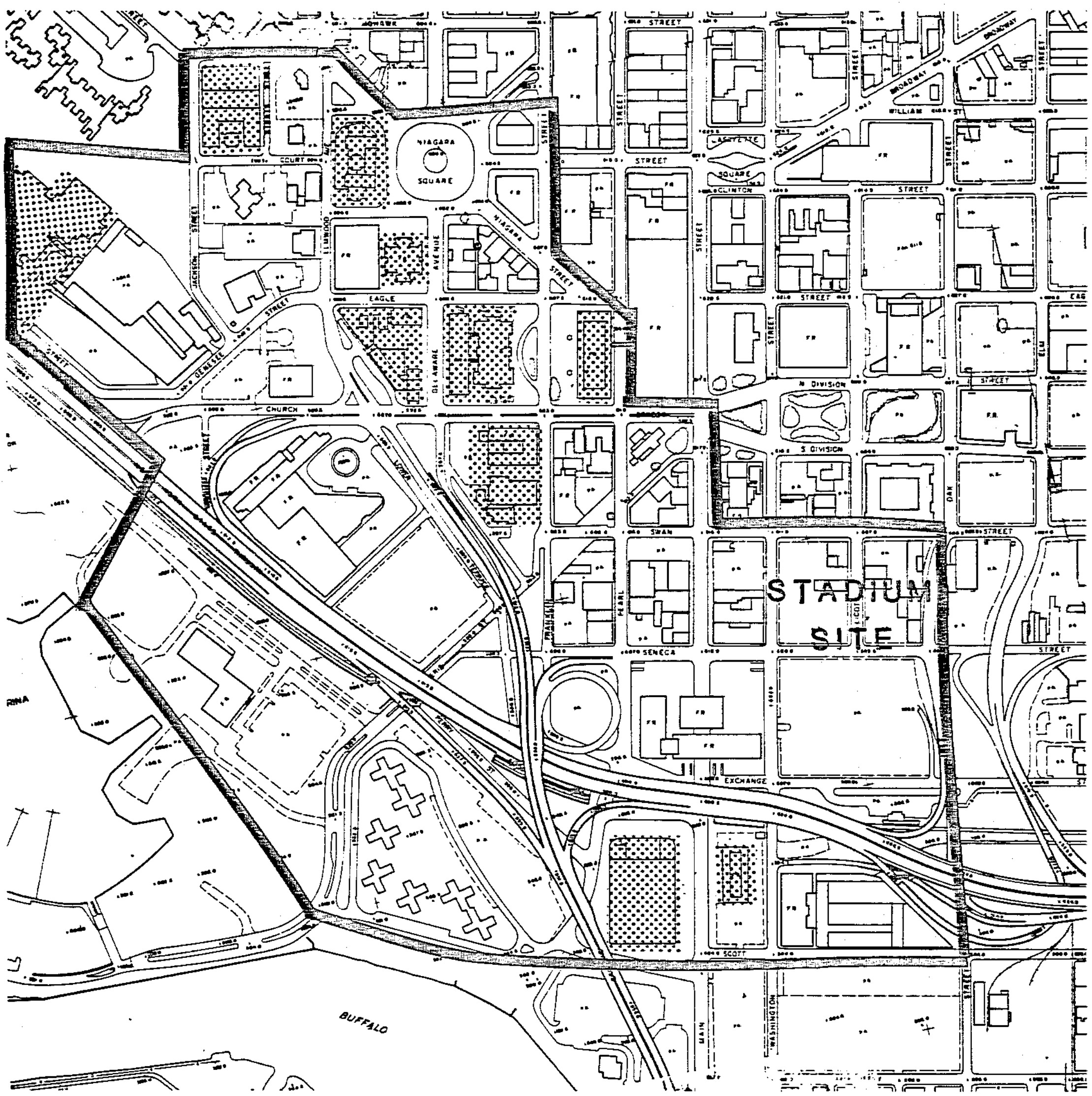
POTENTIAL PROJECT AREAS

In Buffalo's case, the areas of the city with the highest heat density are not necessarily the prime area for initial system development. This is due to considerations concerning age of buildings and their building systems, types of development, and the potential that exists for redevelopment.

For example, Thermal Zone #61 - Main Place Mall exhibits the greatest heat density per acre. The Mall has office towers at either end of the building. It was learned through discussions with the building manager that there are three heating systems in the buildings, one for the mall which has a high cooling load, and one each for the office towers. Currently, the boiler plant in the Main Place Tower provides energy for the Liberty Bank Building at the north end. Essentially, this is already a district heating scheme that would be difficult to compete with initially.

On the other hand, one of the motivating factors of this effort was the concentration of publicly owned buildings in the southwestern CBD. Starting from City Hall and extending to the proposed stadium site are five city owned buildings, three county complexes, two state facilities and a federal building. Additionally, this area contains the Joseph Ellicott Preservation district which is experiencing investment and rehabilitation.

The public sector can benefit from lower costs, and does not require immediate paybacks on investment. As the private sector invests in building renovation, heating systems will be modernized and conservation investments will be made. Qualified buildings over forty years old can benefit from tax credits designed to encourage investment in historic and older properties. Figure 2-4 identifies the boundary of the priority area. The shaded areas are publicly owned buildings.



Publicly Owned Buildings

Figure 2-4. Initial Service Area

Section 3

BUFFALO ENERGY PRICE PROJECTIONS

SUMMARY

Fuel prices are destined to increase in the future. The rate of the increase of energy is one determining factor in assessing the potential of district heating development. Current energy costs for Buffalo are shown in Table 3-1.

Table 3-1

	Nominal Cost	Cost/MMBtu
Natural Gas (commercial)	$ .59/therm	$ 5.93
Natural Gas (industrial)	$ .56/therm	$ 5.61
Electricity	$ .08/kwh	$23.91
Oil #2	$ 1.00/gallon	$ 7.36
Coal	$50.00/ton	$ 2.35

After calculating the conversion efficiency of end use equipment, the costs in Table 3-2 prevail.

Table 3-2

	Average Efficiency	Cost/MMBtu
Natural Gas (commercial)	70%	$ 8.47
Natural Gas (industrial)	70%	$ 8.01
Electricity	100%	$23.91
Oil #2	65%	$11.32
Coal	75%	$ 3.13

Predictions were made estimating the long-term costs of energy. These predictions are based on the review of a number of different forecasts, including local utilities. The projected costs of energy in the year 2000, including the efficiency of the end use conversion, is shown in Table 3-3.

Table 3-3

	Cost/MMBtu
Natural Gas	\$26.84
Electricity	\$84.25
Oil #2	\$40.41
Coal	\$ 9.93

There is an obvious advantage of using coal as a fuel source. As the early-start systems grow, coal will rapidly become the fuel of preference. Gas offers the second best opportunity. Gas also becomes less expensive as usage increases due to tariff structures. In the case of the City Hall system, the prices to the city for gas will decrease by approximately \$1.00/MMBtu before adjustment for efficiency because of the shift to boiler rate natural gas.

ENERGY PRICE PROJECTIONS

Energy price or fuel cost projections are vitally important in assessing the potential of district heating systems. Since district heating substitutes capital and efficiency for direct use of fuel, it is necessary to evaluate trends and predict future prices for the various fuels found in the market place.

Estimating future prices of any commodity involves making assumptions concerning supply, demand, general economic conditions, technological change, global stability, and a variety of other variables that have effect on price. Energy prices are particularly vicissitudinous. World events, regional and global economic conditions, federal and state regulations, labor strikes, weather patterns and personal consumption habits all affect the near-term market price of energy. Substitutability of fuels, economic and technical change, changes in supply sources, governmental policies both domestic and foreign, and economic expectations affect the mid-term prices for energy. In the long-term new technologies, depleted natural resources and political change also affect energy prices.

Facing these uncertainties, the forecaster poses a plausible set of assumptions, researches other forecasts, establishes reasonableness criteria and selects or creates forecasts that satisfy the conditions present and known and that survive the test of reasonableness.

Virtually all forecasts are based on projecting the future from historic trends. That is, when conditions X, Y, and Z have occurred, prices have responded in manner A at rate B. Based on these historic trends and tendancies, forecasters predict the variations in the conditions and predict the response. At the general level, and in the aggregate, trends are very predictable. In any specific instance, the forecast will be less certain.

OIL

Since the OPEC oil embargo, oil prices have been particularly sensitive to supply actions of the OPEC members. Recently, oil field development in Mexico and the North Sea, the Iran-Iraq war, and lack of unity on supply limits within OPEC have caused an excess supply of oil in the world market and have held down price. In the near-term, these conditions will continue. Even if OPEC is successful in controlling member production, the United Kingdom and Norway will continue to operate outside OPEC control. Prices will reflect supply and demand conditions at a world price.

Since the embargo and shortages of the 1970s, the U.S. has been able to shift supply sources and to insulate supply from Middle Eastern disruptions. Mexico is now the highest ranking supplier to the U.S., with the United Kingdom ranking second, and Canada third. Indonesia is the highest ranking OPEC supplier, with Saudi Arabia second. This shift has improved stability, and considering the weakness of the currencies in Mexico and the U.K., these two countries will likely continue to dominate U.S. imports in the mid-term.

COAL

The coal supply in the U.S. appears stable over the long-term. Eastern bituminous supplies are stable. Western coal is becoming more and more available. World coal exports, particularly from Australia and Poland, are up, increasing competition and serving to hold down price. As long as this supply situation continues to exist, there is no reason to anticipate dramatic changes. Coal will be in sufficient supply and prices will continue to fluctuate generally with inflation and by season.

NATURAL GAS

The natural gas situation is different and inherently more uncertain. Deregulation of "new" gas took effect on January 1, 1985. In the short-term this will have limited impact in that most natural gas distribution companies have contracted gas at set prices. As the contracts expire or are renegotiated, prices to the consumer will likely change. Distribution companies are regulated by the individual states for service and price, although supply price increases can generally be passed through to the consumer without regulatory procedures. Gas pipelines and distribution companies are under pressure in a number of states to use the least costly available resources. This pressure tends to hold down price increases.

Canadian supplies of natural gas are in surplus, and are being made available to the U.S. at very competitive prices. This is somewhat the opposite of the situation found a few years ago when Canadian supplies were more expensive. Currently, Canadian gas is being offered in minimum quantities at Toronto equivalent prices. Of course, this gas would be subject to transportation charges from the U.S./Canadian border.

Western New York has reserves of natural gas that are available from independent producers. This gas is available at competitive prices at the wellhead and subject to transportation charges.

Overall, availability of natural gas is not seen as problematic. The American Gas Association projects gas supplies to be sufficient through the year 2000 and will continue to supply at least 25% of the U.S. energy needs. AGA also projects that liquified natural gas will become increasingly more important during the 1990s, taking advantage of more of the world's reserves.

Natural gas prices, in the near-term, will likely show limited price change. The mid-term is subject to a "sort-out" due to the effects of deregulation, self-help gas, alternative sources and the ability of local distribution companies to negotiate supplies and price. In the long run, gas prices will increase due to depletion of reserves, higher cost of locating and tapping new reserves, transportation costs and the fact that natural gas is a premium fuel and environmentally safe.

Since natural gas is the primary fuel for space heating in commercial buildings, the delivered price of gas and the efficiency at which the gas is used establish the bench mark for assessing the potential for district heating systems. That is, the total cost of district heating, including retrofits and financing, must compete with the user's cost of natural gas at existing installations.

The following price projections are based on a number of independent forecasts, including the U.S. Department of Energy's Energy Information Agency, Data Resources, Inc.'s Forecast, New York State Energy Master Plan, and material supplied by the American Gas Association and National Fuel Gas Distribution Corporation.

Table 3-4 projects the price of energy without calculating the efficiency of the customers' conversion equipment. In this table, a base inflation rate of 5% per year is assumed, and this assumption is carried through all the following tables. Table 3-4 projects energy prices based on the price of natural gas to commercial customers such as any individual downtown building. All prices are indicated in dollars per million Btu's delivered to the customer. Prices indicated are in nominal or inflated dollars. This table indicates the cost advantage of coal and the relative advantage of natural gas as a fuel source compared to oil and electricity. When one assumes the handling and environmental costs of coal at small- to medium-sized boilers, the benefits of gas heating are apparent.

Table 3-5 also indicates the nominal projected price of energy. The difference from Table 3-4 is that the natural gas rate used is that offered to large-volume users under the Boiler Fuel Rate (Tariff SC-11). This rate is $1.00 per million Btu's lower, which results in a significant savings over the commercial rate.

Tables 3-6 and 3-7 reflect the effect of the conversion efficiency of the customers' equipment. Table 3-6 is based on the commercial gas rate. Table 3-7 is based on the Boiler Fuel Rate. Again, the relative price positions of coal and natural gas as preferred fuels are apparent.

Table 3-4

FUEL EQUIVALENT COMPARISON -BUFFALO COMMERCIAL GAS - EFF FACTOR

ELECTRIC=	0.08 KWH	USE EFF.=	1.00	CURRENT $/10*6 BTU	23.44
N. GAS =	0.59 THERM	USE EFF.=	1.00	CURRENT $/10*6 BTU	5.93
#2 OIL =	1.00 GALLON	USE EFF.=	1.00	CURRENT $/10*6 BTU	7.14
UTIL COAL	50.00 TON	USE EFF.=	1.00	CURRENT $/10*6 BTU	2.17

	ESCALATION RATES				$/MMBTU			
YEAR	ELECT.	N GAS	OIL	COAL	ELECTRIC	N GAS	OIL	COAL
1985	.02	0	.03	.08	23.91	5.93	7.36	2.35
1986	.019	.06	.03	.08	24.36	6.29	7.58	2.54
1987	.08	.06	.08	.08	26.31	6.66	8.18	2.74
1988	.12	.06	.08	.08	29.47	7.06	8.84	2.96
1989	.125	.06	.095	.08	33.15	7.49	9.68	3.19
1990	.108	.06	.095	.08	36.73	7.94	10.60	3.45
1991	.101	.09	.095	.08	40.44	8.65	11.60	3.73
1992	.094	.09	.095	.08	44.25	9.43	12.71	4.02
1993	.095	.09	.095	.08	48.45	10.28	13.91	4.35
1994	.094	.09	.095	.08	53.00	11.20	15.24	4.69
1995	.094	.09	.095	.08	57.98	12.21	16.68	5.07
1996	.088	.09	.095	.08	63.09	13.31	18.27	5.47
1997	.074	.09	.095	.08	67.76	14.51	20.00	5.91
1998	.074	.09	.095	.08	72.77	15.81	21.90	6.39
1999	.077	.09	.095	.08	78.37	17.24	23.99	6.90
2000	.075	.09	.095	.08	84.25	18.79	26.26	7.45
2001	.109	.09	.095	.08	93.43	20.48	28.76	8.04
2002	.074	.08	.1	.07	100.35	22.12	31.64	8.61
2003	.074	.08	.1	.07	107.77	23.88	34.80	9.21
2004	.074	.08	.1	.07	115.75	25.80	38.28	9.85
2005	.077	.08	.1	.07	124.66	27.86	42.11	10.54
2006	.04	.08	.1	.07	129.65	30.09	46.32	11.28

Table 3-5

FUEL EQUIVALENT COMPARISON -BUFFALO BOILER GAS RATE - EFF FACTOR

ELECTRIC=	0.08 KWH	USE EFF.=	1.00	CURRENT $/10*6 BTU	23.44
N. GAS =	0.49 THERM	USE EFF.=	1.00	CURRENT $/10*6 BTU	4.93
#2 OIL =	1.00GALLON	USE EFF.=	1.00	CURRENT $/10*6 BTU	7.14
UTIL COAL	50.00TON	USE EFF.=	1.00	CURRENT $/10*6 BTU	2.17

	ESCALATION RATES				$/MMBTU			
YEAR	ELECT.	N GAS	OIL	COAL	ELECTRIC	N GAS	OIL	COAL
1985	.02	0	.03	.08	23.91	4.93	7.36	2.35
1986	.019	.06	.03	.08	24.36	5.23	7.58	2.54
1987	.08	.06	.08	.08	26.31	5.54	8.18	2.74
1988	.12	.06	.08	.08	29.47	5.87	8.84	2.96
1989	.125	.06	.095	.08	33.15	6.22	9.68	3.19
1990	.108	.06	.095	.08	36.73	6.60	10.60	3.45
1991	.101	.09	.095	.08	40.44	7.19	11.60	3.73
1992	.094	.09	.095	.08	44.25	7.84	12.71	4.02
1993	.095	.09	.095	.08	48.45	8.54	13.91	4.35
1994	.094	.09	.095	.08	53.00	9.31	15.24	4.69
1995	.094	.09	.095	.08	57.98	10.15	16.68	5.07
1996	.088	.09	.095	.08	63.09	11.06	18.27	5.47
1997	.074	.09	.095	.08	67.76	12.06	20.00	5.91
1998	.074	.09	.095	.08	72.77	13.15	21.90	6.39
1999	.077	.09	.095	.08	78.37	14.33	23.99	6.90
2000	.075	.09	.095	.08	84.25	15.62	26.26	7.45
2001	.109	.09	.095	.08	93.43	17.02	28.76	8.04
2002	.074	.08	.1	.07	100.35	18.39	31.64	8.61
2003	.074	.08	.1	.07	107.77	19.86	34.80	9.21
2004	.074	.08	.1	.07	115.75	21.45	38.28	9.85
2005	.077	.08	.1	.07	124.66	23.16	42.11	10.54
2006	.04	.08	.1	.07	129.65	25.01	46.32	11.28

Table 3-6

FUEL EQUIVALENT COMPARISON -BUFFALO COMMERCIAL GAS   EFFICIENCY FACTOR

ELECTRIC=	0.08 KWH	USE EFF.=	1.00	CURRENT $/10*6 BTU	23.44
N. GAS =	0.59 THERM	USE EFF.=	0.70	CURRENT $/10*6 BTU	8.47
#2 OIL =	1.00 GALLON	USE EFF.=	0.65	CURRENT $/10*6 BTU	10.99
UTIL COAL	50.00 TON	USE EFF.=	0.75	CURRENT $/10*6 BTU	2.90

	ESCALATION RATES				$/MMBTU			
YEAR	ELECT.	N GAS	OIL	COAL	ELECTRIC	N GAS	OIL	COAL
1985	.02	0	.03	.08	23.91	8.47	11.32	3.13
1986	.019	.06	.03	.08	24.36	8.98	11.66	3.38
1987	.08	.06	.08	.08	26.31	9.52	12.59	3.65
1988	.12	.06	.08	.08	29.47	10.09	13.60	3.94
1989	.125	.06	.095	.08	33.15	10.69	14.89	4.26
1990	.108	.06	.095	.08	36.73	11.34	16.30	4.60
1991	.101	.09	.095	.08	40.44	12.36	17.85	4.97
1992	.094	.09	.095	.08	44.25	13.47	19.55	5.37
1993	.095	.09	.095	.08	48.45	14.68	21.41	5.79
1994	.094	.09	.095	.08	53.00	16.00	23.44	6.26
1995	.094	.09	.095	.08	57.98	17.44	25.67	6.76
1996	.088	.09	.095	.08	63.09	19.01	28.11	7.30
1997	.074	.09	.095	.08	67.76	20.72	30.78	7.88
1998	.074	.09	.095	.08	72.77	22.59	33.70	8.51
1999	.077	.09	.095	.08	78.37	24.62	36.90	9.19
2000	.075	.09	.095	.08	84.25	26.84	40.41	9.93
2001	.109	.09	.095	.08	93.43	29.25	44.24	10.72
2002	.074	.08	.1	.07	100.35	31.59	48.67	11.48
2003	.074	.08	.1	.07	107.77	34.12	53.54	12.28
2004	.074	.08	.1	.07	115.75	36.85	58.89	13.14
2005	.077	.08	.1	.07	124.66	39.80	64.78	14.06
2006	.04	.08	.1	.07	129.65	42.98	71.26	15.04

Table 3-7

FUEL EQUIVALENT COMPARISON -BUFFALO BOILER GAS RATE   EFFICIENCY FACTOR

ELECTRIC=	0.08 KWH	USE EFF.=	1.00	CURRENT $/10*6 BTU	23.44
N. GAS =	0.49 THERM	USE EFF.=	0.70	CURRENT $/10*6 BTU	7.04
#2 OIL =	1.00 GALLON	USE EFF.=	0.65	CURRENT $/10*6 BTU	10.99
UTIL COAL	50.00 TON	USE EFF.=	0.75	CURRENT $/10*6 BTU	2.90

	ESCALATION RATES				$/MMBTU			
YEAR	ELECT.	N GAS	OIL	COAL	ELECTRIC	N GAS	OIL	COAL
1985	.02	0	.03	.08	23.91	7.04	11.32	3.13
1986	.019	.06	.03	.08	24.36	7.47	11.66	3.38
1987	.08	.06	.08	.08	26.31	7.91	12.59	3.65
1988	.12	.06	.08	.08	29.47	8.39	13.60	3.94
1989	.125	.06	.095	.08	33.15	8.89	14.89	4.26
1990	.108	.06	.095	.08	36.73	9.42	16.30	4.60
1991	.101	.09	.095	.08	40.44	10.27	17.85	4.97
1992	.094	.09	.095	.08	44.25	11.20	19.55	5.37
1993	.095	.09	.095	.08	48.45	12.21	21.41	5.79
1994	.094	.09	.095	.08	53.00	13.30	23.44	6.26
1995	.094	.09	.095	.08	57.98	14.50	25.67	6.76
1996	.088	.09	.095	.08	63.09	15.81	28.11	7.30
1997	.074	.09	.095	.08	67.76	17.23	30.78	7.88
1998	.074	.09	.095	.08	72.77	18.78	33.70	8.51
1999	.077	.09	.095	.08	78.37	20.47	36.90	9.19
2000	.075	.09	.095	.08	84.25	22.31	40.41	9.93
2001	.109	.09	.095	.08	93.43	24.32	44.24	10.72
2002	.074	.08	.1	.07	100.35	26.27	48.67	11.48
2003	.074	.08	.1	.07	107.77	28.37	53.54	12.28
2004	.074	.08	.1	.07	115.75	30.64	58.89	13.14
2005	.077	.08	.1	.07	124.66	33.09	64.78	14.06
2006	.04	.08	.1	.07	129.65	35.73	71.26	15.04

At the request of the Project Team, the National Fuel Gas Distribution Corporation's Research and Statistical Department provided current projections for natural gas prices through the end of the century. National Fuel indicates that their sources predict a surplus of gas supply at least through part of this period. As a result of this supply condition, National Fuel projects no real price increase in the cost of natural gas to the consumer. Only inflation adjustments to the price are projected.

