District Cooling and Heating Development in Stamford, Connecticut

FINAL REPORT

Prepared for

THE STAMFORD PARTNERSHIP

Supported by

NORTHEAST UTILITIES
and
UNITED STATES DEPARTMENT OF ENERGY

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Prepared by

JOSEPH TECHNOLOGY CORPORATION, INC.
188 BROADWAY WOODCLIFF LAKE, NJ 07675

June, 1990

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SECTION 1

EXECUTIVE SUMMARY

INTRODUCTION

This report summarizes the activities of a study intended to examine the feasibility of introducing district cooling (and heating) for a selected neighborhood of downtown Stamford, CT.

A district energy system as defined for the Stamford project is understood as the production of hot and chilled water at a central energy plant, and its distribution underground to participating buildings in the vicinity. The objective of the study was to investigate implementation of a district energy system in conjunction with advanced cooling technologies to compete with conventional alternatives (which provide heating and cooling for buildings with on-site energy plants) as a means to encourage energy conservation and provide the City with an economic development tool.

The project would serve as a pilot program to demonstrate the inherent flexibility of district energy and the rewards of expanding the system when further innovations and technology options become attractive.

The site selected for district energy development was identified in the Hoyt Street/Strawberry Hill area of the town and featured a balanced mixture of key ingredients which are inclined to foster actual implementation. The prospective market consisted of a core of project supporters, namely City and State buildings, both having expressed interest to participate in an initial project. Coincidentally, construction of a new Stamford Court Complex in this same area offered an added incentive recognizing the potential avoidance of capital investment for its own heating and cooling plant. The area is characterized by a concentration of high-rise apartment buildings, a hospital, public high school and other public buildings.

The goals of the project were to demonstrate district energy systems as an economic development incentive for the City to precipitate future growth opportunities and to remain a highly competitive urban center in the Northeast. Such a project would benefit Stamford by most importantly reducing energy cost to participating buildings as well as promoting a clean technology, eliminating on-site fuel handling, avoiding capital costs for individual heating and cooling plants and reducing operation and maintenance expenditures.

The study was conducted by Joseph Technology Corporation, Inc. and performed for the Stamford Partnership. The study was funded by a grant from the U. S. Department of Energy and Northeast Utilities, the local electric utility.

APPROACH AND RESULTS

The purpose of the study was to initiate the implementation procedure by identifying a system configuration which displayed the proper ingredients to foster actual construction. The study was comprised of those tasks which would give direction to the project, providing coverage to the various aspects affecting project development. This included marketing, analysis of

Stamford buildings, district energy production and distribution and an economic forecast of the overall system configuration.

Technical analysis of Stamford buildings was aimed at determining the cost of heating and cooling with individual on-site energy plants as a means of comparison with a district energy alternative.

Results, as indicated in Figure 1-1, estimated a total cost savings of approximately 25% if selected buildings joined a district energy system.

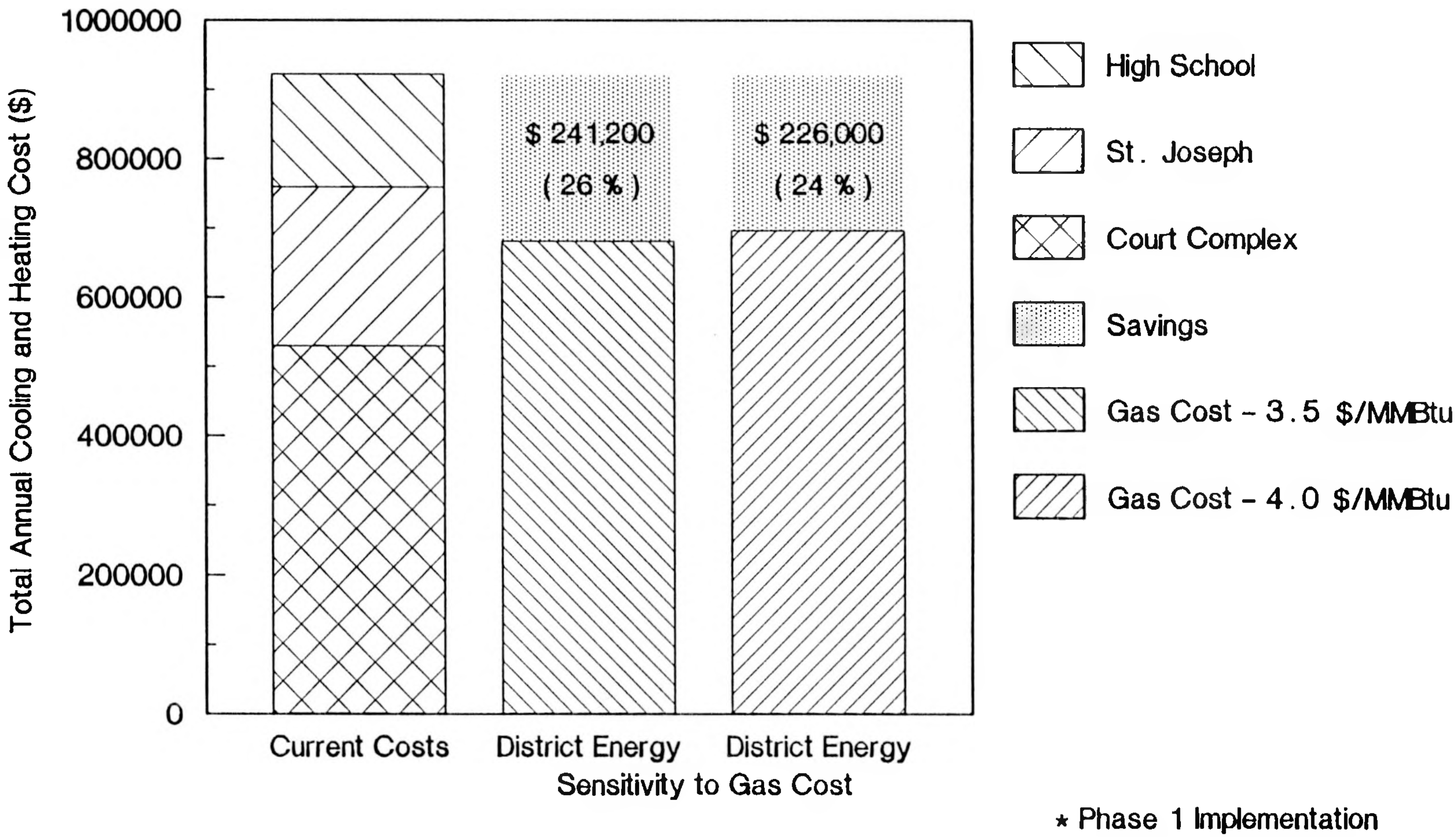
Analysis of the system configuration focused on selecting an arrangement which offered a realistic opportunity for implementation. Although several alternatives were identified, the option most suitable based on economic evaluation and minimal investment sited a heating and cooling plant within the confines of the St. Joseph Medical Center's central energy plant. The plant would consist of steam to hot water heat exchangers to convert steam from the existing boiler plant to low temperature hot water and hi-efficiency electrically driven centrifugal chillers for chilled water production. Both services would be exported to the various buildings which comprise the project.

A cost estimate was prepared to include plant and underground piping components. Two phases of growth were examined for the initial system, each phase to be coordinated with the addition of new customer's buildings with the addition of new thermal capacity. The cost of the complete system after two phases of implementation is estimated at approximately $3,000,000, assuming

Figure 1-1

COMPARISON OF TOTAL ANNUAL COOLING AND HEATING COSTS AND POTENTIAL SAVINGS WITH DISTRICT ENERGY

Stamford District Cooling and Heating Project



financial support from the State.

The overall system configuration was presented in an economic analysis which reflected all the proposed system costs of capital, operation and maintenance associated with the district heating and cooling system. The economic analysis calculated the breakeven unit cost to provide district heating and cooling service and was then compared to the cost assuming individual on-site plants which recognized a 20-30% savings with district service.

ACTION PLAN

This study demonstrated the savings achievable through a district energy alternative to conventional on-site energy plants. The results of this study are preliminary. It remains to build on these results through detailed cost estimates suitable for defining a construction budget.

It is recommended to proceed with the following actions:

1. Announce an intent to build a modern hot and chilled water district energy system to serve a pilot project in the vicinity of Hoyt Street/Strawberry Hill neighborhood of Stamford.
2. Perform detailed cost estimates with sufficient accuracy to authorize a construction budget. This should include the renovation required to house the plant within the existing energy plant at St. Joseph Medical Center as well as the plant itself and the underground distribution system.
3. Refine cost figures prepared for each customer to achieve

sufficient accuracy for committing to system interconnection.

4. Develop cost estimate to permit customer facility to interconnect with the district cooling system.
5. Perform an economic analysis based on customer's current cost (Item 3), customer's retrofit cost (Item 4) and district energy cost. Accumulated savings are presented as a payback to recover the cost of the retrofit.
6. Prepare results of economic analysis and present to customer for review. Revise accordingly, seeking a letter of commitment to join the system.
7. Finalize interconnection agreements as district energy prices and contractual responsibilities are established.
8. Retain a general contractor to construct the system.

SECTION 2

District Energy Market Analysis

- Marketing Objective
- Identifying the Energy Market
- Customer Survey of the Energy Market
- Customer Survey Evaluation
- Develop Customer Current Cooling & Heating Cost
- Summary of Results

SECTION 2

DISTRICT ENERGY MARKET ANALYSIS

MARKETING OBJECTIVE

An essential element of any district energy project is the marketability of the product and the importance of customer awareness and acceptance of the technology to secure their commitment to join the system. A close working relationship must be developed since the customer has the option to retain existing systems and forego further participation. Marketing is required not only for the benefit of the customer, but is needed to confirm first costs of the district cooling system, operations and ultimately profitability.