The information in Table 3-8 was provided for use in this assessment. The gas is for industrial gas using the SC-7 Tariff.

Table 3-8

Natural Gas Cost
($per MMBtu)

Heating Season	Low-Range	Mid-Range	High-Range
1986-87	$5.45	$ 5.61	$ 5.72
1990-91	$6.65	$ 6.82	$ 6.98
1994-95	$8.08	$ 8.28	$ 8.49
1998-99	$9.82	$10.06	$10.31

This forecast assumes that supply is more than sufficient to cover demand, and that production costs of gas will not dramatically increase through the period. Other forecasts are not as optimistic on supply and production costs. However, if these projections are reasonably close to actual price movement, it would certainly bode well for the natural gas user, the natural gas-fired district heating system, and natural gas-based cogeneration. It is especially true concerning cogeneration if electric prices move as projected (due to nuclear power coming in to the generation mix).

Overall, under any of the projections, Buffalo will benefit in the near term from a move in tariff from the commercial rate to the larger volume Boiler Fuel rate, and in the long term to the least expensive fuel source: either coal or natural gas.

Section 4

INSTITUTIONAL ASSESSMENT

SUMMARY

A number of institutional and regulatory issues face the Buffalo district heating developer. These include regulations dealing with the use of various fuel sources, particularly natural gas, environmental regulations on burning of fuels, and the sale of energy.

In Buffalo's case, these will become increasingly important as the system grows in size. In the initial years of the early-start systems, the central plants used will not be subject to extensive regulation due to their size. As the system grows in size and fuel sources change, environmental regulation will be more of an issue to the developer.

Presently, New York State hot water district heating systems are not subject to regulation by the Public Service Commission. Steam systems are regulated. This could change, but currently is not an issue.

There are a number of viable ownership opportunities available in Buffalo. Five basic configurations are posssible:

- City of Buffalo-Public Works Department,
- Development Downtown Inc. Established Non-Profit,
- Development Downtown Inc. Established For-Profit,
- Third Party Component Ownership,
- Cooperative.

In terms of the City Hall early-start project, Option 1 would be the easiest to implement; however, Options 2 and 3 offer more long-term potential.

REGULATION

There are a variety of federal, state and local statutes, rules and regulations that impact upon this project. The significant requirements are summarized in the paragraphs below.

Procedure

The New York State Environmental Quality Review Act (SEQRA) is administered by the New York State Department of Environmental Conservation (NYSDEC). Its stated purpose is to incorporate the consideration of environmental factors into the existing planning review and decision-making of state, regional and local governmental agencies at the earliest possible time. Obtaining any required permits, environmental or otherwise, is made a convenient process by the State Uniform Procedure Act (UPA). All the various state permit procedures and requirements associated with a proposed project are coordinated and combined into a single action. Thus, the party preparing the project can make a single application to NYSDEC which includes any information needed by the various permitting agencies for their review.

Air Pollution Control Permits and Certificates

Part 201: Permits and Certificates. In accordance with the rules of the New New York State Department of Environmental Conservation, the owner of an air contaminant source (stationary combustion installation) must have a Certificate to Operate valid for a period up to three years. To continue operating, the owner must renew his certificate to Operate on or prior to the expiration date. If a source is new or a modification is planned, the owner must secure a Permit to Construct before construction can proceed. Once construction is completed, a Certificate to Operate must be obtained prior to commencement of operation.

Completed application forms 76-19-2 and 76-19-13 must be submitted with three sets of plans to the appropriate Field Representative (air pollution control program) for Erie County. It must be prepared under the direct supervision of and bear the seal of a professional engineer licensed in the State of New York. Once completed these forms are to be sent to:

New York State Department of Environmental Conservation
Region 9
Air Resources
Attention: Mr. Alfred Carlacci
600 Delaware Avenue
Buffalo, New York 14202.

Since the Case 1 scenario has a maximum operating heat input of 50 MMBTU/Hour, the project is well within the definition of "minor" (not>250 MMBTU/Hour) and, therefore, does not have to meet some of the stricter standards such as stack testing and installation of Fuel and Emission Monitoring Equipment. Although the early-start projects are "minor" and certain standards are not applicable, Buffalo will need to submit the application forms identified above.

Part 227: Particulate Emissions, Smoke Emissions, Nitrogen Oxides. A Permit to Construct may not be issued unless the source owner can show that the proposed new stationary combustion installation or modification will comply with the applicable emission standards in this Part. However, since Buffalo would use natural gas without oil back-up, the only pollutant that would apply is nitrogen oxide. Further, due to the limited size of the boilers (i.e. < 250 MMBtu/hr). Buffalo will not have to be concerned about compliance with this Part. In the event that coal, other solid fuel, or oil burning systems were included at some future time, this Part would become applicable.

Part 231: Major Facilities. This Part contains provisions for the prevention of significant deterioration (PSD), the use of best-available control technology (BACT), air quality impact evaluation reports, and requirements of lowest achievable emission rates (LAER). Once again, since the project does not conform to a stationary combustion installation greater that 250 MMTtu/hr, it is considered a minor installation and this Part is inapplicable to the early-start systems.

Part 225: Fuel Sulfur Limitations. No Certificate to Operate will be issued until the owner shows he has a firm commitment from a fuel supplier that sufficient quantities of fuel conforming with fuel sulfur limitations in this Part will be available for the installation. Since natural gas will be the only fuel, Buffalo will automatically be in compliance with this Part. If oil-fired equipment were installed, it would have to comply with the sulfur limitation guidelines.

Certificate of Inspection. Prior to the commencement of operation, the owner must also apply for, obtain and display a Certificate of Inspection from the Industrial Commissioner of the State of New York.

Dual Fuel Requirements. Natural gas fired boilers, within the territory of National Fuel Gas, that require annual purchases of natural gas greater than 100,000 MMCF, must have backup fuel capability or else obtain an exemption from the Public Service Commission. Since this project is well within the limits, the dual fuel requirement is inapplicable.

Powerplant and Industrial Fuel Use Act. Any new major fuel-burning installations with a design capability at a fuel heat input rate of 100 MMBtu/Hour or more must obtain an exemption from the Secretary of the U.S. Department of Energy in order to burn oil or natural gas. Buffalo will not exceed 100 MMBtu/hr and, therefore, the facility may burn natural gas without having to secure an exemption.

OWNERSHIP OPTIONS

The issue of system ownership is one of the more important considerations that must be addressed. The structure of the ownership will dictate how the system will operate and more importantly, how it will grow in the long term. Growth is a prime objective, for growth allows the system developer to economically move from heat only boilers fired by natural gas to solid fuel fired systems, or cogeneration based systems.

The owner must be committed to initiating actions that will cause the system to grow. Since district heating is capital intensive, the owner must be able to assemble the necessary capital with an appropriate ratio of equity to debt. The owner often must be patient. District heating is usually not a financial bonanza; rather, it is a long-term investment in future productivity and secondary economic benefit.

Over time the ownership may need to change. In Buffalo, the most likely ownership scenario for the City Hall early-start system is the city or a developer that is a city sponsored company. As the system grows and the decision approaches to build a new central plant to serve the system, a private sector company might be a more appropriate owner. The City of Buffalo would have derived the benefit from starting a system, proving its effectiveness, and establishing its value to the community, but the financial requirements of operating an energy utility may require a stronger commitment than the city would be willing to make. A private sector operator, on the other hand, would find the early system development risks mitigated, and the opportunity for investment and cash flow attractive. This is obviously a hypothetical option, and one that may not transpire, but the city should recognize that the initial owner may not necessarily be the ultimate owner. For example, Buffalo could take the initial development risk and sell the project to the private sector once it has been proven to be financially successful.

There are five basic ownership options available for the City Hall early-start system. Each has advantages and disadvantages associated with it. The options are: City of Buffalo-Public Works Department; Development Downtown, Inc. Established Non-Profit; Development Downtown, Inc. Established For-Profit; Third Party Component Ownership; and a Cooperative.

I. City of Buffalo-Public Works Department

In this first option, the Public Works Department would develop, finance and own the system just as it would any Buffalo municipal building heat system. The development and expansion of the system would be a normal budget item that would be submitted by the Commissioner and Mayor and approved by the City Council.

Advantages

- Currently operates building systems
- Can budget from future energy savings
- No threat of regulation as long as only city buildings are involved
- Would not require contractual arrangements for operating, system ownership, or maintenance (as long as only city buildings would be involved)
- Lowest financing rate possible

Disadvantages

- No reason to encourage system expansion beyond city-owned buildings
- Limited, if any, economic benefit beyond internal cost savings
- Annual appropriation required
- Could potentially be made a political issue

The principal advantage of this option is the ease of implementation: no new entities are required, and as long as the system can save the city money it makes sense. The principal disadvantage is that there is no built-in impetus to pursue expansion beyond the public customers.

II. Development Downtown, Inc. Established Non-Profit

In this ownership option, DDI would establish a non-profit company, e.g., Buffalo District Heating Corporation (BDHC). The company would be chartered to develop, own, operate, contract, expand and explore district heating opportunities in Buffalo. The BDHC should initially focus its efforts in the downtown, but should not be limited to that geographic area. This company could be funded by the city, and some of the initial system costs of the City Hall system could be financed through cost savings realized by the City of Buffalo. This company would be established to break even with overcharges rebated and under charges assessed annually. It should be staffed more as a marketing company as opposed to an engineering/operating company. Operations should be contracted to the Public Works Department. This company would be similar in scope to the Saint Paul District Heating Development Company. In the early start system, it is likely that the City of Buffalo would own the boilers, and BDHC would own the distribution system.

Advantages

- Could encourage system expansion
- Could easily enter into contracts with the City and private sector for operation and energy sales
- Could be initially funded from operating programs and budgets
- CDBG eligibility insured for economic development projects consistent with other activities from a development standpoint
- Could subsidize early years' operations from city-savings
- Could benefit from tax exempt financing

Disadvantages

- Could not take advantage of tax incentives
- City Hall steam line might be subject to regulation
- Contracts for operation and maintenance would be necessary

The principal advantage is that the developer would be in place to encourage system expansion. There are no overwhelming disadvantages. Contracting would not be a problem and lower financing rates would partially offset the lack of tax credits. The steam line could be institutionally handled to avoid regulation; for example, the steam line could be owned by Public Works and not be considered part of the district heating system. In this case the institutional issue of regulation is not a barrier to system development, but an issue that can be dealt with.

III. Development Downtown, Inc. Established For-Profit

This option is essentially the same functionally as Option II (non-profit). The main differences would be in how the company's books would be set up, and the company would be subject to federal, state and local income taxes.

Advantages

- Would be encouraged to develop profitable systems
- Could depreciate system components
- Could take eligible tax credits
- Would encourage growth
- Could be capitalized
- Could easily contract with city and private sector

Disadvantages

- Public attitude to city sponsored "for-profit" may create institutional problems
- City Hall steam line might be subject to regulation
- Contracts for operation and maintenance would be necessary
- Tax status concerning IDB's and investment tax credits on property serving City building is unclear as to treatment of such an enterprise

Again, the principal advantage would be the company's ability to encourage growth. The tax benefits are less important; unless there was an equity investor, the benefits could flow into a partnership arrangement. The major disadvantage would be institutional. It is difficult to speculate the public reaction to a DDI established for-profit company. This may not be a problem. But if it is, the company might be immediately diverted by the need to justify its organization rather than its mission.

IV. Third Party Component Ownership

In this option, a third party owns the thermal distribution system from the city-owned heat exchanger to the end user. For example, the owner of the 69 Delaware Building (Buffalo Athletic Club) owns his own hot water line. Under this scenario, DDI or BDHC is established as a broker and seller of energy. The capital requirement for the initial system would be spread over an additional entity, lowering the City of Buffalo's share. Tax advantages would flow to the private sector owner of the equipment. Buffalo could expand the system by finding other building owners willing to buy their way into the system. Buffalo would then procure the system for the owner (to insure compatibility) and transfer title when the system was installed.

Advantages

- Maintenance responsibility shifts from City or BDHC
- Tax advantages transfer to private sector, i.e., depreciation and eligible tax credits for distribution only
- City can offer "cost recovery" financing
- Expansions could be financed by CDBG or UDAG loans at favorable rates
- Long-term connections would be more assured due to the building owners greater imbedded system costs
- Expansion packages could be encouraged and developed
- Central plant additions or a new central plant could be financially transferred to private sector

Disadvantages

- Contractural arrangements may be complex
- Private sector willingness to contract with City for new service is uncertain
- City/BDHC loses control of parts of system

The principal advantage would be the transfer of responsibility and the reduced front-end financial requirement. The major disadvantage is the loss of controlling the system. While the contractual arrangements may be complex, it should not be overwhelmingly burdensome.

V. Cooperative

This option offers the ability to transfer some of the financial burden while maintaining single ownership. Effectively a cooperative company would be established as a non-profit entity with each member (building) assessed based on its energy requirements (design capacity-peak load). Each would share proportionally in all financially related manners, i.e., debt service, capital reserve, and fuel cost would be charged based on actual consumption.

Advantages

- Customer participation in ownership
- Growth is possible
- The benefits would flow proportionally

Disadvantages

- The role for DDI or BDHC is more limited to that of broker
- The control and expansion of the system would be managed by a cooperative rather than a developer

This option presents a realistic potential in the near term, but has more potential as an ultimate system ownership arrangement when a new central plant would be necessary. In the early years, the lack of an aggressive developer or development-minded company would hinder growth.

Overall, Options II, III and IV present the most favorable long-term development potential due to growth advantages and economic development potential. However, the lack of control and the complexity of contractual requirements under Option IV make it less attractive. Option I, limited to City buildings, is the easiest to implement, but provide the least potential benefits to the downtown area.

Option V might be considered as an ultimate ownership option. Cooperatives tend to work better and more effectively when there are many members to share in the costs and benefits. The early-start system based at City Hall does not offer a broad enough base for an effective cooperative ownership.

Section 5

POTENTIAL SYSTEMS

SUMMARY

This section presents the case analyses of the early-start options, and the system serving the southwestern CBD. Each analysis includes a system description, cost estimate and a financial analysis.

Cases 1, 2, 3a and 3b all include a system connecting City Hall, City Court and Fire Headquarters. Case 1 is only these three buildings. Case 2 adds a domestic hot water system to Pine Harbor Apartments. Cases 3a and 3b evaluate adding the Old City Court building at 42 Delaware Avenue and the Buffalo Athletic Club building at 69 Delaware Avenue. All of these options are based on the addition of new boiler capacity at Fire Headquarters, providing steam to City Hall, and hot water service to the other buildings. The piping configurations vary in Cases 3a and 3b.

These configurations result in cost savings in three areas. First, newer boilers will result in increased boiler efficiencies, hence lower operating cost. Second, by centralizing the heating plant for at least three buildings, the city will qualify for a lower rate for natural gas. The rate is based on annual consumption of gas and is approximately $1.00 per MMBtu less. Third, the City Court building is heated electrically; by shifting to gas-based heat there will be a considerable savings in energy purchase price. Electric heat is approximately $17.40 per MMBtu and gas cost, adjusted for boiler efficiency, approximately $7.05 per MMBtu. This results in a savings of over $10.00 per MMBtu.

In addition, the boilers in City Hall are in need of repair to keep the them in operating condition, not to improve their capacity or efficiency. The funds budgeted for boiler repair could be reallocated to the proposed system.

Cases 2, 3a and 3b add private customers to the systems. The system offers savings potential in the mid-term from lower fuel and operating costs--elimination of boiler maintenance, insurance and operators. Over the long-term, these buildings will also operate more efficiently. In Case 3a and 3b the buildings will benefit from reduced energy use in converting from steam to hot water.

Two additional early-start projects were evaluated. Configurations were identified for the Majorka Village sub-division and a cogeneration system for the proposed Buffalo Stadium. The Majorka Village project, a private development proposed for the far east side of Buffalo, does not demonstrate sufficient savings to justify the initial investment based on a heat-only system. If central air conditioning were installed it could be economically attractive. However, in Buffalo central air conditioning is not generally necessary, nor is it demanded by the buyer of a home.

Cases 4a and 4b are early systems designed for the Buffalo Stadium and Marine Midland Tower. In both cases, a 3000 kw diesel engine fired by natural gas serves as the central plant. Heat is recovered from the exhaust gases and serves the Stadium and Marine Midland heating requirements. Electricity is sold at $.06/kwh either to Niagara Mohawk or to an electric agency. In Case 4a, only heating and power are provided. In Case 4b, a chiller-heater which can simultaneously provide chilled water for cooling and hot water for heating is added to the system. Chilled water is sold to Marine Midland and provides cooling at the Stadium. Heat is still provided to both, and electric is sold as in Case 4a. Case 4b offers a much better economic outlook and is recommended.