The marketing strategy addresses the issues which enable both system owners and potential customers to make educated decisions regarding district energy service to his building. The primary goal of this strategy is to determine a customer's current cost to supply cooling and heating with existing on-site equipment. This result can then be compared to the cost of delivering district service by a utility to determine savings.

IDENTIFYING THE ENERGY MARKET

When attempting to develop district energy systems from inception, it is generally agreed that public support and participation greatly facilitates the opportunity to implement a project. For this project, public support has been expressed on City and State levels. The City of Stamford, through the mayor's office, public works and planning departments, has endorsed the concept.

The Energy Division of the Office of Policy and Management for the State of Connecticut has actively encouraged investigations at several sites including Hartford and New Haven, as well as Stamford. This public support was then keyed to a service area where public participation was possible. Such an area was identified in the Strawberry Hill section of Stamford. The area is graced with a high concentration of mixed-use buildings. Included in this population is a public high school, several court buildings and police headquarters which represent the prospective public participants of a project. It is notable that the existing court buildings will be demolished for construction of a new and larger state-funded court complex. Implementing a district energy system in conjunction with new building construction is an added incentive since there is a capital cost avoidance associated for on-site thermal generating equipment which would be required for the court if district energy does not become available.

The area is also rich in multiple high-rise residential dwellings which often serve as superior anchor customers owing to their high annual heating and cooling loads.

The final player which represents substantial anchor load has also been identified as the thermal source plant for the system, i.e., St. Joseph Medical Center. As will be discussed in a following section, St. Joseph appears to feature excess thermal capacity which could be exported to a district energy system.

CUSTOMER SURVEY OF THE ENERGY MARKET

To assess the potential market for district energy in the Strawberry Hill section of Stamford, a site survey of buildings was conducted in the vicinity of St. Joseph's Medical Center. The survey was accomplished both with mailed questionnaires and on-site visits. The objective of each approach was to solicit responses regarding the technical aspects of installed cooling systems, energy consumption and cost, and maintenance expenditures. This information was retained for subsequent analyses to determine each customer's current cost to cool and heat his building.

The engineer's primary goal of the survey involves the collection of information which complements efforts to calculate annual cooling and heating loads, calculate current costs, and to identify the compatibility with a district energy system. During the survey, fuel and electric records are requested which indicate both quantities and cost. Plant operations are reviewed to determine personnel requirements, cost of service contracts and materials including spare parts, water, sewer and chemicals. The existing cooling and heating plant is examined for age, reliability, available free space, rated output and percent utilized, location within the building, operating temperatures and pressures, comfort setting control and maintenance procedures.

These visits also accomplish a less apparent but equally important function of creating an awareness and enthusiasm regarding district energy and its advantages. Benefits discussed range from the potential energy savings to be claimed by the individual customer to the broad issues of introducing district energy to provide an economic incentive to the area. The interest displayed by prospective customers is vital to the success of the project.

CUSTOMER SURVEY EVALUATION

A summary of the customer survey evaluation is contained in Table 2-1. The table indicates pertinent information regarding existing systems and estimated loads. Eight building surveys were evaluated to determine the feasibility of introducing district energy to the area. For each building where information is available, building floor area, central chiller and boiler capacity, systems type year of installation, and fuel source are listed.

These buildings include:

- St. Joseph Medical Center
- Stamford High School
- Stamford Police Department
- Stamford Court Complex (under development)
- Dwelling Unit Rental Complex (under development)
- Hampshire House
- 71 Fountain Terrace
- 91 Fountain Terrace

DEVELOP CUSTOMER'S CURRENT COOLING AND HEATING COST

An analysis was performed for selected potential customers to determine their current cooling and heating cost as a means of comparison to the cost of district energy. The analysis was

Table 2-1

Stamford District Cooling and Heating Project

SUMMARY OF CUSTOMER SURVEY RESPONSES

			COOLING				HEATING			
Ref. Number	Customer Name	Building Area (sqft)	Central Cooling System?	Installed Capacity (Tons)	Cooling System Type	Cooling Fuel Type	Central Heating System?	Installed Capacity MMbtu/hr	Heating System Type	Heating Fuel Type
1	St. Joseph Medical Center	250,000	partial	300	cw	elec	Yes	23	hw	gas/oil
2	Stamford High School	230,000	none	40	dx	elec	Yes	30	hw	gas/oil
3	Stamford Court House (planned)	250,000	yes	1200	cw	elec	Yes	6.7	hw	gas/oil
4	Stamford Police Department	50,000	yes	50	cw	elec	Yes	3.2	stm	gas
5	Hampshire House	120,000	none	n/a	dx	elec	Yes	n/a	stm	oil
6	71 Fountain Terrace	178,000	none	n/a	dx	elec	Yes	n/a	stm	oil
7	91 Fountain Terrace	178,000	none	n/a	dx	elec	Yes	n/a	stm	oil
8	Condos (under development)	200,000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

based on survey information and estimates based on experience from other projects. The analysis was conducted for the following buildings:

* * * *

Table 2-2: Estimated Heating and Cooling Cost with On-Site Production Plants for the Stamford Court Complex

Table 2-3: Estimated Heating and Cooling Cost with On-Site Production Plants for St. Joseph's Medical Center

Table 2-4: Estimated Heating and Cooling Cost with On-Site Production Plants for Stamford High School

* * * *

The cost categories which comprise the customer's current cooling and heating cost include: 1) capital component, 2) energy component and 3) operations and maintenance component. Summation of these components and converting this result to a unit cost by dividing by the annual load provides a methodology of comparison to the price of district energy. Unit costs are expressed in $/ton-hr for cooling and $/MMBtu for heating.

o CAPITAL COMPONENT

The capital component of current cooling and heating cost includes the central equipment and related components which would be replaced in a district energy retrofit. Specific items include chillers, boilers, cooling towers, evaporator and condenser pumps and piping components, controls and installation. The new construction for the Stamford Court Complex suggests additional cost avoidance since the structural work needed to house on-site equipment is eliminated. Structural items include foundations, heavy steel framing, noise isolation, ventilation, rigging, etc. The analysis calculates costs on an annual basis.

Table 2-2

Stamford District Cooling and Heating Project

ESTIMATED COOLING AND HEATING COST WITH ON-SITE PRODUCTION PLANTS

Customer: Stamford Court Complex		COOLING		HEATING		TOTALS	
--- THERMAL LOAD ESTIMATE							
Peak Load		850	tons	5.0	mmbtu/hr		
Annual Full Load Operating Hours		1,000	hr	1,700	hr		
Annual Load		850,000	ton-hr	8,500	mmbtu		
--- CAPITAL COST							
Capital Cost						1,640,000	$
Heat plant includes 2 x 3.35 mmbtu/hr boilers							
Cool Plant includes 2 x 600 ton chillers							
Capital Recovery Factor (assuming 11.0% interest, 20 yr. period)						12.6	%
Annual Capital Cost Component						205,900	$
--- ANNUAL OPERATIONS							
Energy Efficiency		1.00	kw/ton	75.0	eff-%		
Electric Consumption @	0.09 $/kw-hr	76,500	$	1,600	$		
Gas/Oil Consumption @	4.50 $/mmbtu	0	$	51,000	$		
DHC Pumping Electric @	0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)		76,500	$	52,600	$	129,100	$
Personnel						60,000	$
Replacement Parts/Service						20,000	$
Boiler Lease from St Joseph						0	$
Water,Sewer,Chemicals						10,000	$
Insurance,Taxes,Misc (1.5% of invest)						25,000	$
Loss of Rented Space -	20 $/sqft					80,000	$
Subtotal (non fuel)						195,000	$
--- ON-SITE COOLING AND HEATING COST CALCULATION							
Annual Capital Cost Component						205,900	$
Annual Fuel						129,100	$
Annual Non-fuel Operations						195,000	$
Annual Total Costs		397,500	$	132,500	$	530,000	$
Estimated Cost Apportionment		75%		25%			
Annual Cooling/Heating Load		850,000	ton-hrs	8,500	mmbtu	18,700	mmbtu
Unit Cooling/Heating Cost >>>>>>>>>>>>>>>>>>		0.47	$/ton-hr	15.59	$/mmbtu	28.34	$/mmbtu

Table 2-3

Stamford District Cooling and Heating Project

ESTIMATED COOLING AND HEATING COST WITH ON-SITE PRODUCTION PLANTS

Customer: St Joseph Medical Center		[---- COOLING ----]		[---- HEATING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE ---							
Peak Load		300	tons	5.0	mmbtu/hr		
Annual Full Load Operating Hours		1,000	hr	1,700	hr		
Annual Load		300,000	ton-hr	8,500	mmbtu		
--- CAPITAL COST ---							
Capital Cost Heat plant includes 2 x 5.0 mmbtu/hr boiler Cool Plant includes 3 x 100 ton chillers (assumed)						360,000	$
Capital Recovery Factor (assuming 11.0% interest, 20 yr. period)						12.6	%
Annual Capital Cost Component						45,200	$
--- ANNUAL OPERATIONS ---							
Energy Efficiency		1.20	kw/ton	70.0	eff-%		
Electric Consumption @	0.09 $/kw-hr	32,400	$	1,600	$		
Gas/Oil Consumption @	4.50 $/mmbtu	0	$	54,600	$		
DHC Pumping Electric @	0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)		32,400	$	56,200	$	88,600	$
Personnel						60,000	$
Replacement Parts/Service						20,000	$
Boiler Lease from St Joseph						0	$
Water,Sewer,Chemicals						10,000	$
Insurance,Taxes,Misc (1.5% of invest)						5,000	$
Loss of Rented Space -	20 $/sqft					0	$
Subtotal (non fuel)						95,000	$
--- ON-SITE COOLING AND HEATING COST CALCULATION ---							
Annual Capital Cost Component						45,200	$
Annual Fuel						88,600	$
Annual Non-fuel Operations						95,000	$
Annual Total Costs		125,800	$	103,000	$	228,800	$
Estimated Cost Apportionment		55%		45%			
Annual Cooling/Heating Load		300,000	ton-hrs	8,500	mmbtu	12,100	mmbtu
Unit Cooling/Heating Cost >>>>>>>>>>>>>>>>>>		0.42	$/ton-hr	12.11	$/mmbtu	18.91	$/mmbtu