An ultimate system serving the southwestern CBD is also presented as a long range goal. In this system, a coal-fired power plant is developed and provides base and intermediate load to a mature hot water system. The early-start systems and other excess boiler capacity in buildings would supply peak power. Electricity could be generated if desired without adding significantly to the cost of the system. Such a will have economic merit, but since conditions will likely change between now and when sufficient demand justifies development, detailed discussion is postponed.

EARLY-START SYSTEMS

The following cases are descriptions and preliminary analyses of district heating systems that have identified technical merit. With the exception of Majorka Village, the systems demonstrate economic merit. The systems also have the potential to grow and expand over time offering the most benefit and economic advantage.

Each case is presented as a complete package. The cases are subject to modification in the design process to optimize the technical and economic arrangements for the future of the systems in Buffalo.

CASE 1

The City Hall Building and the City Court Building, located adjacent to Niagara Square in downtown Buffalo, offer a high potential for energy savings with district heating. Both are large office buildings with existing steam and hot water heating systems. The age and condition of the existing boilers in the City Hall Building dictates certain replacement in the near future.

The City Hall is presently equipped with three (3) gas-fired steam boilers rated at 12 MMBtu/hr input each and one (1) coal-fired steam boiler rated at 8 MMBtu/hr input. Only two of these boilers are functional. One gas boiler developed a crack of unknown size in the refractory some time ago and is not in sound operating condition. The coal-fired boiler is a manual stoker type which was used primarily for standby and is not readily adaptable for placement into continuous service. The system is also equipped with a shell and tube heat exchanger for domestic hot water production during the heating season. A small hot water generator is used to produce domestic hot water during periods when the heating system is off.

The City Court Building is presently equipped with four (4) 540 KW and one (1) 420 KW electric hot water boilers designed to produce 180°F hot water for building heating.

In addition, there are two (2) small electric hot water generators for providing domestic hot water. The high operating cost of these boilers makes replacement with a more efficient production hot water method for space heating and domestic hot water attractive.

It is recommended that the boilers in each of these buildings be taken out of service and replaced by one gas-fired steam boiler. The new boiler would supply steam for both space heating and domestic hot water for the City Hall and the City Court Buildings. The Fire Headquarters Building, located directly behind City Hall, has new gas boilers for steam production for its own heating system. Since this building's boiler system must be maintained, it would provide an optimum site for location of the new boiler. By locating the new boiler in the Fire Headquarters mechanical room, the necessity for manned boiler rooms in the other two buildings would be eliminated and the city's maintenance personnel would be freed for other purposes. Some other reasons for this location are:

- All steam producing equipment will be located in one area.
- Ease of maintaining equipment.
- Only one water treatment facility needed.
- Existing fire headquarters boiler and new boiler can be piped to act as standby for each other.
- With a minimum of extra piping and valves, only one boiler would be fired in summertime for all three domestic hot water loads.

Figure 5-1 shows the underground piping system layout presented as Case 1. Figure 5-2 illustrates the schematic representation of this system.

The new boiler would produce approximately 30,000 lbs/hr of medium pressure steam under the Case 1 configuration. The steam would be piped to City Hall in pre-insulated, underground district heating pipes. After entering City Hall, the steam pipe would branch off and pass through a pressure-reducing station before connecting to the existing heating and domestic hot water system. The other branch of the new steam pipe would connect to a new steam-to-hot water heat exchanger system to produce water for both space heating and domestic hot water for the City Court Building. This hot water would be pumped through an underground piping system to the City Court Building to connect to the existing heating system. A small water-to-water heat exchanger would be provided for domestic hot water. The return water would be carried back to the City Hall through the underground piping system. The system would function as a primary-secondary pumping system by utilizing the new pump and underground pipes as the primary loop, and the existing hot water pumps and building piping system as the secondary loop. This system can easily be designed for automatic water temperature reset dependent upon the outside air temperature.

The above described system can be adapted to the existing in-building heating system with relative ease. With summertime retrofit, the system can be installed without disturbing the day-to-day business schedule in the buildings.

Tables 5-1 and 5-2 present cost estimates and operating costs respectively for Case 1.

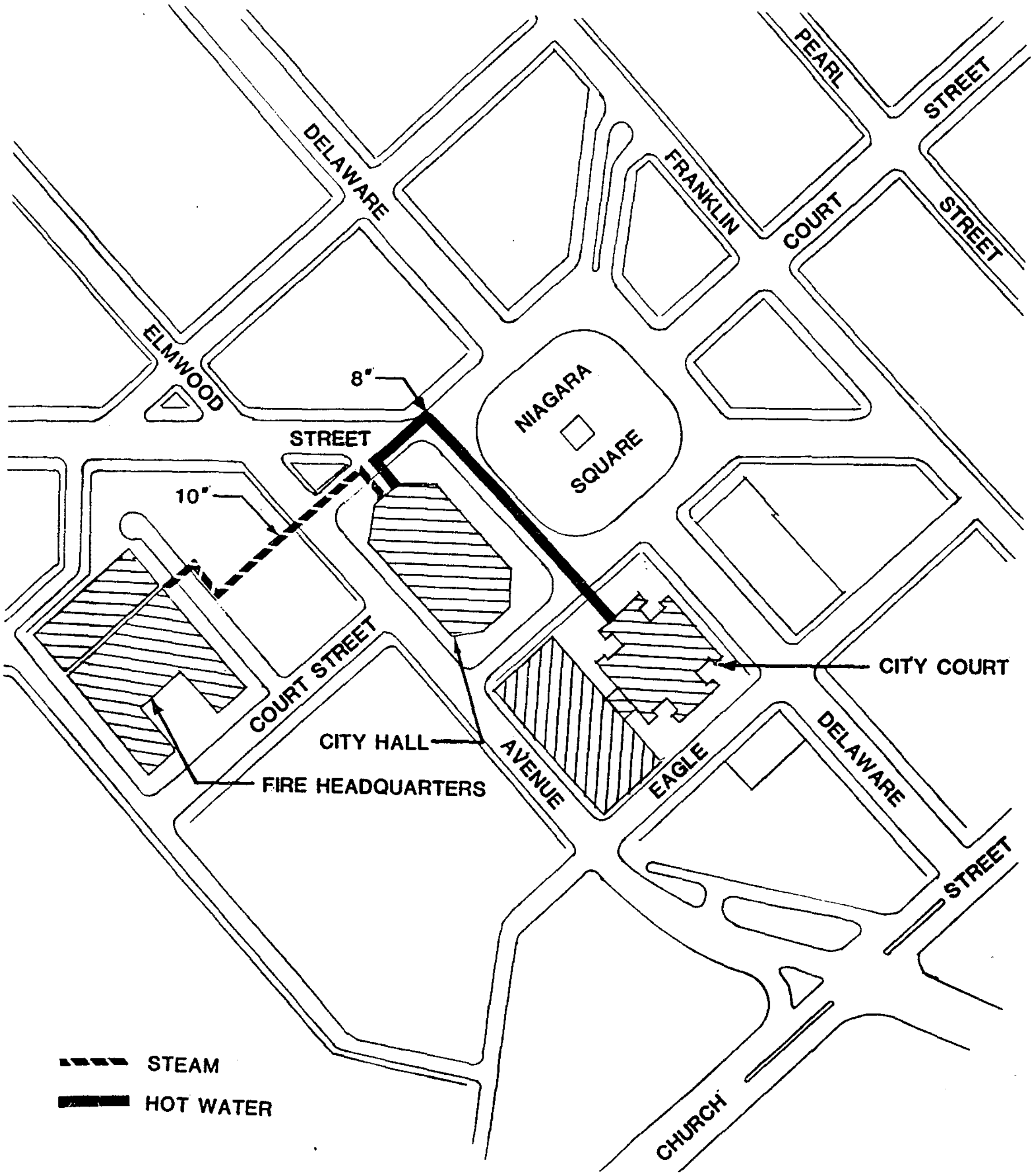


Figure 5-1. Piping Diagram-Case 1

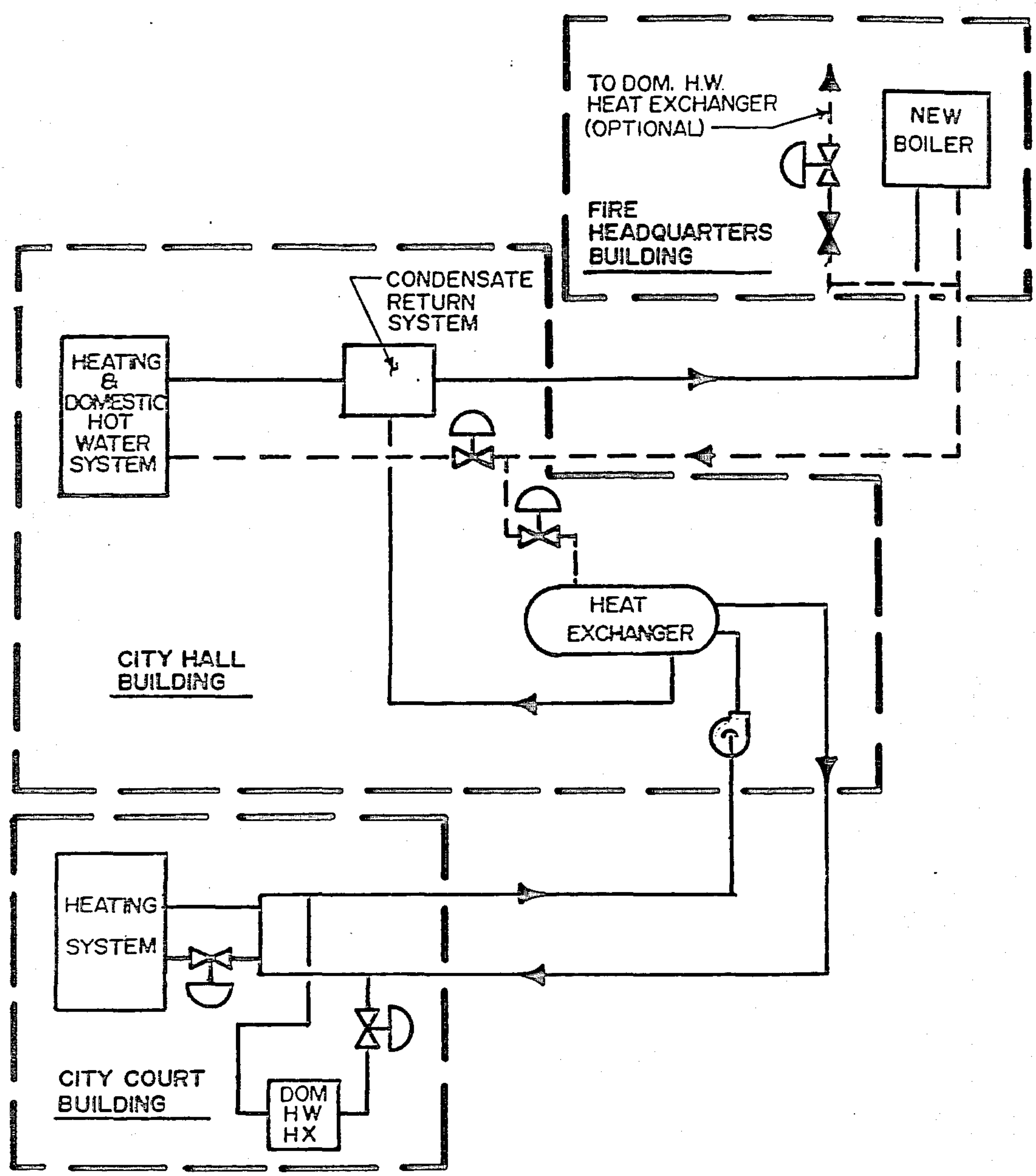


Figure 5-2. System Schematic-Case 1

Table 5-1

Resource Development Associates

CONSTRUCTION COST ESTIMATE	DATE 3/20/85	SHEET	OF
PROJECT Buffalo	JOB Case 1		
LOCATION	ESTIMATOR	DRAWING #	

ITEM AND DESCRIPTION	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR HRS. PER UNIT	LABOR $ PER HOUR	LABOR TOTAL $	MATERIALS $ PER UNIT	MATERIALS TOTAL $	SUB-CONTRACT	TOTAL COST
8" HW Pipe	680					55.78		$55.78	$ 37930
10" Steam Pipe	550				86		86	= $172	$ 94600
									$ 132530
+ extras - (20%)									27470
DH Piping									$ 16000
Boilers									
(2)x600 hp (20085MBH)	2				35500ea.		67500ea.		$ 206000
= 40170 MBH									
Cond. Ret.									$ 5000
Controls									$ 10000
Pumps									$ 10000
Heat Exchangers									$ 10000
Misc. Piping/Valves									$ 15000
									$ 416000

Table 5-2

OPERATING COST ANALYSIS BUFFALO DISTRICT HEATING

CASE - 1 RESOURCE DEVELOPMENT ASSOCIATES

REG. GAS COST = 5.93 $/MMBTU \
DISC. GAS COST = 4.93 $/MMBTU > AVERAGES
ELECT. COST = 17.4 $/MMBTU /
EST. CAP. COST = 416000 $

BUILDING	BOILER EFF.	HEAT DEMAND (MBH)	ANNUAL INPUT (MMBTU)	ANNUAL OUTPUT (MMBTU)	ANN FUEL COST ($)	ANN LAB. COST ($)	ANN MAINT COST ($)	TOT ANN COST ($)
CITY HALL	.65	15400	37193	24175	220554.5	19000	3648.04	243202.5
CITY COURT	1	10000	13102	13102	228209	19000	3764.60	250973.6
FIRE HDQTRS	.7	6700	12058	8441	71503.94	19000	1378.23	91882.17
TOTALS								586058.3
TOTAL CONS.				45718				
TOTAL DEMAND		32100						
INCL. LOSSES		35310		50290				
NEW BOILER OUTPUT	.7	35310	71843	50290	354184	19000	5683.01	378867.3

NEW BOILER INPUT 50443 MBH ANNUAL SAVINGS = $207191
OR 50443 LBS/HR

SIMPLE PAYBACK PER.= 2.0 YRS

CASE 2

In addition to the anchor buildings of Fire Headquarters, City Hall and City Court, Case 2 includes the Pine Harbor Apartments located west of 7th Street. Figure 5-3 shows the anticipated configuration for Case 2, including underground pipe routing, pipe diameters, and buildings served by the system. The housing complex contains 89 family dwelling units. Currently, space heating is provided by electric baseboard devices, and domestic hot water is generated from a central hot water generator. It is envisioned that the domestic hot water requirements of this complex can be provided by the start-up system (Case 1) by extending a 2 1/2" hot water pipe from the Fire Headquarters to Pine Harbor. A schematic representation of the system's technical characteristics is illustrated in Figure 5-4. Steam is generated at the Fire Headquarters boilers and most of it is transmitted to the City Hall Building for use in its heating system. A small amount of steam is passed through a shell-and-tube heat exchanger located in the Fire Headquarters building to produce hot water. From there, hot water is pumped through a pipe to the apartments for use in a central heat exchanger used to provide domestic hot water to each of the 89 dwelling units. A cost estimate and operating summary of Case 2 are provided in Tables 5-3 and 5-4, respectively.