Table 2-4

Stamford District Cooling and Heating Project

ESTIMATED COOLING AND HEATING COST WITH ON-SITE PRODUCTION PLANTS

Customer: Stamford High School	[---- COOLING ----]		[---- HEATING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE						
Peak Load	100	tons	4.3	mmbtu/hr		
Annual Full Load Operating Hours	1,000	hr	1,700	hr		
Annual Load	100,000	ton-hr	7,310	mmbtu		
--- CAPITAL COST						
Capital Cost Heat plant includes 2 x 3.35 mmbtu/hr boilers Cool Plant includes 2 x 80 ton chillers					292,000	$
Capital Recovery Factor (assuming 11.0% interest, 20 yr. period)					12.6	%
Annual Capital Cost Component					36,700	$
--- ANNUAL OPERATIONS						
Energy Efficiency	1.00	kw/ton	65.0	eff-%		
Electric Consumption @ 0.09 $/kw-hr	9,000	$	1,600	$		
Gas/Oil Consumption @ 4.50 $/mmbtu	0	$	50,600	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	9,000	$	52,200	$	61,200	$
Personnel					40,000	$
Replacement Parts/Service					15,000	$
Boiler Lease from St Joseph					0	$
Water,Sewer,Chemicals					7,000	$
Insurance,Taxes,Misc (1.5% of invest)					4,000	$
Loss of Rented Space - 20 $/sqft					0	$
Subtotal (non fuel)					66,000	$
--- ON-SITE COOLING AND HEATING COST CALCULATION						
Annual Capital Cost Component					36,700	$
Annual Fuel					61,200	$
Annual Non-fuel Operations					66,000	$
Annual Total Costs	49,200	$	114,700	$	163,900	$
Estimated Cost Apportionment	30%		70%			
Annual Cooling/Heating Load	100,000	ton-hrs	7,310	mmbtu	8,510	mmbtu
Unit Cooling/Heating Cost >>>>>>>>>>>>>>>>>>	0.49	$/ton-hr	15.69	$/mmbtu	19.26	$/mmbtu

To present the capital component on an annual basis a capital recovery factor is applied to the total cost. For purposes of this analysis, the capital recovery factor was assumed at 11% interest for a 20-year term.

o ENERGY COMPONENT

The energy component consists of the energy cost for cooling and heating production within the building and includes the cost of gas, oil, and electricity. The energy component includes the efficiency of the central equipment; more energy is expended to produce a given quantity of useful thermal output. This criteria is often not fully understood by the customer who measures his cooling and heating loads directly as the amount of electricity and fuel consumed. For cooling, this is further complicated since electric cooling is usually added to other electric auxiliaries and lighting in the building for billing purposes making it difficult to determine actual cooling cost and load.

o O&M COMPONENT

The O&M component which is credited to current cost is comprised of those items which would be displaced in the event district energy became available. It generally considers the effort required to operate/maintain the central cooling and heating equipment described previously. Specific items include operating labor, water treatment, water and sewer cost, and service contracts. Other even less apparent costs are the implied reductions in property tax and insurance. Where floor space is a premium, the elimination of central equipment and the associated noise, smell and dirt will enable these areas to be converted to useful working areas. The inherent loss of this space is a hidden cost of present systems.

SUMMARY OF RESULTS

The capital, energy and O&M components for each customer were summated as indicated in Tables 2-2 to 2-4. Based on the annual cooling and heating loads estimated for each customer, a unit cooling and heating cost was determined by dividing total cost by the annual thermal loads.

Results indicate a calculated current cooling and heating unit cost which are presented below:

	CALCULATED UNIT COSTS	
CUSTOMER NAME	COOLING ($/ton-hr)	HEATING ($/MMBtu)
St. Joseph Medical Center	.42	12.1
Stamford High School	.49	15.7
Stamford Court Complex	.47	15.6

These results are compared to the unit energy costs determined for district energy in Section 3.

SECTION 3

District Energy System Configuration Analysis

- Configuration Criteria
- Advantages of Centralizing Thermal Production at St. Joseph Medical Center
- Capital Cost of the Proposed Configuration
- Economic Analysis of District Energy Service for the Proposed Configuration

SECTION 3

DISTRICT ENERGY SYSTEM CONFIGURATION ANALYSIS

CONFIGURATION CRITERIA

Configuring a district energy system in an established city without prior experience recognizes the need for a modest start at minimal cost to enhance its prospects for success from both economic and institutional considerations. To achieve this end, a small compact system provides a cautious approach to any implementation strategy. Although small, the configured system must still abide by the rules of economic feasibility through the proper complement of load versus piping distance from the central energy plant. Any new building construction should be identified for inclusion in the system recognizing the substantial first cost savings which the customer will avoid for an on-site cooling and heating plant.