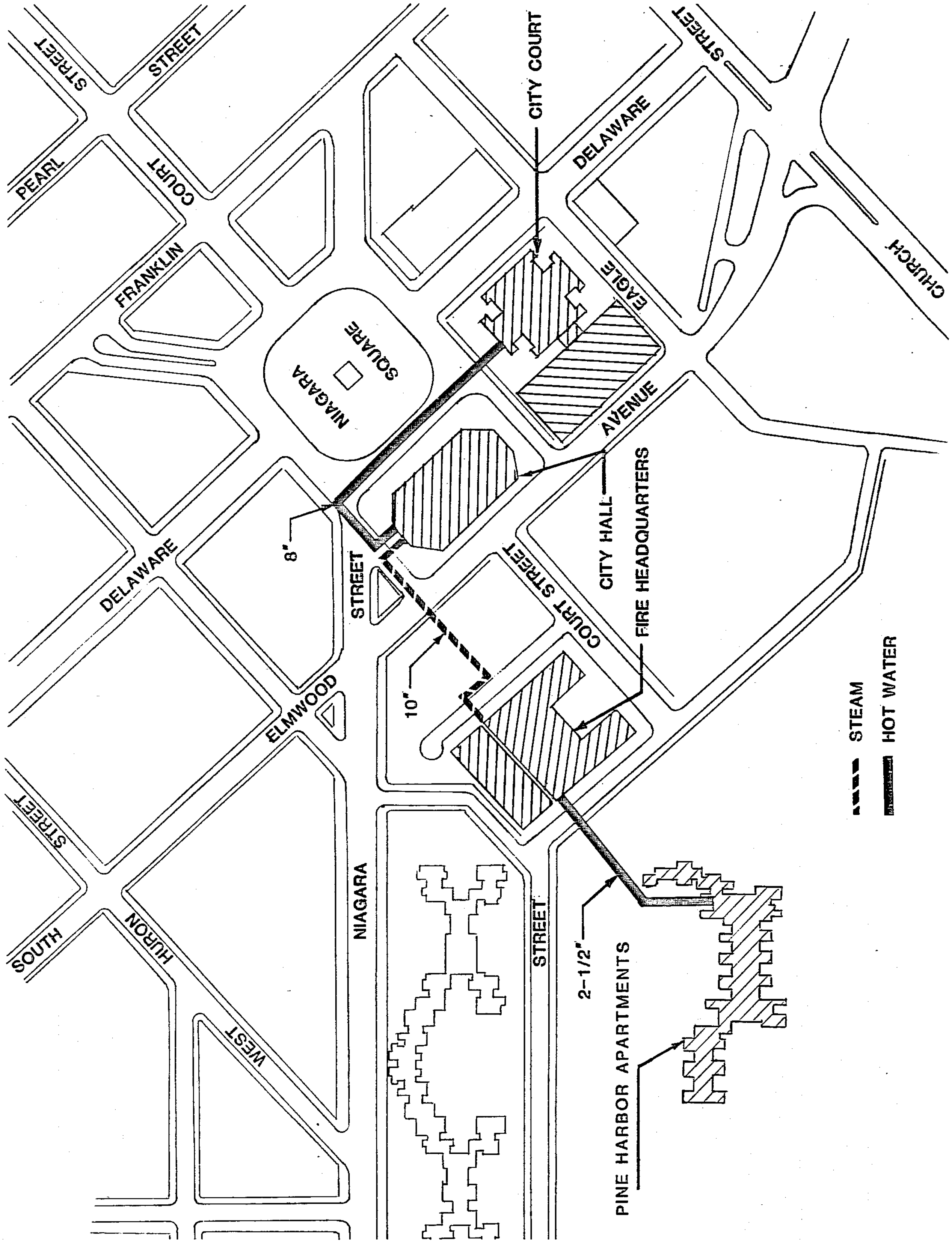


Figure 5-3. Piping Diagram-Case 2

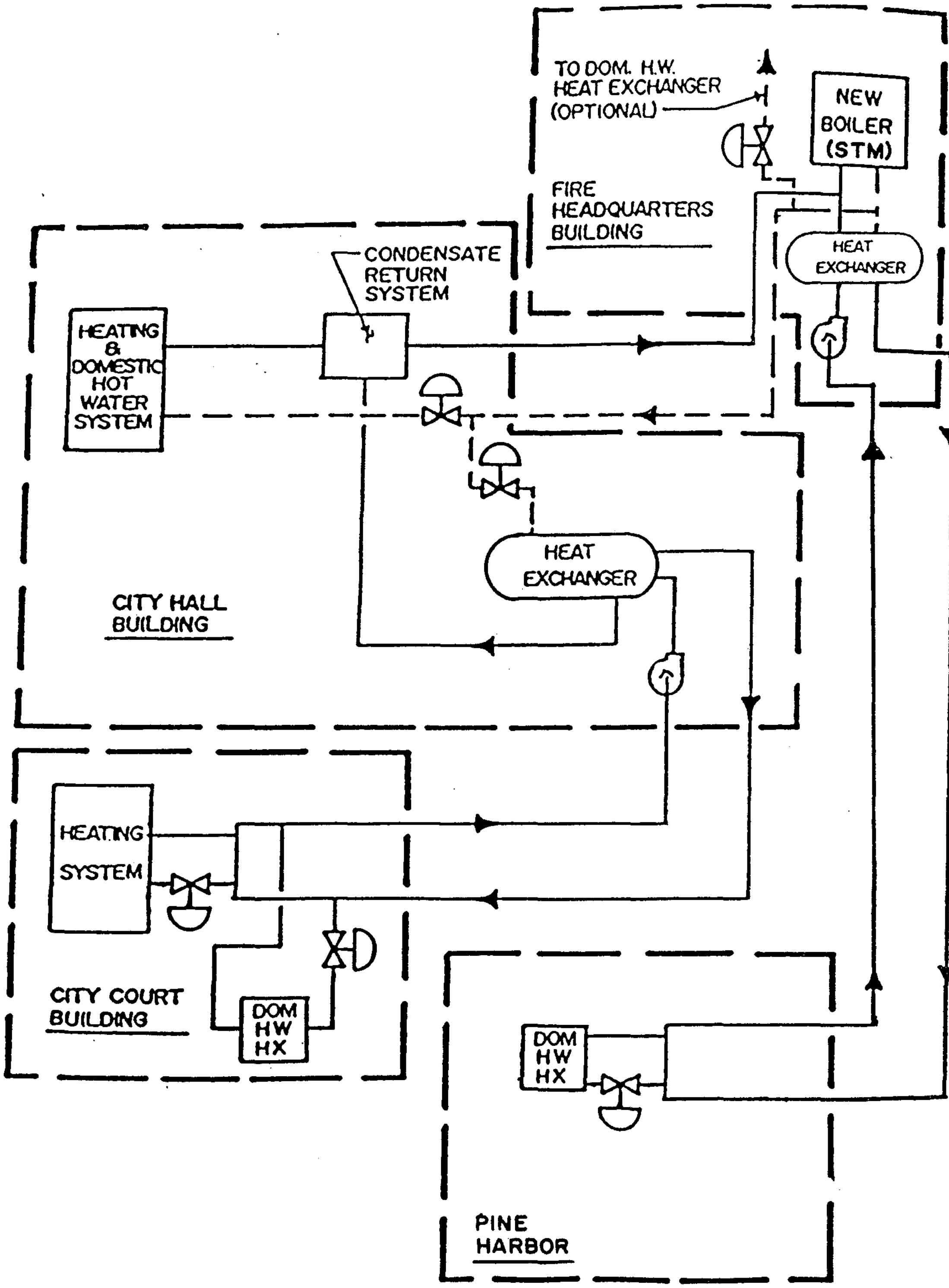


Figure 5-4. System Schematic-Case 2

Table 5-3

Resource Development Associates

CONSTRUCTION COST ESTIMATE	DATE 3/20/85	SHEET OF
PROJECT Buffalo	JOB Case 2	
LOCATION 37000MBH	ESTIMATOR	DRAWING #

ITEM AND DESCRIPTION	QUANTITY		LABOR			MATERIALS		SUB-CONTRACT	TOTAL COST
	NO. UNITS	UNIT MEAS.	HRS. PER UNIT	$ PER HOUR	TOTAL $	$ PER UNIT	TOTAL $		
8" HW Pipe	680					55.78		55.78	$ 37930
10" Steam Pipe	550				86		86		$ 94600
2½" HW Pipe	500					29		29 +	$ 14500
									$ 147030
+ extras - (20%)									$ 29406
									$ 176436
Boilers					D.H.				
(2)x600 hp (20085MBH)	2				35500		67500		$ 206000
= 40170 MBH									
Cond. Ret.									$ 5000
Controls									$ 10000
Pumps									$ 14000
Heat Exchangers									$ 14000
Misc. Piping/Valves									$ 18000
									$ 443436

Table 5-4

OPERATING COST ANALYSIS — BUFFALO DISTRICT HEATING

CASE - 2 — RESOURCE DEVELOPMENT ASSOCIATES

REG. GAS COST = 5.93 $/MMBTU \
DISC. GAS COST = 4.93 $/MMBTU) AVERAGES
ELECT. COST = 17.4 $/MMBTU /
EST. CAP. COST = 443436 $

BUILDING	BOILER EFF.	HEAT DEMAND (MBH)	ANNUAL INPUT (MMBTU)	ANNUAL OUTPUT (MMBTU)	ANN FUEL COST ($)	ANN LAB. COST ($)	ANN MAINT COST ($)	TOT ANN COST ($)
CITY HALL	.65	15400	37193	24175	220554.5	19000	3648.04	243202.5
CITY COURT	1	10000	13102	13102	228209	19000	3764.60	250973.6
FIRE HDQTRS	.7	6700	12058	8441	71503.94	19000	1378.23	91882.17
PINE HARBOR	.7	1072	1414	990	8386.714	19000	417.06	27803.77
TOTALS								613862.1
TOTAL CONS.				46708				
TOTAL DEMAND		33172						
INCL. LOSSES		36489.2		51379				
NEW BOILER OUTPUT	.7	36489	73398	51379	361854	19000	5799.81	386653.7

NEW BOILER INPUT 52127 MBH
OR 52127 LBS/HR

ANNUAL SAVINGS = $227208

SIMPLE PAYBACK PER.= 2.0 YRS

CASE 3A

The Case 1 start-up district heating system for downtown Buffalo consists of three buildings: City Hall, City Court and the Fire Headquarters. Case 3a modifies Case 1 by adding two more buildings to the system: the Old City Court, located at 42 Delaware Street and the Buffalo Athletic Club building located at 69 Delaware Street. The Old City Court building contains approximately 58,800 square feet of office space. Heating for the Old City Court building is provided by two gas-fired steam boilers rated at 4MMBtu/hr input each. Steam generated from the boilers is distributed to the various terminal units, mostly radiators and coils. The Buffalo Athletic Club is located on Niagara Square, facing Delaware Street and is estimated to have 150,000 square feet. This building, like the Old City Court building, uses steam for heating and domestic hot water purposes. Figure 5-5 shows the location of the buildings and the proposed pipe routing to provide steam and hot water district heating from the Fire Headquarters Building Boilers. Figure 5-6 shows the proposed piping schematic for Case 3a, including the district heating interface for the Old City Court building and the Buffalo Athletic Club.

The system would operate as follows. Steam would be generated in the Fire Headquarters building as in Case 1, and would provide heating and domestic hot water for the Fire Headquarters building. The steam then would be transmitted through a twelve-inch pipe to the City Hall building, where it would be used directly in the City Hall's heating system and domestic hot water system. In the basement of City Hall, steam would also be passed through a shell-and-tube heat exchanger where district heating hot water would be generated. Pumps located in the basement would circulate the hot water from City Hall to the City Court building, the Buffalo Athletic Club, and the retrofitted Old City Court building. In all three buildings, the hot water would be used for space heating and domestic hot water.

The initial capital cost estimate of this system is detailed in Table 5-5, and operating costs are presented in Table 5-6.

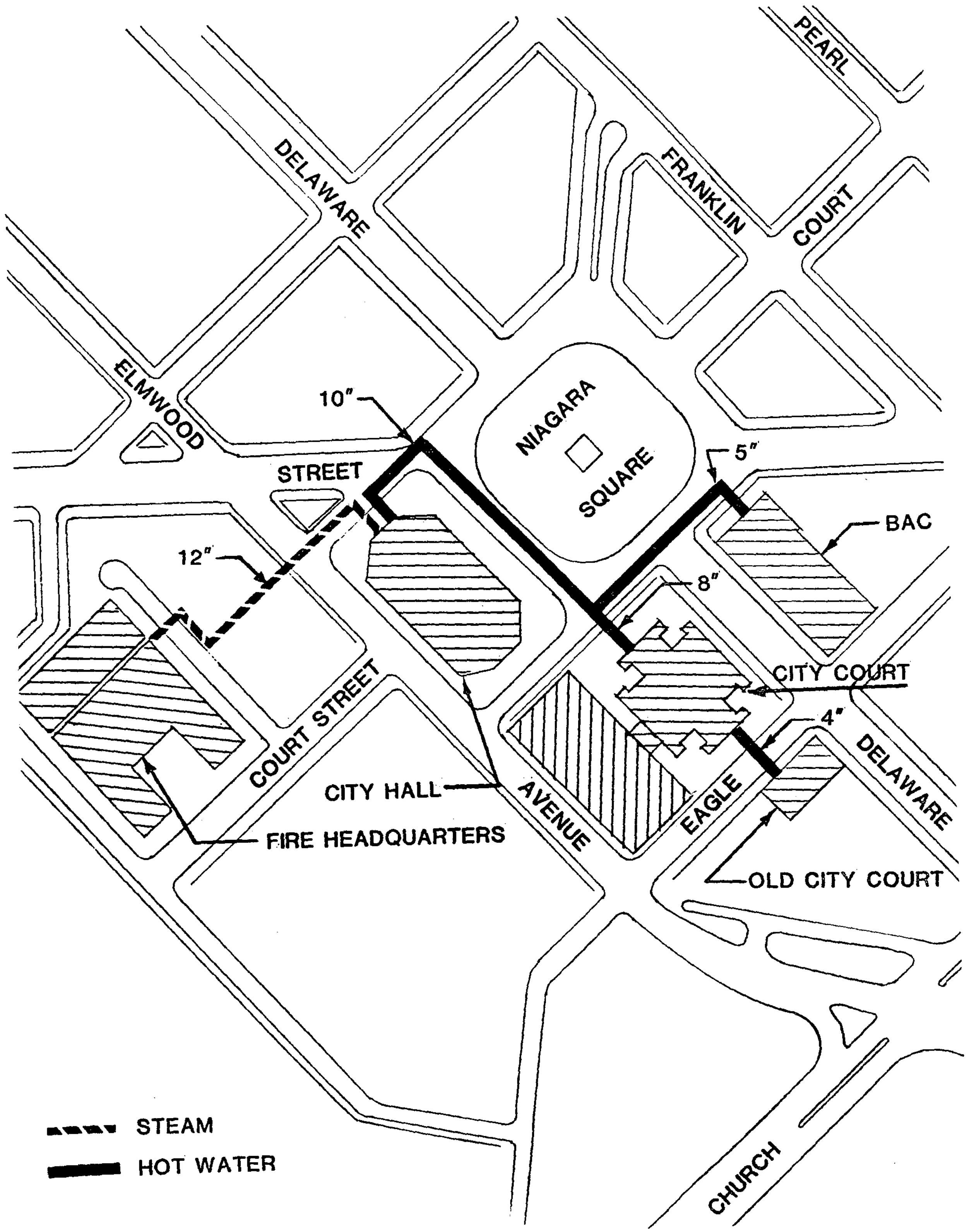


Figure 5-5. Piping Diagram-Case 3a

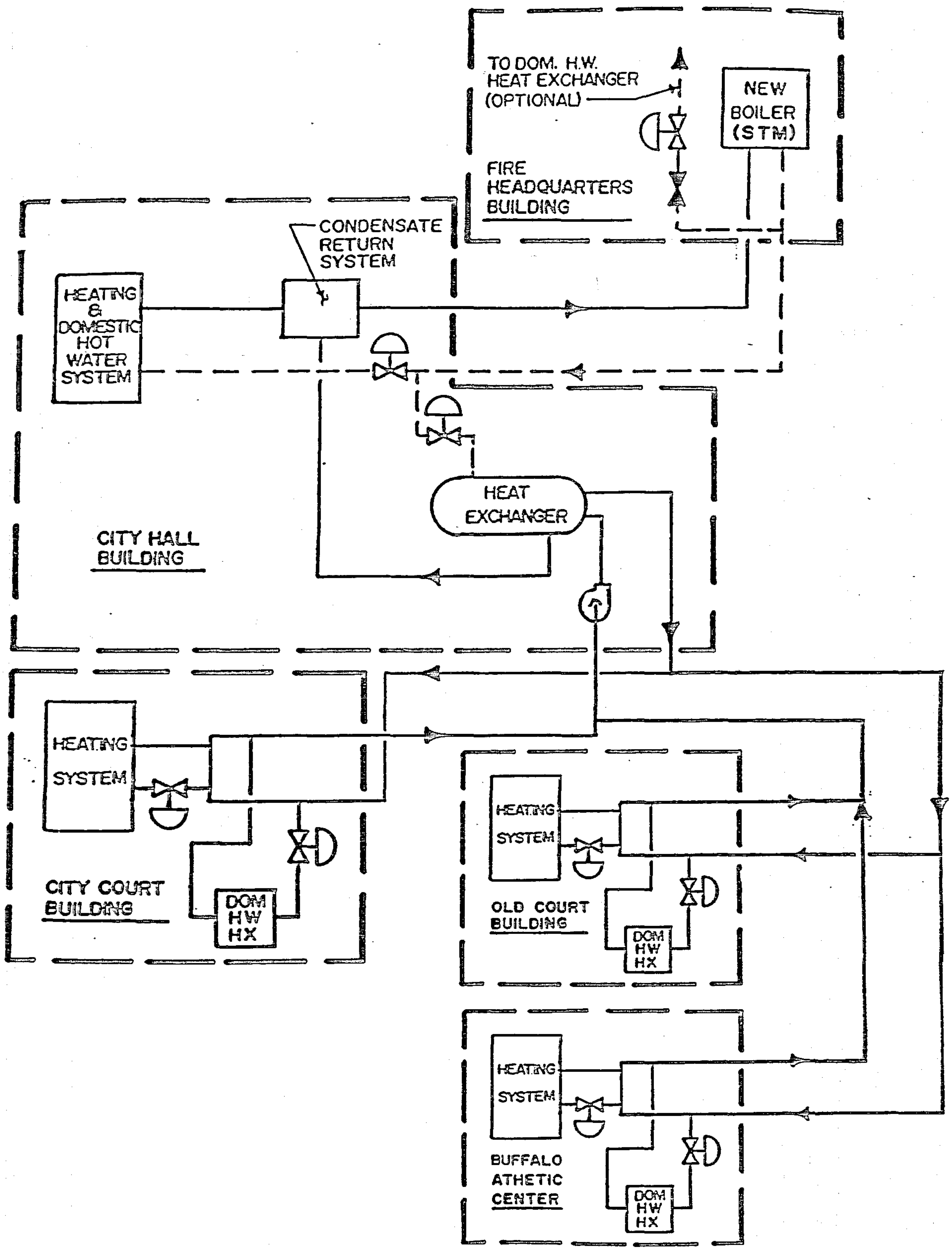


Figure 5-6. System Schematic-Case 3a

Table 5-5

Resource Development Associates

CONSTRUCTION COST ESTIMATE	DATE 3/20/85	SHEET	OF
PROJECT Buffalo	JOB Case 3a		
LOCATION	ESTIMATOR	DRAWING #	

ITEM AND DESCRIPTION	QUANTITY		LABOR			MATERIALS		SUB-CONTRACT	TOTAL COST
	NO. UNITS	UNIT MEAS.	HRS. PER UNIT	$ PER HOUR	TOTAL $	$ PER UNIT	TOTAL $		
4" Pipe	300						34.47		$ 10341
5" Pipe	310						37.16		$ 11520
6" Pipe									
8" Pipe	100						55.78		$ 5578
10" HW Pipe	1110						64.52		$ 71617
8" Steam Pipe	630				70		70		$ 88200
	2450								$ 187256
+ extras - (20%)									$ 37451
D.H. System									$ 224707
Boilers									
(2)x800 hp (26780MBH)	2				43000		82000	--	$ 250000
= 53560 MBH									
Heat Exchangers									$ 18000
Cond. Ret.									$ 8000
Controls									$ 12000
Pumps									$ 15000
Misc. Piping/Valves									$ 20000
									$ 547707

Table 5-6

OPERATING COST ANALYSIS BUFFALO DISTRICT HEATING

CASE - 3A RESOURCE DEVELOPMENT ASSOCIATES

REG. GAS COST = 5.93 $/MMBTU \
DISC. GAS COST = 4.93 $/MMBTU) AVERAGES
ELECT. COST = 17.4 $/MMBTU /
EST. CAP. COST = 547707 $

BUILDING	BOILER EFF.	HEAT DEMAND (MBH)	ANNUAL INPUT (MMBTU)	ANNUAL OUTPUT (MMBTU)	ANN FUEL COST ($)	ANN LAB. COST ($)	ANN MAINT COST ($)	TOT ANN COST ($)
CITY HALL	.65	15400	37193	24175	220554.5	19000	3648.04	243202.5
CITY COURT	1	10000	13102	13102	228209	19000	3764.60	250973.6
FIRE HDQTRS	.7	6700	12058	8441	71503.94	19000	1378.23	91882.17
BUF ATH CLUB	.7	6164	8806	6164	52217.89	19000	1084.54	72302.42
OLD CITY CT.	.7	2352	5133	3593	30437.84	19000	752.86	50190.7
TOTALS								708551.4
TOTAL CONS.				55475				
TOTAL DEMAND		40616						
INCL. LOSSES		44677.6		61023				
NEW BOILER OUTPUT	.7	44678	87175	61023	429773	19000	6834.11	455607.2

NEW BOILER INPUT 63825 MBH
OR 63825 LBS/HR

ANNUAL SAVINGS = $252944

SIMPLE PAYBACK PER.= 2.2 YRS

CASE 3B

The buildings served under the Case 3b scenario are the same buildings as those served under Case 3a. However, in Case 3b, the hot water buildings (City Court, Old City Court, and the Buffalo Athletic Club) are served in parallel to the steam building (City Hall), while in Case 3a the hot water buildings are served in series after the steam building.

Under this configuration, steam is generated in the Fire Headquarters building, where part of the steam is directed into the Fire Headquarters heating system. A second portion of the steam is transmitted to the City hall building via an eight-inch underground pipe for use in its heating system and also in domestic hot water generation. The remainder of the steam is passed through a shell-and-tube heat exchanger, where district heating hot water is generated. This hot water is pumped from the Fire Headquarters Building through a set of hot water pipes as shown in Figures 5-7 and 5-8 for service to the City Court, Old City Court, and BAC buildings.

The advantages of this system are that a) all equipment lies in one building (Fire Headquarters) as opposed to having steam/hot water heat exchangers in the City Hall basement, and b) two distinctly independent systems are operated--steam district heating and hot water district heating. Table 5-7 shows the estimated capital cost of this configuration, and Table 5-8 presents the associated operating cost.