Options for the central energy plant should first seek existing plants with sufficient capacity to enable district energy export without heavy capital expenditures.

From an institutional perspective and as was addressed in the previous discussion, the service area should be comprised of participants who will anchor the system, encouraging the success of the project. In the case of Stamford, city and state buildings are attractive anchors recognizing their support for this project.

To a varying degree, all these criteria are satisfied in the Strawberry Hill area of Stamford. The presented configuration was identified after a survey in the vicinity of St. Joseph Medical Center. The configuration criteria is summarized below for the selected option which is sketched in Figure 3-1.

o PUBLIC PARTICIPATION

Within the configured system, several public buildings would serve to anchor the system. These include two city-owned buildings, Stamford High School and Stamford Police Department and a state-funded project, the Stamford Court Complex.

o NEW CONSTRUCTION

Coincident with public participation, it also happens that the existing court buildings which face Hoyt Street will be demolished and replaced with a new and larger state-funded court complex. This situation offers a unique opportunity for the state to demonstrate its commitment to district energy while avoiding the first costs of an on-site plant.

A residential complex (condominiums) consisting of approximately 260 units is proposed for a site which lies to the west of St. Joseph Medical Center bordering Morgan Street. This is another opportunity which could be embraced within a district energy project.

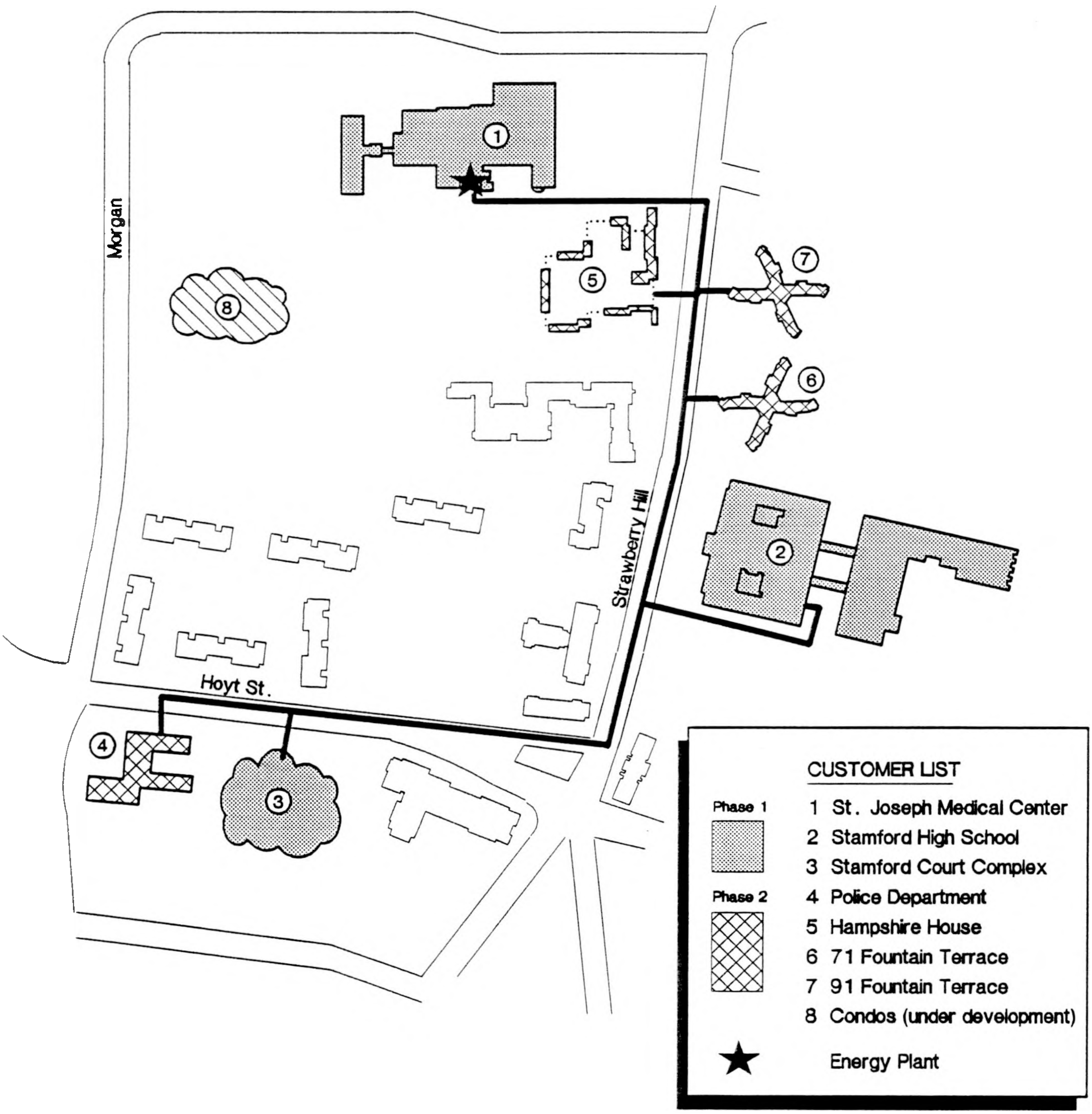
o SYSTEM SIZE

All prospective customers are within a half mile of each other, making the system compact. Their close proximity will reduce the percentage that the underground piping system will cost with respect to the total budget.

Figure 3-1

PROPOSED DISTRICT ENERGY SYSTEM CONFIGURATION

Stamford District Cooling and Heating Project



The first phase would witness construction of a four-pipe underground distribution system between the hospital and the Court Complex. To accommodate the requirements of the Court Complex and permit the addition of loads from other potential customers, an 8 inch hot water and a 12 inch chilled water supply and return system was estimated. The Stamford High School is assumed as a connected customer in Phase 1.

In the second phase, other existing buildings in close proximity to the distribution system are interconnected. For purposes of discussion, these customers include Hampshire House, 71 and 91 Fountain Terrace Condominiums and the Stamford Police Department. An additional hot water convertor is installed at the hospital to provide sufficient heating capacity for the new customers. Distribution work would include burial of service piping from the main header to each customer.

The implementation strategy is summarized in Table 3-1, indicating the participants, loads and equipment dispatch schedule. Note that a third phase is indicated for a future development site.

o CENTRAL ENERGY PLANT

Excess thermal capacity was identified at St. Joseph Medical Center's central energy plant. With the installation of additional hi-efficiency chillers, this site could serve as an energy plant for the system at lower cost than if a new plant were constructed elsewhere. Refer to Figure 3-2 for a plan view of St. Joseph Medical Center, the location of the energy plant

Table 3-1

Stamford District Cooling and Heating Project

EQUIPMENT CAPACITIES AND DISPATCH TO MEET LOAD ASSUMING ENERGY PLANT AT ST JOSEPH MEDICAL CENTER

****

Phase 1 : Core Customers
Phase 2 : Add Secondary Customers
Phase 3 : Add Secondary Customers