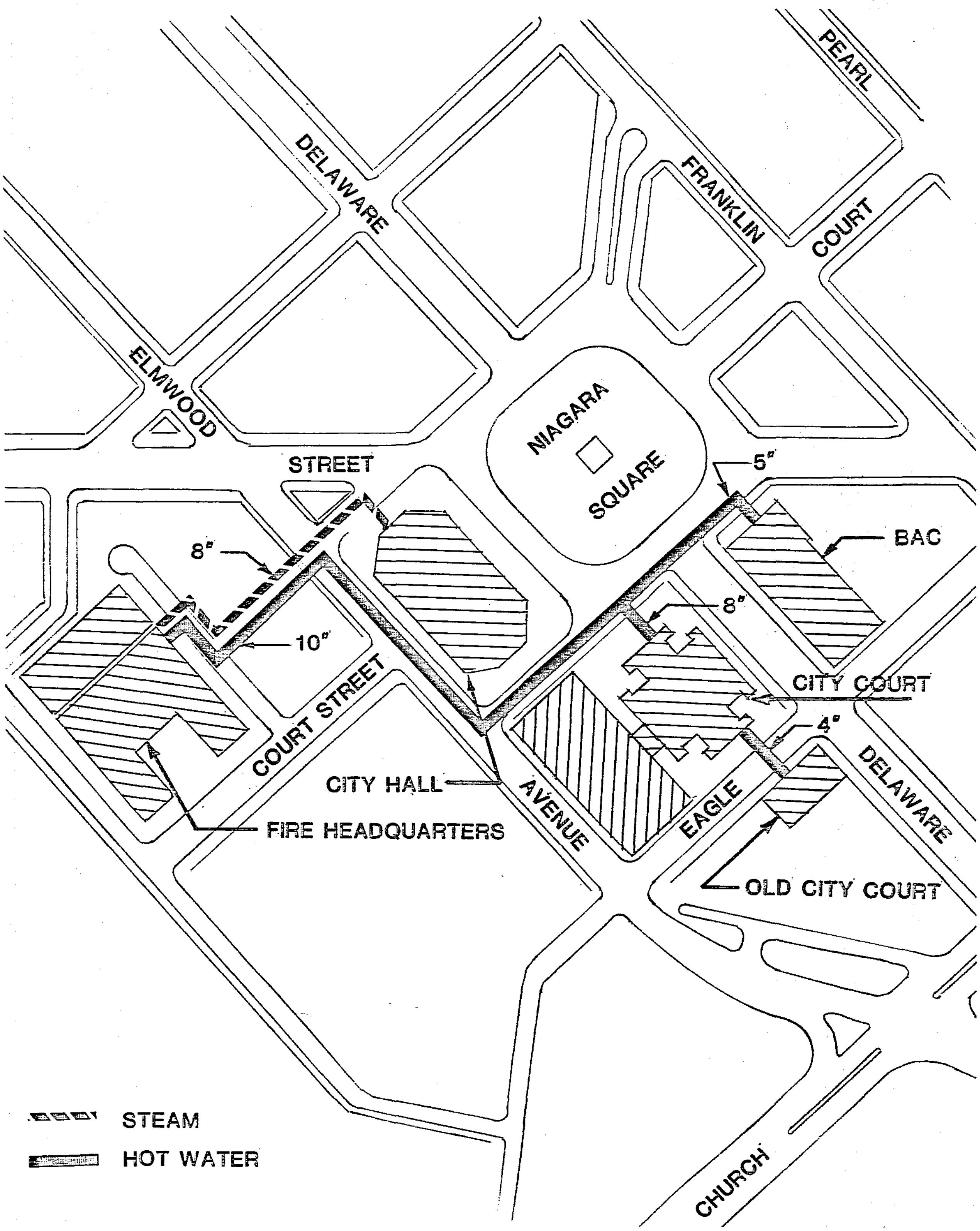


Figure 5-7. Piping Diagram-Case 3b

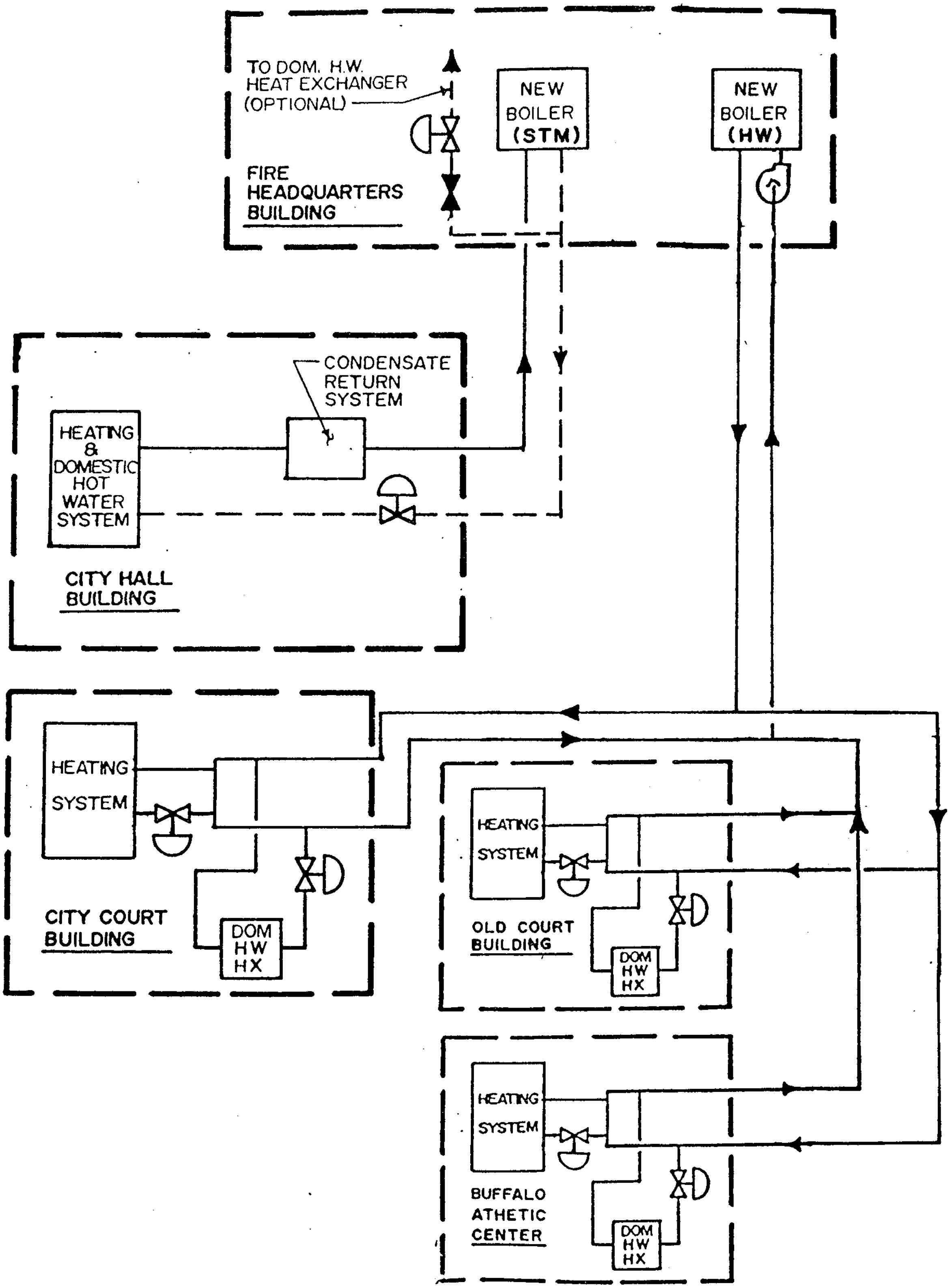


Figure 5-8. System Schematic-Case 3b

Table 5-7

Resource Development Associates

CONSTRUCTION COST ESTIMATE	DATE 3/20/85	SHEET	OF
PROJECT Buffalo	JOB Case 3b		
LOCATION	ESTIMATOR	DRAWING #	

ITEM AND DESCRIPTION	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR HRS. PER UNIT	LABOR $ PER HOUR	LABOR TOTAL $	MATERIALS $ PER UNIT	MATERIALS TOTAL $	SUB-CONTRACT	TOTAL COST
4" Pipe	300						34.47		$ 10341
5" Pipe	310						37.16		$ 11520
8" Pipe	100						55.78		$ 5578
10" Pipe	570						64.52		$ 36776
12" Steam Pipe	660				100			100	$ 132000
	1940								$ 196215
+ extras - (20%)									$ 39243
D.H. System									$ 235458
Boilers									
(2)x10044MBH HW	2				21000		44500		$ 131000
= 20088MBH									
(1)x16740MBH					30600		60400		$ 91000
Cond. Ret.									$ 5000
Controls									$ 15000
Pumps									$ 15000
Misc. Piping/Valves									$ 20000
									$ 512458

Table 5-8

OPERATING COST ANALYSIS — BUFFALO DISTRICT HEATING

CASE - 3B — RESOURCE DEVELOPMENT ASSOCIATES

REG. GAS COST = 5.93 $/MMBTU \
DISC. GAS COST = 4.93 $/MMBTU) AVERAGES
ELECT. COST = 17.4 $/MMBTU /
EST. CAP. COST = 512458 $

BUILDING	BOILER EFF.	HEAT DEMAND (MBH)	ANNUAL INPUT (MMBTU)	ANNUAL OUTPUT (MMBTU)	ANN FUEL COST ($)	ANN LAB. COST ($)	ANN MAINT COST ($)	TOT ANN COST ($)
CITY HALL	.65	15400	37193	24175	220554.5	19000	3648.04	243202.5
CITY COURT	1	10000	13102	13102	228209	19000	3764.60	250973.6
FIRE HDQTRS	.7	6700	12058	8441	71503.94	19000	1378.23	91882.17
BUF ATH CLUB	.7	6164	8806	6164	52217.89	19000	1084.54	72302.42
OLD CITY CT.	.7	2352	5133	3593	30437.84	19000	752.86	50190.7
TOTALS								708551.4
TOTAL CONS.				55475				
TOTAL DEMAND		40616						
INCL. LOSSES		44677.6		61023				
NEW BOILER OUTPUT	.7	44678	87175	61023	429773	19000	6834.11	455607.2

NEW BOILER INPUT 63825 MBH
OR 63825 LBS/HR

ANNUAL SAVINGS = $252944

SIMPLE PAYBACK PER.= 2.0 YRS

INCREMENTAL COST ANALYSIS

The options presented are based on recovering the cost of the distribution lines and the capital cost increments imposed by systems beyond that described in Case 1. That is, the additional cost of added size in the boiler plant, heat exchangers, pumps etc. of each additional Case is applied to the customer as a service charge.

Five options for the cost recovery are presented based on different financing scenarios. The cost of energy per million Btu for each option is presented for the first year:

- Option 1 - No Financing, full incremental cost is borne by the customer in the first year,
- Option 2 - Incremental costs are charged at 9.5% interest and financed for seven years,
- Option 3 - Incremental costs are charged at 13% interest and financed for seven years,
- Option 4 - Incremental costs are charged at 13% interest and financed for five years,
- Option 5 - Incremental costs are charged at 13% interest and financed for three years.

Tables 5-9, 5-10 and 5-11 present the costs of these options to end users in the first year of operation. The interest rates were selected to reflect both industrial development bonds and conventional borrowing rates. Only the cost increment over the Case 1 cost is subject to financing. Retrofit costs are an estimate and are not included in the capital financing assumptions.

Table 5-9

BUFFALO DISTRICT HEATING

INCREMENTAL COST ANALYSIS

CASE NO.= 2- PINE HARBOR APARTMENTS

OPTION	CAPITAL	FUEL	LABOR	MAINT	TOT COST	LOAD	$/MMBTU
100% EQTY	27436	7670		117	35223	1089	32.34
9.5%.7YRS	5381	7670		117	13168	1089	12.09
13%. 7YRS	5989	7670		117	13776	1089	12.65
13%. 5YRS	7491	7670		117	15278	1089	14.03
13%. 3YRS	11093	7670		117	18880	1089	17.34

Table 5-10

BUFFALO DISTRICT HEATING

INCREMENTAL COST ANALYSIS

CASE NO.= 3A- CITY HALL SYSTEM+BAC &OLD CITY COURTS IN SERIES

OPTION	CAPITAL	FUEL	LABOR	MAINT	TOT COST	LOAD	$/MMBTU
100% EQTY	131707	75589		1151	208447	10733	19.42
9.5%.7YRS	25831	75589		1151	102571	10733	9.56
13%. 7YRS	28752	75589		1151	105492	10733	9.83
13%. 5YRS	35960	75589		1151	112700	10733	10.50
13%. 3YRS	53253	75589		1151	129993	10733	12.11

Table 5-11

BUFFALO DISTRICT HEATING

INCREMENTAL COST ANALYSIS

CASE NO.= 3B- CITY HALL SYSTEM+BAC & OLD CITY COURTS IN PARALLEL

OPTION	CAPITAL	FUEL	LABOR	MAINT	TOT COST	LOAD	$/MMBTU
100% EQTY	96458	75589		1151	173198	10733	16.14
9.5%.7YRS	18918	75589		1151	95658	10733	8.91
13%. 7YRS	21057	75589		1151	97797	10733	9.11
13%. 5YRS	26337	75589		1151	103077	10733	9.60
13%. 3YRS	39000	75589		1151	115740	10733	10.78

Based on first year cost per million Btu's, Case 3b with the incremental cost recovered over seven years at a 9.5% interest rate offers the most favorable cost. The energy and capital cost of $8.91 per MMBtu is projected at $.44 above the effective price of natural gas. Of the $8.91 cost, $1.76 is in capital. If the capital component is reduced further by extended financing or grants, the rate could easily beat the current cost of natural gas to the owners of either 69 Delaware or 42 Delaware. Case 3b also offers the superior technical arrangement, in that operations are centralized, and the steam and hot water systems are isolated from each other.

Tables 5-12 through 5-17 present the cost savings to the end user over the early life of the project. It is assumed that a non-profit Buffalo District Heating Company will own and operate the system. Operation and maintenance costs are based on the increment above the Case 1 scenario.

The savings presented are for the non-city owned buildings. It is assumed that savings from the conversion of the City Courts Building from electric heat to natural gas heat, estimated to have a two year payback, will be sufficient to cover Buffalo's investment in the project. The net present value of the building owners' savings based on a 10% discount rate is indicated in the lower right of each table.

Table 5-12

BUFFALO DISTRICT HEATING

OPERATING COST SUMMARY

CASE NO.= 2- PINE HARBOR APARTMENTS

OPTION: 100% EQTY

YEAR	CAPITAL	FUEL	O & M	SYSTEM TOTAL	RETROFIT	TOTAL	$/MMBTU	CURRENT COST	CURRENT O & M	CURRENT $/MMBTU	SAVINGS
1986	27436	7670	117	35223	2500	37723	34.64	8387	1500	9.99	-27836
1987		8130	124	8254		8254	7.58	8890	1590	10.59	2226
1988		8618	131	8749		8749	8.03	9424	1685	11.22	2360
1989		9135	139	9274		9274	8.52	9989	1787	11.89	2501
1990		9683	148	9831		9831	9.03	10588	1894	12.61	2651
1991		10555	157	10711		10711	9.84	11541	2007	13.69	2837
1992		11505	166	11671		11671	10.72	12580	2128	14.86	3037
1993		12540	176	12716		12716	11.68	13712	2255	16.13	3252
1994		13669	186	13855		13855	12.72	14946	2391	17.51	3482
1995		14899	198	15096		15096	13.86	16292	2534	19.02	3729
1996		16240	210	16449		16449	15.10	17758	2686	20.65	3995
1997		17701	222	17923		17923	16.46	19356	2847	22.43	4280
1998		19294	235	19530		19530	17.93	21098	3018	24.36	4587
1999		21031	250	21280		21280	19.54	22997	3199	26.46	4916
2000		22924	265	23188		23188	21.29	25067	3391	28.75	5270
						236252		222625			21287

NET PRESENT VALUE= -4098

Table 5-13

BUFFALO DISTRICT HEATING

OPERATING COST SUMMARY

CASE NO.= 2- PINE HARBOR APARTMENTS

OPTION: 9.5%.7YRS

YEAR	CAPITAL	FUEL	O & M	SYSTEM TOTAL	RETROFIT	TOTAL	$/MMBTU	CURRENT COST	CURRENT O & M	CURRENT $/MMBTU	SAVINGS
1986	5381	7670	117	13168	2500	15668	14.39	8387	1500	9.99	-5781
1987	5381	8130	124	13635		13635	12.52	8890	1590	10.59	-3155
1988	5381	8618	131	14130		14130	12.98	9424	1685	11.22	-3021
1989	5381	9135	139	14655		14655	13.46	9989	1787	11.89	-2880
1990	5381	9683	148	15212		15212	13.97	10588	1894	12.61	-2730
1991	5381	10555	157	16092		16092	14.78	11541	2007	13.69	-2544
1992	5381	11505	166	17052		17052	15.66	12580	2128	14.86	-2344
1993		12540	176	12716		12716	11.68	13712	2255	16.13	3252
1994		13669	186	13855		13855	12.72	14946	2391	17.51	3482
1995		14899	198	15096		15096	13.86	16292	2534	19.02	3729
1996		16240	210	16449		16449	15.10	17758	2686	20.65	3995
1997		17701	222	17923		17923	16.46	19356	2847	22.43	4280
1998		19294	235	19530		19530	17.93	21098	3018	24.36	4587
1999		21031	250	21280		21280	19.54	22997	3199	26.46	4916
2000		22924	265	23188		23188	21.29	25067	3391	28.75	5270
						246483		222625			11056

NET PRESENT VALUE= -5353

Table 5-14

BUFFALO DISTRICT HEATING

OPERATING COST SUMMARY

CASE NO.= 3A-CITY HALL SYSTEM+BAC & OLD CITY COURTS IN SERIES

OPTION: 100% EQTY

YEAR	CAPITAL	FUEL	O & M	SYSTEM TOTAL	RETROFIT	TOTAL	$/MMBTU	CURRENT COST	CURRENT O & M	CURRENT $/MMBTU	SAVING
1986	131707	75589	1151	208447	215740	424187	39.52	82656	38000	8.47	-303531
1987		80124	1220	81344		81344	7.58	87615	40280	8.98	46551
1988		84932	1293	86225		86225	8.03	92872	42697	9.52	49344
1989		90028	1371	91399		91399	8.52	98445	45259	10.09	52305
1990		95429	1453	96882		96882	9.03	104351	47974	10.70	55443
1991		104018	1540	105558		105558	9.83	113743	50853	11.66	59037
1992		113380	1633	115012		115012	10.72	123980	53904	12.71	62871
1993		123584	1731	125314		125314	11.68	135138	57138	13.85	66961
1994		134706	1835	136541		136541	12.72	147300	60566	15.10	71326
1995		146830	1945	148775		148775	13.86	160557	64200	16.46	75983
1996		160045	2061	162106		162106	15.10	175008	68052	17.94	80954
1997		174449	2185	176634		176634	16.46	190758	72135	19.55	86260
1998		190149	2316	192465		192465	17.93	207926	76463	21.31	91925
1999		207262	2455	209717		209717	19.54	226640	81051	23.23	97974
2000		225916	2602	228518		228518	21.29	247037	85914	25.32	104433
						2380678		2194028			697836

NET PRESENT VALUE= 159414

Table 5-15

BUFFALO DISTRICT HEATING

OPERATING COST SUMMARY

CASE NO.= 3A-CITY HALL SYSTEM+BAC & OLD CITY COURTS IN SERIES

OPTION: 9.5%.7YRS

YEAR	CAPITAL	FUEL	O & M	SYSTEM TOTAL	RETROFIT	TOTAL	$/MMBTU	CURRENT COST	CURRENT O & M	CURRENT $/MMBTU	SAVING
1986	20451	75589	1151	97191	215740	312931	29.16	82656	38000	8.47	-192275
1987	20451	80124	1220	101795		101795	9.48	87615	40280	8.98	26100
1988	20451	84932	1293	106676		106676	9.94	92872	42697	9.52	28893
1989	20451	90028	1371	111850		111850	10.42	98445	45259	10.09	31854
1990	20451	95429	1453	117333		117333	10.93	104351	47974	10.70	34992
1991	20451	104018	1540	126009		126009	11.74	113743	50853	11.66	38586
1992	20451	113380	1633	135463		135463	12.62	123980	53904	12.71	42420
1993		123584	1731	125314		125314	11.68	135138	57138	13.85	66961
1994		134706	1835	136541		136541	12.72	147300	60566	15.10	71326
1995		146830	1945	148775		148775	13.86	160557	64200	16.46	75983
1996		160045	2061	162106		162106	15.10	175008	68052	17.94	80954
1997		174449	2185	176634		176634	16.46	190758	72135	19.55	86260
1998		190149	2316	192465		192465	17.93	207926	76463	21.31	91925
1999		207262	2455	209717		209717	19.54	226640	81051	23.23	97974
2000		225916	2602	228518		228518	21.29	247037	85914	25.32	104433
						2392128		2194028			686386