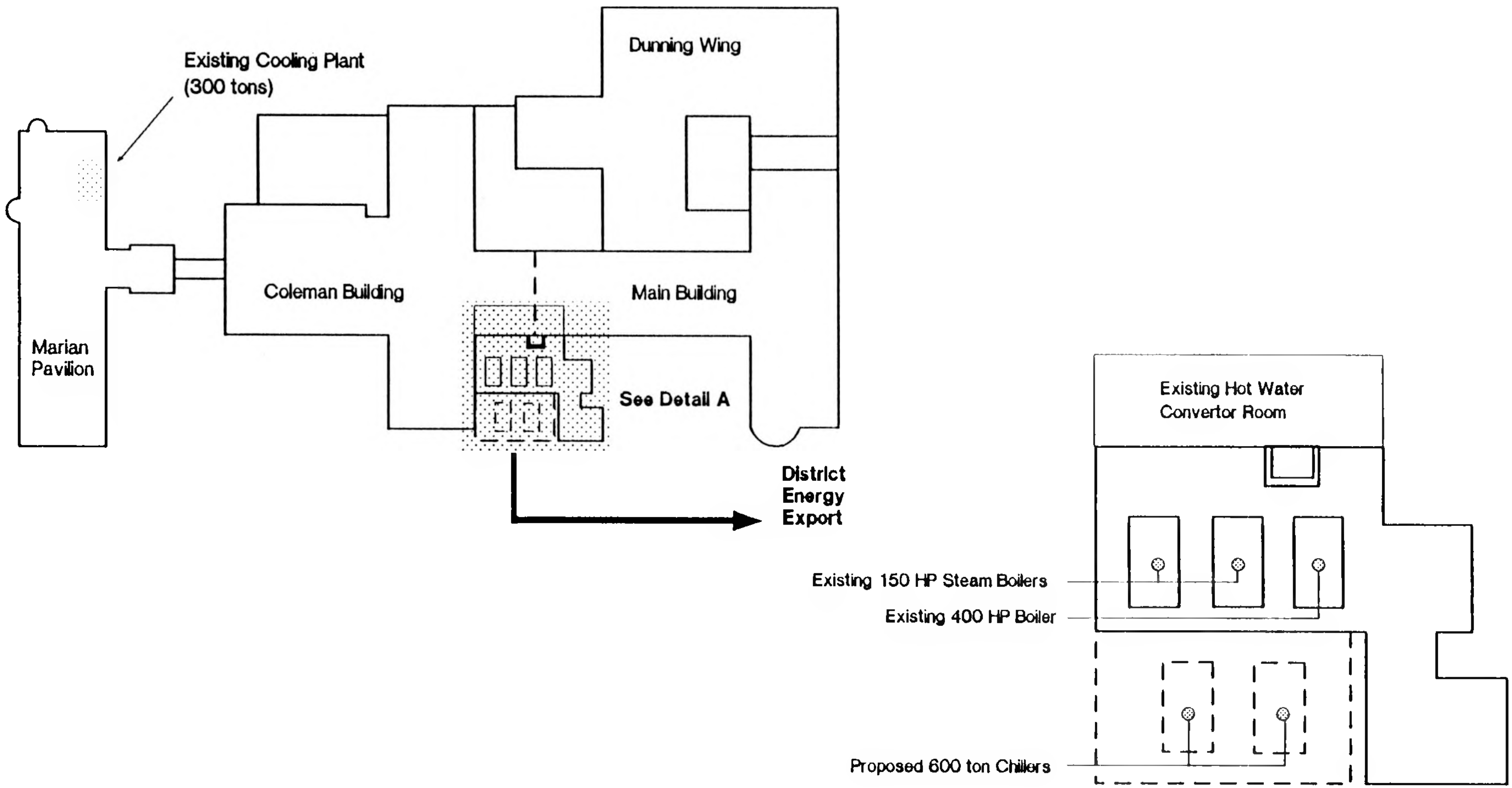
****

PHASE	CUSTOMER NAME	COOLING Peak Load (tons)	COOLING Add New Capacity (tons) (1)	COOLING Existing Capacity (tons) (2)	COOLING Total Capacity (tons) (1+2)	HEATING Peak Load (mmbtu/hr)	HEATING Add New Capacity (mmbtu/hr) (3)	HEATING Existing Capacity (mmbtu/hr) (4)	HEATING Total Capacity (mmbtu/hr) (3+4)
1	St. Joseph Medical Center	300	1200	300	1500	5.0	0.0	23.0	23.0
	Stamford Court Complex(planned)	850	0	0	0	5.0	0.0	0.0	0.0
	Stamford High School	100	0	0	0	4.3	0.0	0.0	0.0
	Total Phase 1	1250	1200	300	1500	14.3	0.0	23.0	23.0
	Diversified	1063				12.2			
2	Stamford Police Department	150	0	0	0	1.1	0.0	0.0	0.0
	Hampshire House	0	0	0	0	2.2	0.0	0.0	0.0
	71 Fountain Terrace	0	0	0	0	3.2	0.0	0.0	0.0
	91 Fountain Terrace	0	0	0	0	3.2	0.0	0.0	0.0
	Total Phase 2	150	0	0	0	9.7	0.0	0.0	0.0
	Diversified	128				8.2			
3	Condos (under development)	400	0	0	0	3.0	0.0	0.0	0.0
	Total Phase 3	400	0	0	0	3.0	0.0	0.0	0.0
	Diversified								
	Total	1800	1200	300	1500	27.0	0.0	23.0	23.0
	Diversified	1530				23.0			

Figure 3-2

PROPOSED ENERGY PLANT FOR THE DISTRICT ENERGY SYSTEM

St. Joseph Medical Center Plan



" DETAIL A "
PROPOSED ENERGY PLANT

with respect to the complex, and equipment location and layout within the plant. Two 600-ton chillers would be installed in an expanded energy plant. The existing hot water convertor room would be modified to utilize the existing steam boilers at the hospital to produce the hot water for the system. Existing boiler capacity at the hospital consists of two 5 MMBtu/hr (150 HP each) and one 