NET PRESENT VALUE= 179584

Table 5-16

BUFFALO DISTRICT HEATING

OPERATING COST SUMMARY

CASE NO.= 3B-CITY HALL SYSTEM+BAC & OLD CITY COURTS IN PARALLEL

OPTION: 100% EQTY

YEAR	CAPITAL	FUEL	O & M	SYSTEM TOTAL	RETROFIT	TOTAL	$/MMBTU	CURRENT COST	CURRENT O & M	CURRENT $/MMBTU	SAVING
1986	96458	75589	1151	173198	215740	388938	36.24	82656	38000	8.47	-268282
1987		80124	1220	81344		81344	7.58	87615	40280	8.98	46551
1988		84932	1293	86225		86225	8.03	92872	42697	9.52	49344
1989		90028	1371	91399		91399	8.52	98445	45259	10.09	52305
1990		95429	1453	96882		96882	9.03	104351	47974	10.70	55443
1991		104018	1540	105558		105558	9.83	113743	50853	11.66	59037
1992		113380	1633	115012		115012	10.72	123980	53904	12.71	62871
1993		123584	1731	125314		125314	11.68	135138	57138	13.85	66961
1994		134706	1835	136541		136541	12.72	147300	60566	15.10	71326
1995		146830	1945	148775		148775	13.86	160557	64200	16.46	75983
1996		160045	2061	162106		162106	15.10	175008	68052	17.94	80954
1997		174449	2185	176634		176634	16.46	190758	72135	19.55	86260
1998		190149	2316	192465		192465	17.93	207926	76463	21.31	91925
1999		207262	2455	209717		209717	19.54	226640	81051	23.23	97974
2000		225916	2602	228518		228518	21.29	247037	85914	25.32	104433
						2345429		2194028			733085

NET PRESENT VALUE= 191459

Table 5-17

BUFFALO DISTRICT HEATING

OPERATING COST SUMMARY

CASE NO.= 3B-CITY HALL SYSTEM+BAC & OLD CITY COURTS IN PARALLEL

OPTION: 9.5%.7YRS

YEAR	CAPITAL	FUEL	O & M	SYSTEM TOTAL	RETROFIT	TOTAL	$/MMBTU	CURRENT COST	CURRENT O & M	CURRENT $/MMBTU	SAVING
1986	14978	75589	1151	91718	215740	307458	28.65	82656	38000	8.47	-186802
1987	14978	80124	1220	96322		96322	8.97	87615	40280	8.98	31573
1988	14978	84932	1293	101203		101203	9.43	92872	42697	9.52	34366
1989	14978	90028	1371	106377		106377	9.91	98445	45259	10.09	37327
1990	14978	95429	1453	111860		111860	10.42	104351	47974	10.70	40465
1991	14978	104018	1540	120536		120536	11.23	113743	50853	11.66	44059
1992	14978	113380	1633	129990		129990	12.11	123980	53904	12.71	47893
1993		123584	1731	125314		125314	11.68	135138	57138	13.85	66961
1994		134706	1835	136541		136541	12.72	147300	60566	15.10	71326
1995		146830	1945	148775		148775	13.86	160557	64200	16.46	75983
1996		160045	2061	162106		162106	15.10	175008	68052	17.94	80954
1997		174449	2185	176634		176634	16.46	190758	72135	19.55	86260
1998		190149	2316	192465		192465	17.93	207926	76463	21.31	91925
1999		207262	2455	209717		209717	19.54	226640	81051	23.23	97974
2000		225916	2602	228518		228518	21.29	247037	85914	25.32	104433
						2353817		2194028			724697

NET PRESENT VALUE= 206228

A review of the operating costs projected for fifteen years also indicates that Case 3b is preferred. The net present value of the savings when the capital and retrofit costs are recovered is estimated to be over two hundred thousand dollars. The project breaks even in 1991 or in six years at a simple rate before taxes.

The following case discussions present the other early-start options. Majorka Village is a proposed single-family sub-division that will be built over the next few years. A small heating/cooling system was modeled for this project. Two scenarios for cogeneration development for the new Buffalo Stadium are presented. Both scenarios assume that the Marine Midland Center will participate as a customer of the system along with the stadium. This system could either be owned by the stadium or by a third-party investor.

MAJORKA VILLAGE HOUSING DEVELOPMENT

The purpose of this section is to evaluate how district heating and cooling can serve new residential development. Over the past several years, the City of Buffalo has encouraged residential in-fill in various neighborhoods in the city. These developments have generally been small subdivisions of twenty to forty dwelling units each. It is anticipated that this trend will continue with similar projects occurring periodically. Majorka Village is one such project.

Majorka Village is a proposed twenty-four unit, single family, middle income housing development, sponsored by the Muszynski family. Construction of the first unit in Phase I began in Spring, 1985 on a 4.22 acre parcel which is part of a 13.67 acre parcel of vacant land owned by the Muszynski family. In total, there is the potential to expand the development to approximately 40 acres.

The first phase of 4.22 acres is broken down into 1.734 acres of public streets and 2.489 acres of developable lots. The typical house is a two-story, detached, single-family dwelling with approximately 1200 square feet of living area (not including basement or garage). Assuming that the houses will be well constructed and built using current insulation and energy conservation techniques, including double glazed windows, ceiling insulation with an estimated R-value of 30, wall insulation rated at R-19, and normal weather sealing, it is estimated that each house will consume 44,000 Btu's/square foot in space heating annually. This yields a built-out energy load of 1.2672 billion Btu's.

It is assumed that each house will have individual heating units for space heating and that central air conditioning will not be included. It is further assumed that the heating systems will be impulse, gas-fired, forced air systems using a 100,000 Btu/hr furnace system. Domestic hot water will be supplied by gas-fired 40 gallon water heaters.

The developer, Mr. Henry Muszynski, indicated that he would consider hydronic heating systems for Majorka Village Phase I. This would facilitate the installation of district heating. Based on the 1980 census, either central warm-air or hydronic systems are acceptable in Buffalo. Mr. Muszynski also indicated that on-site gas wells are possible, although no test wells in the immediate areas are known.

The district heating system for the area would entail locating a small central plant in the development. The prime mover would be an impulse boiler that would supply low-temperature hot water to the individual homes. The system would also provide for domestic hot water. The design of the distribution and end-use systems would be similar to those inspected in Denmark, if hydronic end-use systems were selected by the developer. If warm air systems were selected, a fan coil unit would provide heat exchange at the customers unit. Figure 5-9 shows the proposed development and the district heating system installation.

Cost Analysis

In order to compare the costs of the various systems, cost estimates for a base case warm-air furnace were developed. The costs were taken from Means Residential/Light Commercial Cost Date-1985 Edition. The estimated installed cost for a gas-fired, forced-air heating system for a 1200 square foot house is estimated to be $2,475.00.

The cost for a gas-fired, hydronic system would be $5,500. The cost of a forced-air system using an impulse furnace would be approximately $2,900 per unit.

District Heating, assuming Danish type design standards, reduces each of the system costs by the cost of the furnace or boiler, and substitutes a small heat exchanger at each home. In any event, a gas-fired, forced-air furnace offers the lowest first cost.

Table 5-18 indicates the installation and operating costs of the customer heating-system options. The payback presented indicates the number of years of energy savings necessary to recover the additional investment. Based on the projected paybacks, district heating is not justifiable.

Table 5-18

MAJORKA VILLAGE HEATING SYSTEM COST COMPARISON

AVG. DEM= 40 B/H-SQFT
AVG CONS= 44000 B/Y-SQFT
NO.UNITS= 24 UNITS
FL. AREA= 1200 SQFT/UNIT

SYSTEM TYPE	HEAT SYSTEM COST ($/UNIT)	D.H.W. SYSTEM COST ($/UNIT)	MISC. SYSTEM COST ($)	DEVELOP COST ($)	OPER. EFF. (%)	ANNUAL USAGE (MMBTU)	ENERGY INPUT (MMBTU)	D.H.W. EFF. (%)	D.H.W. USAGE (MMBTU)	D.H.W. INPUT (MMBTU)	TOTAL INPUT (MMBTU)	ENERGY RATE ($/MMBTU)	ANNUAL ENERGY COST ($)	ANNUAL MAINT. COST ($)	ANNUAL LABOR COST ($)	ANNUAL TOTAL COST ($)	20 YEAR ANNUAL EQUIV. COST ($)
1. WARM AIR-CONVENTIONAL	2475	910		81240	.75	1267.2	1689.6	.8	328.8	411.0	2100.6	6.93	11709	585		12294	16356
2. HYDRONIC-CONVENTIONAL																	
RADIATION	5500	910		153840	.8	1267.2	1584.0	.8	328.8	411.0	1995.0	6.93	10977	549		11526	19218
FAN-COIL	5000	910		141840	.8	1267.2	1584.0	.8	328.8	411.0	1995.0	6.93	10977	549		11526	18618
3. WARM AIR-IMPULSE	2900	910		91440	.85	1267.2	1490.8	.8	328.8	411.0	1901.9	6.93	10331	517		10848	15420
4. DISTRICT HEAT																	
RADIATION	3900	1600	50000	182000	.85	1267.2	1490.8	.85	328.8	386.9	1877.7	5.93	8841	442		9283	18383
FAN-COIL	2410	1600	50000	146240	.85	1267.2	1490.8	.85	328.8	386.9	1877.7	5.93	8841	442		9283	16595

PAY BACK YEARS :	
DH VS. WARM AIR	33
DH VS. HYDRONIC RD	13
DH VS. HYDRONIC FC	18
DH VS. IMPULSE	58

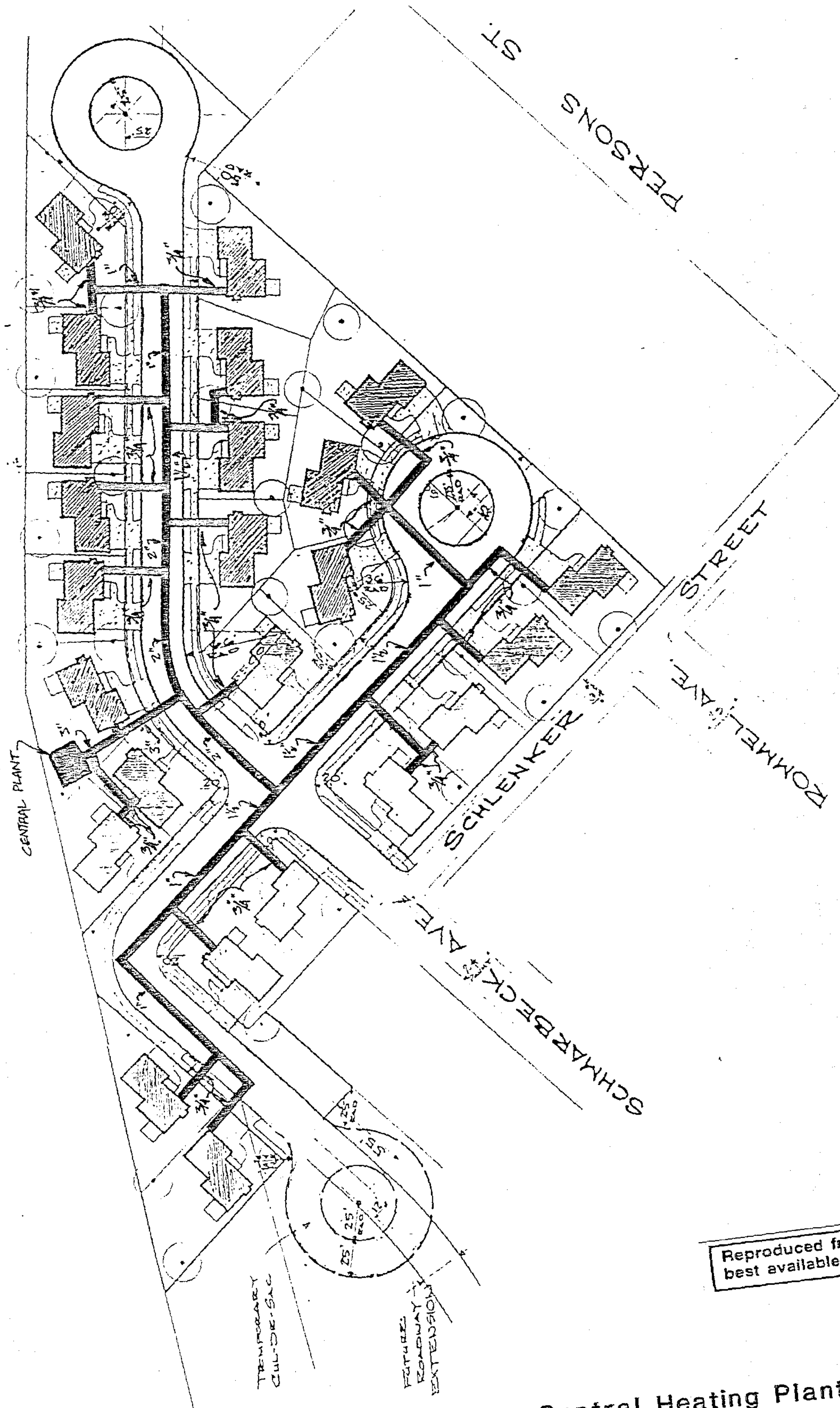


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Figure 5-9. Majorka Village Central Heating Plant

STADIUM SYSTEM

Another "Heat Island" to be considered in downtown Buffalo is the area bounded by Swan, Oak, Exchange and Pearl Streets. This area presents itself as a likely candidate for cogeneration and district heating and cooling because of two primary entities: Marine Midland Center and the Downtown Buffalo Sports Complex (Stadium). A significant portion of the thermal load in this area is attributed to the Marine Midland Center. Similarly, a large amount of heating, cooling and electric generating capacity could be installed in the not-yet-built stadium complex. The economic and technical aspects of a joint cogeneration operation were investigated: The Stadium would supply energy to Marine Midland and would sell excess electrical power to the utility grid. Case 4a is a scenario in which the stadium utilizes a diesel engine generator set for power production and employs a heat recovery device for the generation of hot water. Case 4b is similar to the Case 4a scenario except that a chiller-heater package is substituted for the waste heat boiler and chilled water is produced in addition to, and simultaneously with, hot water for better system efficiency and a more balanced seasonal operation.

MARINE MIDLAND CENTER

One Marine Midland Center

The Marine Midland Center is located on Main Street between Exchange Street & Seneca Street straddling the newly opened Main Street Transit System. The building is 42 stories tall and was completed in 1972. The center contains over one million square feet of floor area, with net leasable space of 880,000 square feet. Normal occupancy is eight hours a day, five and one-half days a week, fifty-two weeks a year, although the computer center is run twenty-four hours a day.

Hot water is generated both on the thirty-ninth floor and in the basement mechanical rooms for circulation throughout the building's heating system. The basement boilers are two electric hot water generators rated at 1320 KW each, or 132 BHP. Their thirty-ninth floor counterparts are natural gas-fired firetube boilers rated at 600

HP each. Hot water generated from the basement electric boilers is circulated throughout the building perimeter in finned tube radiation units, through the eight perimeter air handling units, and through the four interior air handling units. Steam generated from the two thirty-ninth floor boilers is sent through a heat exchanger, where it supplies heat to the building's circulating hot water system.

Housed in the basement are six chillers that produce chilled water for circulation throughout the buildings cooling system. Three of the six chillers are dedicated solely to the Marine Midland Computer Center. The computer center chillers were manufactured by the Trane Company and are rated at 230 tons each. The other three chillers provide cooling for the remainder of the building. These three chillers were also manufactured by the Trane Co., but two are rated at 2000 tons and the third is rated at 475 tons. All chillers are of the electrically driven centrifugal type. Cooling towers for all of the chillers are located on the rooftop. Steam from the firetube boilers is sent through a heat exchanger where it produces domestic hot water.

DESCRIPTION OF STADIUM COMPLEX

The proposed 20,000 seat stadium when completed would lie in the area outlined by Exchange, Seneca, Oak, and Washington Streets, immediately adjacent to the Marine Midland Center. Activities in the Phase I stadium will extend from early Spring to late Fall with the maintenance area functioning on a year-round basis. The structure is comprised of four distinct levels: The service (lowest), main, mezzanine, and club levels. The stadium is designed for a two-phase expansion program. Phase II would add additional seating capacity and an additional level. Phase III would add a dome for all-weather use of the facility and a cooling system for summer air-conditioning.

Heating for the stadium as of April, 1985, is planned to be provided by two Cleaver Brooks boilers rated at 5021 MMBtu/hr output each (or 150 hp). The selection of these boilers was based on an estimated heating load of 5 MMBtu/hr. Phase II and

III are designed with a 12 MMBtu/hr and 27 MMBtu/hr heat loss, respectively. Provisions for the purchase of added boiler capacity will be required upon the expansion from Phase I to Phases II and III. A water glycol anti-freeze solution is envisioned as the heat transfer media. HVAC units located on the service level and cabinet heaters located in all restrooms on all levels make up the terminal heating units.

Cooling is planned for parts of the service, club, and upper levels with no corresponding increase in interior cooling capacity planned for subsequent seating increases in Phases II and III. A nominal 600-ton Trane refrigeration machine was designed into the chilled water system. Chilled water is used in the various HVAC units. Domestic hot water would be generated from the Cleaver Brooks boilers.

Technical Options

The two potential cogeneration scenarios, Case 4a and Case 4b, were analyzed to better judge the merits of either configuration. Both cases are based on the role of Marine Midland as a multi-energy consumer and the stadium as a multi-energy producer. The following is a description of the physical and operational characteristics of these two configurations.

CASE 4A

Energy in the form of hot water and electricity are the commodities being exchanged in this case. The operation would be centered around a diesel generator-set housed on the service level of the stadium. A heat recovery device would be attached to the exhaust stream of the diesel engine. Heat from both the engine cooling water and the hot exhast gases would be recoverable, thereby boosting the overall fuel efficiency from about 30% (electric only) to about 70% (thermal and electric). This recovered heat would then be pumped throughout an insulated piping system in the form of hot water where individual users (Marine Midland and the stadium, initially) would extract their specific heating requirements. A small, hot water boiler would be used when loads are insufficient (usually 25%) to justify diesel operation. The engine would be run at the level which would satisfy the thermal demand as a first priority and electrical demand as a secondary priority. This type of operation is desirable because, during periods of high demands for heat, the electrical purchasing rate is generally low.

CASE 4B

Case 4b is an investigation of not only hot water and electricity production as analyzed in Case 4a, but also includes equipment for chilled water production. Simultaneous production of these three energy streams could be realized under the following scheme. The prime-mover diesel engine is incorporated as the energy source. The exhaust from the diesel would be passed through a packaged chiller-heater where both hot water and chilled water would be produced. Internally, the chiller-heater uses a simple heat exchange principle for hot water production whereby the hot exhaust gases transmit their heat to the circulating hot water. Chilled water is produced using an absorption refrigeration cycle whereby heat is removed from the chilled water as induced by the hot exhaust stream. The engine would operate to satisfy all chilled water and hot water demands while the by-product, electricity, is either consumed within the system or sold to the power grid at the going rate, currently $.06/kwh.

Operation of this configuration will result in a more flexible energy supply scheme. During hot summer months, there would be a high demand for chilled water and electricity and a low demand for hot water. Therefore, the production of chilled water would be emphasized and the electricity by-product could be sold to the grid at reasonable prices. During cold winter months, hot water demand is high, electrical and chilled water demand are lower, so hot water would be generated with electricity as a by-product. This is satisfactory during the day when electricity demand is moderate and current electrical rates are moderate. At night electric demand is low and often creates an in-balance in cogenerating systems. In this case, however, Marine Midland would not be heated extensively at night so the effects of this "off-balance" would not be significant. Nevertheless, a small boiler is recommended for night time and seasonal use because it could achieve a better efficiency at low loads.

Figures 5-10 and 5-11 present the location and configuration of Case 4a. As discussed, this system only provides heat to the Stadium and Marine Midland Center. In order to optimize efficiency and cost, the system is not operated during the summer months when loads are minimal. Tables 5-19 and 5-20 present the cost estimate and operating profile of the system.

The system as configured has a positive operating net revenue of approximately $250,000 in the first year. Assuming that this revenue would be targetted to debt service, the system debt could be retired in 11.4 years. This assumes 9.5% interest and 100% financing. This does not present a sufficient return to interest private sector investment.

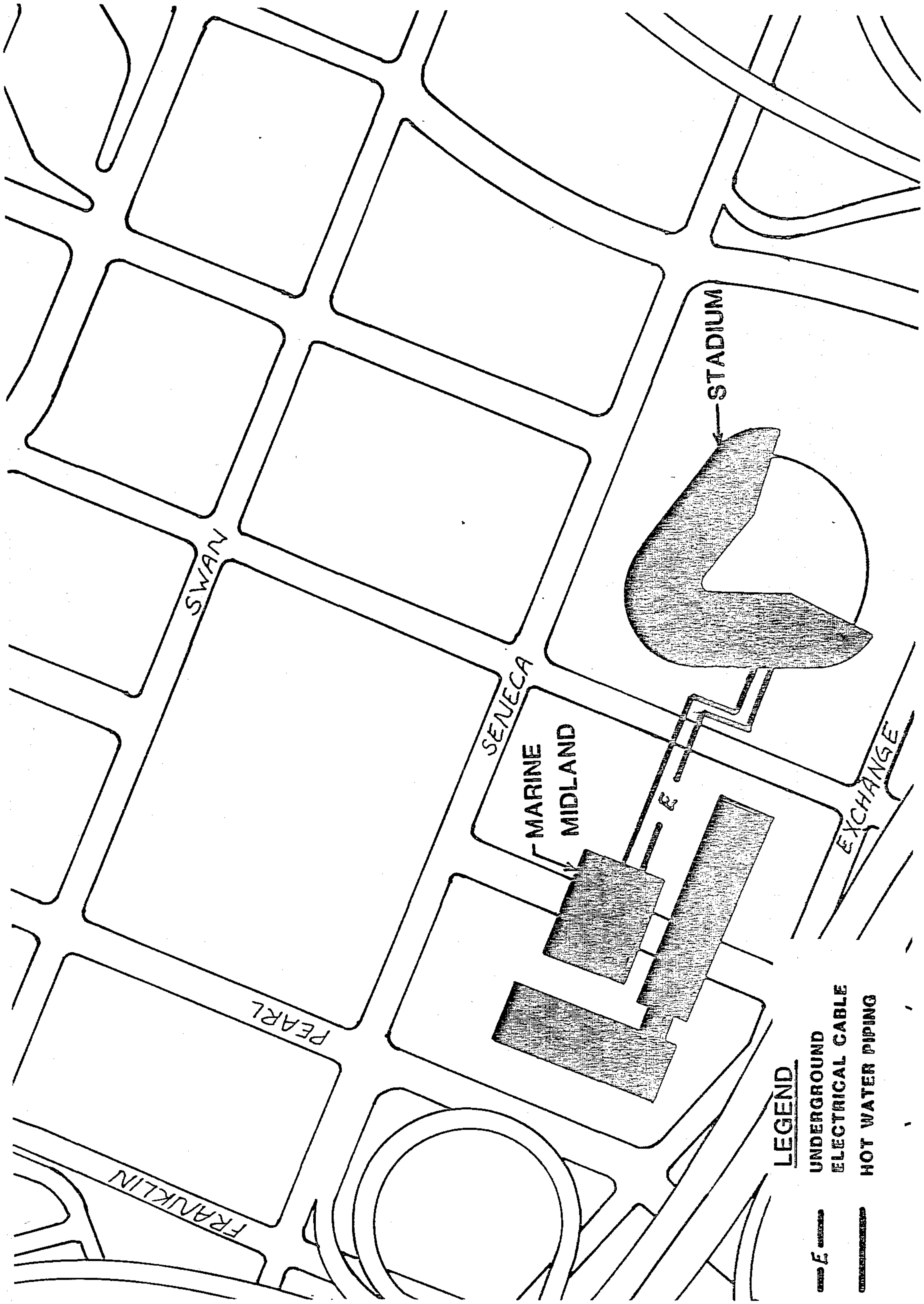

Figure 5-10. Stadium Cogeneration Case 4a

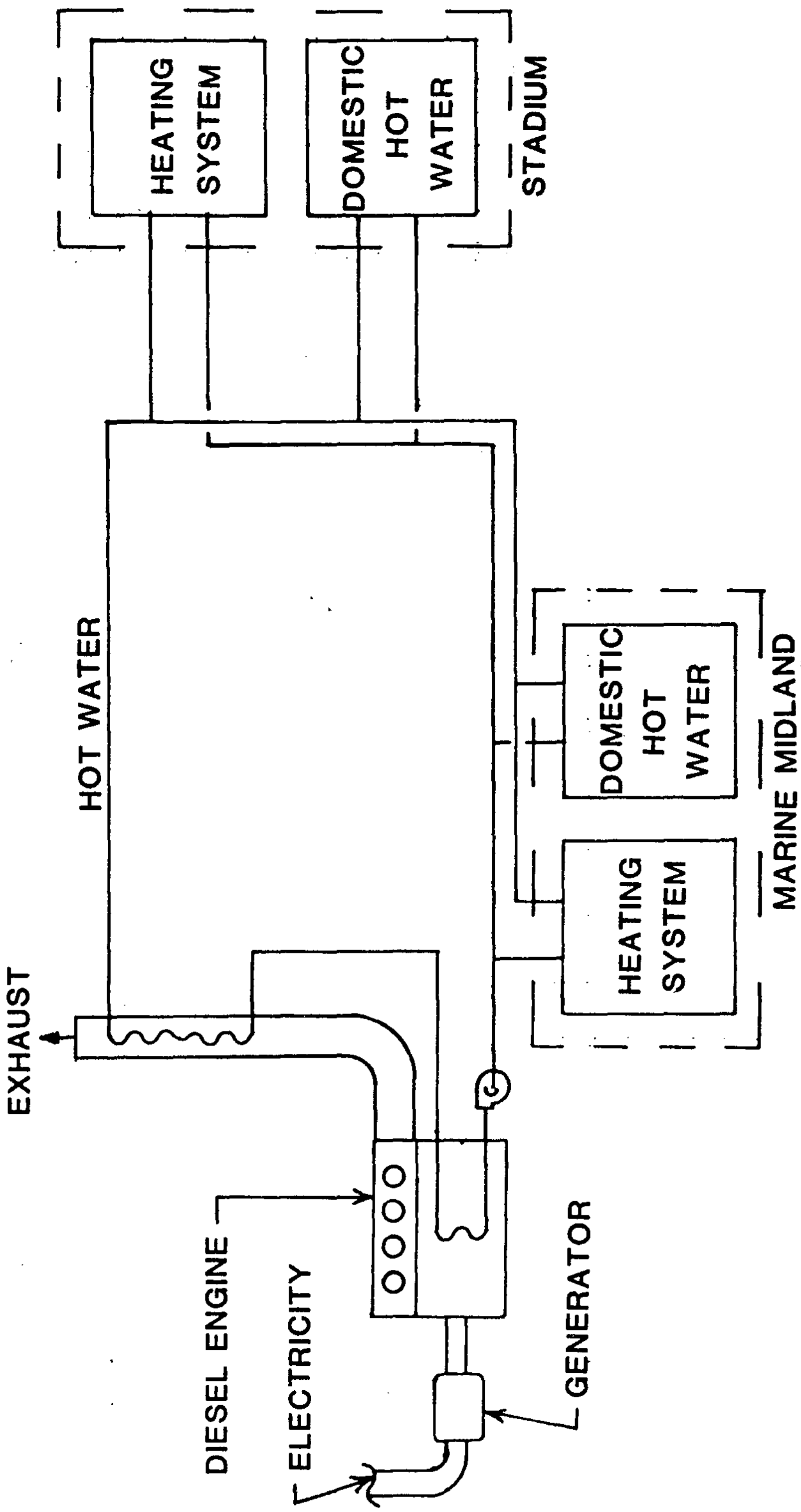

Figure 5-11. Stadium Cogeneration-Case 4a

Table 5-19

Resource Development Associates

CONSTRUCTION COST ESTIMATE	DATE 3/20/85	SHEET OF
PROJECT Buffalo	JOB Case 4a	
LOCATION	ESTIMATOR	DRAWING #

ITEM AND DESCRIPTION	QUANTITY		LABOR			MATERIALS		SUB-CONTRACT	TOTAL COST
	NO. UNITS	UNIT MEAS.	HRS. PER UNIT	$ PER HOUR	TOTAL $	$ PER UNIT	TOTAL $		
Diesel-Generator									$ 1400000
w/ Heat Recovery									
(3MW)									
D.H. Pumps									$ 10000
D.H. Piping & Fittings									$ 50000
Electrical Switchgear									$ 50000
Controls									$ 90000
Subtotal									$ 1600000
Contractor OH&P									$ 288000
(@18%)									
Subtotal									$ 1688000
Engineering & Contingencies									$ 135040
(@8%)									
TOTAL									$ 1823040

Table 5-20

BUFFALO DISTRICT HEATING

COGENERATION ANALYSIS - STADIUM AREA

CASE 4A

RESOURCE DEVELOPMENT ASSOCIATES

dayton/atlanta

MARINE MIDLAND BANK

TEMP. DEP COOLING=	4475 TONS
CONSTANT COOLING=	690 TONS
INSTALLED HEATING=	49000 MBH
TEMP. DEP HEATING=	40000 MBH
CONSTANT HEATING=	348 MBH
ANNUAL HEATING=	40000 MMBTU
ESTIMATED COOLING=	2500 TONS

STADIUM

INSTALLED COOLING=	600 TONS
ESTIMATED COOLING=	TONS
INSTALLED HEATING=	10000 MBH
ESTIMATED HEATING=	5000 MBH
ANNUAL COOLING=	TON-HR
ANNUAL HEATING=	5000 MMBTU

CENTRIF. CHLR COP=	2
ELECT COST =	.06 $/KWH
BOILER EFFICIENCY=	.75
NATURAL GAS HHV =	1000 BTU/CF
NATURAL GAS COST =	5.28 $/MMBTU
% FUEL RECOV-EXH=	22%
% ELECT. GEN DSL =	30%

THERMAL SALES =	9 $/MMBTU
GENERATOR CAP. =	3000 KW

MONTH	STADIUM HT CONS (MMBTU)	MAR MID HT CONS (MMBTU)	TOTAL HT CONS (MMBTU)	INPUT ENERGY (MMBTU)	HTG COST ($)	STADIUM COOLING (T-HR)	MAR MID CONST COOLING (T-HR)	MAR MID TEM DEP COOLING (T-HR)	TOTAL COOLING (T-HR)	TOTAL COOLING (MMBTU)	INPUT REQ'D (MMBTU)	INPUT REQ'D (KWH)	ELEC COST ($)	FUEL INPUT (MMBTU)	ELECT AVAIL. (KWH)	HEAT AVAIL. (MMBTU)	HEATING REVENUE ($)	ELECTRIC REVENUE ($)	FUEL COST ($)	MISC COST ($)	NET REVENUE ($)
JANUARY	300	7833	8133	10843	57253	0	154008	0	154008	1848	924	270744	16245	25393	2232000	5586	50278	133920	134074	5000	45124
FEBRUARY	300	6092	6392	8523	45003	0	139104	0	139104	1669	835	244543	14673	22935	2016000	5046	45412	120960	121099	5000	40273
MARCH	300	5129	5429	7239	38222	0	154008	0	154008	1848	924	270744	16245	24678	2232000	5586	48863	130153	130302	5000	43714
APRIL	300	3117	3417	4556	24057	1648	149040	8581	159269	1911	956	279992	16800	15533	2160000	5406	30755	81920	82013	5000	25661
MAY	192	1626	1819	2425	12804	6727	154008	35037	195772	2349	1175	344165	20650	8267	2232000	5586	16369	43601	43651	5000	11319
JUNE	69	639	708	944	4985	16798	149040	87488	253326	3040	1520	445343	26721	3219	2160000	5406	625	0	560	5000	-4935
JULY	0	86	86	115	608	24500	154008	127605	306113	3673	1837	538141	32288	392	2232000	5586	0	0	0	5000	-5000
AUGUST	0	86	86	115	608	22839	154008	118953	295801	3550	1775	520013	31201	392	2232000	5586	0	0	0	5000	-5000
SEPTEMBER	67	619	686	914	4828	11775	149040	61326	222140	2666	1333	390519	23431	3117	2160000	5406	600	0	550	5000	-4950
OCTOBER	300	2856	3156	4208	22216	3613	154008	18816	176437	2117	1059	310173	18610	14344	2232000	5586	28401	75649	75735	5000	23314
NOVEMBER	300	5695	5995	7993	42204	362	149040	1884	151285	1815	908	265957	15957	24574	2160000	5406	48656	129600	129749	5000	43507
DECEMBER	300	7238	7538	10050	53065	0	154008	0	154008	1848	924	270744	16245	25393	2232000	5586	50278	133920	134074	5000	45124
ANNUAL	2429	41016	43445	57927	305853	88261	1813320	459691	2361271	28335	14168	4151078	249065	168237	26280000	65775	320236	849722	851806	60000	258152

In Case 4b the inclusion of chilled water significantly improves the economics over those modelled in Case 4a. In this scenario, a four-pipe system for hot water supply and return and for chilled water supply and return are added as shown in Figures 5-12 and 5-13. Table 5-21 indicates that the piping system and packaged chiller-heater add approximately $700,000 to the system cost over the costs of Case 4a. However, in Table 5-22 the operating net revenues are substantially higher in the first year. This is due to the ability to sell chilled water. Since cooling competes with electricity, a higher price for the commodity can be charged.

In this case the system operating priorities are: Stadium heating, Stadium cooling, Marine Midland constant cooling (computer center), Marine Midland temperature-dependent cooling, and Marine Midland heating. The system is capable of supplying the total heating and cooling requirements for all but the total Marine Midland heating load in the winter. Even in the winter the system is capable of supplying base load heat to Marine Midland Center.

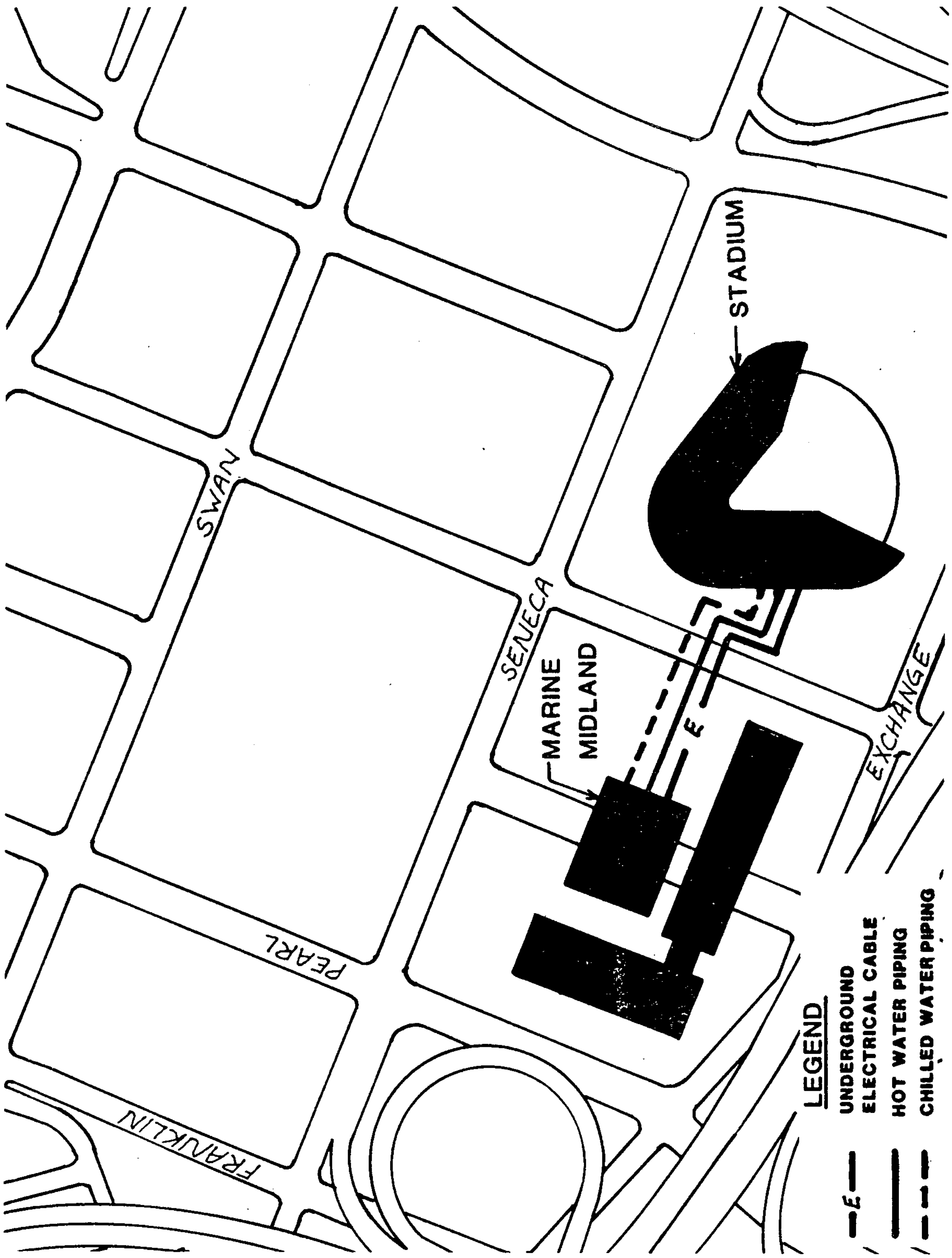

Figure 5-12. Stadium Cogeneration -Case 4b

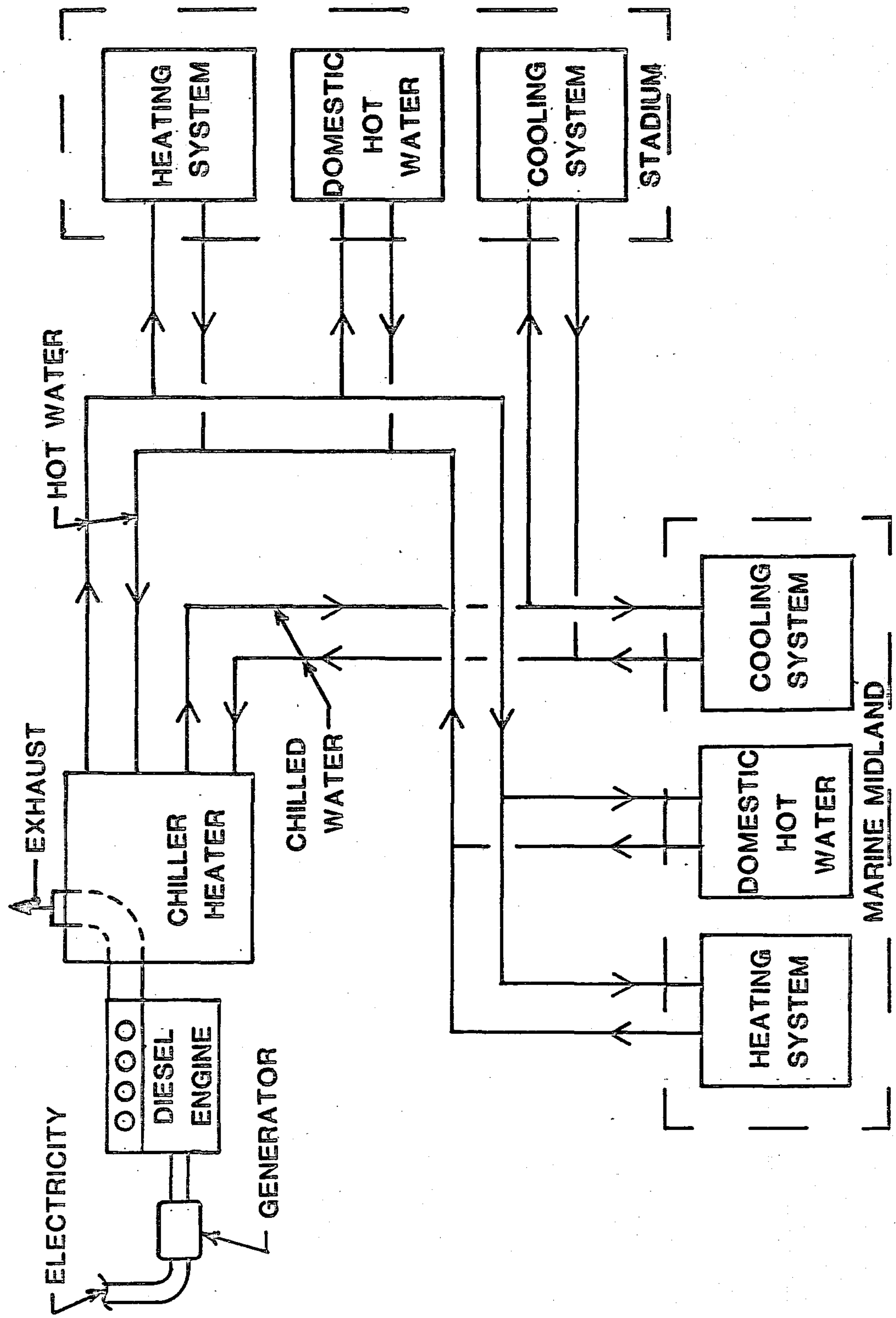

Figure 5-13. Stadium Cogeneration-Case 4b

Table 5-21

Resource Development Associates

CONSTRUCTION COST ESTIMATE	DATE 3/20/85	SHEET OF
PROJECT Buffalo	JOB Case 4b	
LOCATION	ESTIMATOR	DRAWING #

ITEM AND DESCRIPTION	QUANTITY		LABOR			MATERIALS		SUB-CONTRACT	TOTAL COST
	NO. UNITS	UNIT MEAS.	HRS. PER UNIT	$ PER HOUR	TOTAL $	$ PER UNIT	TOTAL $		
Diesel-Generator									$ 1000000
(3MW)									
Chiller-Heater									$ 550000
D.H. Pumps									$ 25000
D.H.C. Piping									$ 80000
Misc. Piping & Fittings									$ 160000
Controls									$ 130000
Electrical Switchgear									50000
Subtotal									$ 1995000
Contractor OH&P									$ 359100
(@18%)									
Subtotal									$ 2354100
Engineering & Contingencies									$ 188330
(@8%)									
TOTAL									$ 2542430

Table 5-22

BUFFALO DISTRICT HEATING
COGENERATION ANALYSIS - STADIUM AREA   4B

RESOURCE DEVELOPMENT ASSOCIATES
dayton/atlanta

MARINE MIDLAND BANK	
TEMP. DEP COOLING=	4475 TONS
CONSTANT COOLING=	690 TONS
INSTALLED HEATING=	49000 MBH
TEMP. DEP HEATING=	40000 MBH
CONSTANT HEATING=	348 MBH
ANNUAL HEATING=	40000 MMBTU
ESTIMATED COOLING=	2500 TONS

STADIUM	
INSTALLED COOLING=	600 TONS
ESTIMATED COOLING=	TONS
INSTALLED HEATING=	10000 MBH
ESTIMATED HEATING=	5000 MBH
ANNUAL COOLING=	TON-HR
ANNUAL HEATING=	5000 MMBTU

CENTRIF. CHLR COP=	2
ELECT COST =	.06 $/KWH
BOILER EFFICIENCY=	.75
NATURAL GAS HHV =	1000 BTU/CF
NATURAL GAS COST =	5.20 $/MMBTU
% FUEL RECOV-EXH=	22%
% ELECT. GEN DSL =	30%

THERMAL SALES =	9 $/MMBTU
CH. WATER SALES =	18.34 $/MMBTU
CHLLR-HTR COP =	1.1
GENERATOR CAP. =	3000 KW
CHILLER-HTR CAP. =	1000 TON

MONTH	STADIUM HT CONS (MMBTU)	MAR MID HT CONS (MMBTU)	TOTAL HT CONS (MMBTU)	INPUT ENERGY (MMBTU)	STADIUM COOLING (MMBTU)	MAR MID CONST COOLING (MMBTU)	MAR MID TEM DEP COOLING (MMBTU)	TOTAL COOLING (MMBTU)	TOTAL ENERGY AVAIL. (MMBTU)	ELECT GEN (MMBTU)	ENERGY AVAIL. (MMBTU)	REQ'D ENERGY (MMBTU)	HEATING REV STAD ($)	COOLING REV STAD ($)	CONSTANT COOLING REV MM ($)	TEMP DEP COOLING REV MM ($)	VARIABLE ENERGY AVAIL. (MMBTU)	HEATING REV MM ($)	ELECTRIC REVENUE ($)	FUEL COST ($)	MISC. COST ($)	NET INCOME ($)
JANUARY	300	7833	8133	10843	0	1848	0	1848	25393	7618	5586	9813	2700	0	33894	0	3438	30945	133920	134074	10000	57385
FEBRUARY	300	6092	6392	8523	0	1669	0	1669	22935	6881	5046	7910	2700	0	30614	0	3077	27689	120960	121099	10000	50864
MARCH	300	5129	5429	7239	0	1848	0	1848	25393	7618	5586	7109	2700	0	33894	0	3438	30945	133920	134074	10000	57385
APRIL	300	3117	3417	4556	20	1788	103	1911	24574	7372	5406	5155	2700	363	32801	1889	3195	28055	123571	123713	10000	55665
MAY	192	1626	1819	2425	81	1848	420	2349	25393	7618	5586	3954	1732	1481	33894	7711	3045	14637	94799	94908	10000	49346
JUNE	69	639	708	944	202	1788	1050	3040	24574	7372	5406	3472	625	3697	32801	19254	2297	5748	83225	83320	10000	52030
JULY	0	86	86	115	294	1848	1531	3673	25393	7618	5586	3426	0	5392	33894	28083	1913	777	82123	82217	10000	58052
AUGUST	0	86	86	115	274	1848	1427	3550	25393	7618	5586	3313	0	5026	33894	26179	2037	777	79426	79517	10000	55785
SEPTEMBER	67	619	686	914	141	1788	736	2666	24574	7372	5406	3109	602	2591	32801	13497	2674	5570	74534	74620	10000	44975
OCTOBER	300	2856	3156	4208	43	1848	226	2117	25393	7618	5586	5080	2700	795	33894	4141	3169	25701	121790	121930	10000	57091
NOVEMBER	300	5695	5995	7993	4	1788	23	1815	24574	7372	5406	7645	2700	80	32801	415	3291	29617	129600	129749	10000	55463
DECEMBER	300	7238	7538	10050	0	1848	0	1848	25393	7618	5586	9218	2700	0	33894	0	3438	30945	133920	134074	10000	57385
ANNUAL	2429	41016	43445	57927	1059	21760	5516	28335	298979	89694	65775	69204	21859	19424	399075	101169	35011	231404	1311788	1313292	120000	651428

Based on the projected operations, the system generates revenue sufficient to retire the capital cost in 5.1 years assuming 9.5% interest and 100% financing. This should be sufficient to interest private sector ownership. In future years, the economics of the system improve primarily due to projected increases in the price of electricity and slower escalations in the price of natural gas. Table 5-23 provides a fifteen-year revenue projection based on the fuel cost projections from Table 3-4. Cooling revenues escalate with electric projections, heating revenues escalate based on gas projections. Financing is assumed at 9.5% interest for seven years at 100% financing. Net present value is calculated using a 10% discount rate.

Table 5-23

OPERATING REVENUE PROJECTIONS

CASE= 4B

	ESCALATION FACTORS			REVENUE						OPERATING COSTS				
				STADIUM		MARINE MIDLAND CENTER						NET OPERATING	SYSTEM DEBT	SYSTEM NET
YEAR	INFLATION	NAT GAS	ELECT	HEATING	COOLING	CON COOL	TD COOL	HEATING	ELECTRIC	FUEL	MISC	REVENUE	SERVICE	REVENUE
1985	.05	0	.02	21859	19424	399075	101169	231404	1311788	1313292	120000	651427	510000	141427
1986	.05	.06	.019	23171	19793	406657	103091	245288	1336712	1392090	126000	616623	510000	106623
1987	.05	.06	.08	24561	21377	439190	111339	260006	1443649	1475615	132300	692205	510000	182205
1988	.05	.06	.12	26034	23942	491893	124699	275606	1616887	1564152	138915	855994	510000	345994
1989	.05	.06	.125	27596	26934	553379	140287	292142	1818998	1658001	145861	1055475	510000	545475
1990	.05	.06	.108	29252	29843	613144	155437	309671	2015449	1757481	153154	1242163	510000	732163
1991	.05	.09	.101	31885	32857	675072	171137	337541	2219010	1915654	160811	1391036	510000	881036
1992	.05	.09	.094	34755	35946	738529	187223	367920	2427597	2088063	168852	1535054		1535054
1993	.05	.09	.095	37883	39361	808689	205010	401033	2658218	2275989	177295	1696910		1696910
1994	.05	.09	.094	41292	43061	884706	224281	437126	2908091	2480828	186159	1871569		1871569
1995	.04	.09	.094	45008	47109	967868	245363	476467	3181451	2704102	193606	2065558		2065558
1996	.04	.09	.088	49059	51254	1053040	266955	519349	3461419	2947471	201350	2252255		2252255
1997	.04	.09	.074	53474	55047	1130965	286710	566090	3717564	3212744	209404	2387703		2387703
1998	.04	.09	.074	58287	59120	1214657	307926	617038	3992664	3501891	217780	2530022		2530022
1999	.04	.09	.077	63533	63673	1308186	331636	672572	4300099	3817061	226491	2696146		2696146
2000	.04	.09	.075	69251	68448	1406299	356509	733103	4622607	4160597	235551	2860070		2860070
				636900	637189	13091350	3318772	6742355	43032203	38265030	2793529	26400210	3570000	22830210
											NET PRESENT VALUE=	10501569		8018676

Section 6

PLAN OF ACTION

SUMMARY

In the evaluation of district heating and cooling in Buffalo, two small, early-start projects have been identified as priorities for development. The early-start system based at City Hall, including the buildings at 42 and 69 Delaware Avenue (Case 3b), and the cogeneration project at the proposed Buffalo Stadium and Marine Midland Center (Case 4b), offer the best potential technically and economically.

The City Hall system will become the core of a development program that can be broadened to include other publicly and privately owned buildings in the southwestern CBD. In fact, expanding this initial system is the objective of the district heating developer. The early-start system at the stadium also offers expansion potential from the core system. Since district heating and cooling systems substitute capital for fuel, the system developer must be prepared to expand the early-start systems incrementally, and recognize that the early-start systems represent only the first increment of development. As hot water district heating becomes accepted in the market place by building owners, each additional increment will be easier to market.

ACTION PLAN

In order to accomplish the longer term goal of an extensive district heating system, Buffalo proposes an interim program with four objectives:

1. Demonstrate the technical and economic merit of district heating and cooling development in downtown Buffalo.
2. Market the concept of hot water district heating technology, and cogeneration to building owners.
3. Facilitate private district heating system development by providing public cooperation and support for system development.
4. Provide a system design standard to insure future systems connectibility.

This approach is similar to the program of development found in Denmark, that is, to start with small economically and technically feasible projects that have immediate benefits and are consistent with a long-term development plan. This is also consistant with Buffalo's commitment to implement projects designed to enhance the long-term viability of the downtown.

The elements of the plan concentrate on the marketing of the concept. In order to market the DHC idea, particularly the benefits of hot water, it will be necessary to show the community a working model. The demonstration system will provide the community with confidence in hardware - heat exchangers, piping systems, and related equipment - and with working contractual relationships for energy between suppliers and consumers.

The future cogeneration system at the proposed stadium will be part of a new development. It will provide design standards, secure owners and customers, and provide methodologies and models for the sale of energy - both thermal and electric.

The overall plan of system growth will provide the community with an orderly program that can be pursued by the City of Buffalo or its designated agency to insure compatible system development.

Task 1 - System Development Program

The district heating development in Buffalo will occur over an extended period. As buildings are renovated, HVAC systems are improved and modernized, and district heating becomes a meaningful option for building owners, architects and engineers. In the long term, a district heating network in Buffalo based on early-start systems, designed for expansion, can provide building owners with an energy delivery option using least-cost fuels and more efficient energy source technology.

In order to achieve the goal of developing a district energy network, Buffalo will need to develop an institutional framework for guiding development. The objective of this task is to establish a consistent set of standards for energy system development, building modernization, and the encouragement of thermal energy sales as a strategy for building owners to follow.

Concept Design. Central to the task is the development of a conceptual design for the overall system. This entails predicting a built-out system for the target area, and working backward through a series of logical development increments to the early-start system. By establishing a conceptual path for development, the City of Buffalo, building owners and the general public will be better able to understand the requirements for system expansion, the need for building owner cooperation and the role each can play in encouraging development. This work element will result in a long-term plan for use by Buffalo in encouraging district heating development.

Design Standards. The design standards will be based on the schematic design. In this work element, Buffalo will develop system sizing guidelines for the built-out system. These guidelines will dictate that building-to-building system piping will be sized to allow connection when the permanent transmission and distribution lines are installed. Included in the design will be piping standards, i.e., general material specifications and installation guidelines; a new methodology for the orderly transfer of ownership at the time of installation; and city policies for the opening of streets and the maintenance of system components. This, coupled with the schematic design, will form the working document for development policies and procedures.

Schematic Design. Critical to the long-term successful development of district heating, building owners, engineers and architects must be made aware of the plans for district heating development to insure that new buildings or HVAC system modifications provide for the future connection to a hot water district heating system. Building owners near the early-start system should be aware that expansion potential exists within the near future. Early in the effort, Buffalo will develop a schematic design that will identify the design standards of the system, connection policies and rate setting procedures. Within the schematic design will be elements dealing with the in-ground piping system, should building-to-building systems be developed, and in-building HVAC standards to insure that future connections will be compatible.

Cogeneration Systems. In both the early-start system and the intermediate and built out stages of development, cogeneration can play a vital role in the district heating development program. It will be the objective of this task to encourage the development of cogeneration in Buffalo. To encourage system development, the project team will continue to evaluate, refine and encourage the development of an early-start cogeneration system at the proposed Buffalo Stadium. This will include evaluating ownership and financing options, contractual arrangements and market expansion options.

Financing Plan. The objective of this work element is to put in place a plan for financing the incremental development of the early-start systems. This will involve evaluating optimal financing arrangements including Industrial Revenue Bond financing under different potential ownership arrangements and financing using energy savings in the private market. The financing plan will identify Equity requirements and rate setting for the various system expansions anticipated. The result of this work element will be preliminary agreements on financing methodology for system expansion and model contracts for sale of energy.

The project team will work with funding and financing agencies and lenders such as Erie County Industrial Development Agency, local banks, state and federal agencies, and other identified sources as appropriate.

Corporate Entity - District Heating Development Corporation. This task will establish the corporate entity to develop, own, manage, direct and operate district heating development in Buffalo. It is likely that the corporation will be a non-profit development corporation established by Development Downtown, Inc. and be chartered to enter into contracts for system development. In the long term as the system develops, alternate forms of corporate management such as a cooperative may be more appropriate. These alternatives will be explored and identified for future consideration.

Task 2 - Marketing Program: Plan

The remaining two tasks constitute the marketing element for the Phase II District Heating and Cooling program in Buffalo. Task 2 will establish the plans and programs necessary to market district heating development and expansion. In Task 3, a demonstration system is developed to give building owners, engineers, architects and the general community a first hand look at the technology, construction techniques and operating performance of a modern district heating system.

Within Task 2 are three work elements: System Marketing Plan, Building Owner Contact Program, and Documented Savings Program. These work elements will occur through the entire Phase II effort. They will be targeted generally to the community and specifically to those in the target area.

System Marketing Plan. Based on the ownership option selected, a marketing plan for the long-term development of district heating will be developed and put into operation. The marketing plan will have three target markets. First, those buildings near the early-start systems will be targeted and attempts will be made to include these buildings as customers for early-system expansion. The goal is to begin system expansion as soon as possible. The second target will be building owners in the downtown that could implement service from building to building under the design requirements established in Task 1, that is, shared boiler systems. Third, investigations will continue in other parts of the city to identify system development opportunities. The project team will particularly concentrate on projects that could potentially provide service to residential customers.

The marketing plan will provide the guiding document for the long term growth of district heating. It will establish direction and methodologies for future system development. It will also provide staff with materials and methods for securing customer contracts for immediate expansion.

Contact Building Owners. Under this element, the project team will make contact with building owners for possible connection to or development of district heating systems. The team will use materials developed in the previous work element. An informative and educational contact program will be established to provide an introduction to district heating and Buffalo's program, and specific contacts will be made to convince building owners to participate in the growth of district heating in Buffalo.

Documented Savings Program. To support the marketing efforts, particularly in the Building Owner Contact program, the project team will keep detailed records that document the savings from participation in a district heating system. The documentation will come predominately from two sources. First, the experience gained from the early-start system in Buffalo. Second, the experience from systems in Provo, Utah; St. Paul, Minnesota; Jamestown, New York; and other projects that have developed modern hot water district heating systems. This effort and the experience of other building owners will greatly assist in convincing additional building owners of the reliability and cost effectiveness of hot water district heating.

Task 3 - Marketing Program: System Development

An integral part of the program in Buffalo lies in establishing an operating district heating system. The purpose of this is to allow the community, building owners, architects, mechanical engineers, and others to observe the technology, installation, operation, and reliability of district heating. Since many engineers are generally unfamiliar with available components of hot water systems, this task should help to convince the market that district heating would be economically feasible in Buffalo.

Design. In this element, a design for an early-start system will be developed. The design, based on the concept developed for Case 3b, is centered on the City Hall. It will include provisions for system expansion to other buildings in the area.

One of the sub-elements of the design will be working with the building owner of 42 and 69 Delaware Avenue on building retrofit plans and contractual arrangements for service.

Implementation. In this element, the early-start system will be constructed. The construction will be documented for use in marketing efforts. The documentation will be useful for Buffalo and could be used in other cities and programs to document construction techniques, retrofit techniques and physical obstacles of construction found in major, older cities.

Project Management. Initially the project will be managed by Development Downtown Inc., currently the Phase I project manager. Upon the establishment of the organizational unit charged with district heating development, responsibility for implementation will be shifted to this new unit. DDI will continue to participate, handle financial arrangements, and monitor system arrangements and progress.

Consulting services will be secured to develop system designs, marketing efforts and materials, evaluate and monitor energy savings and benefits, and provide other services as needed.