13 MMBtu/hr (400 HP) high pressure boilers. An existing convertor room converts the boiler steam to hot water for distribution within the complex. Since the boilers are high pressure, the sendout temperatures needed for district heating can be easily accomplished.

ADVANTAGES OF CENTRALIZING THERMAL PRODUCTION AT ST. JOSEPH'S MEDICAL CENTER

o REDUCE FIRST COSTS FOR THE COURT COMPLEX

A district energy alternative reduces the first costs associated with the installation of cooling and heating systems in new construction. This cost saving is achieved by all the involved architectural/engineering disciplines. The mechanical engineer avoids the installation of heating and cooling production equipment, associated piping, controls, fuel supply and ventilation requirements. Removal of production equipment from the plans allows the architect to integrate these areas with the balance of useful floor space. Since the weight of the equipment is removed, the structural engineer can relax framing/foundation requirements. The electrical engineer can reduce the service to the building since cooling production is removed to an off-site location.

For existing buildings, central plant upgrading due to age or unreliable equipment can be avoided. A district energy retrofit does not involve high maintenance items and provide years of service.

o REDUCE INSTALLED CAPACITY AT THE CENTRAL ENERGY PLANT

Centralization of cooling and heating at St. Joseph's Medical Center enables engineers to reduce the installed thermal production capacity and subsequent cost of the plant over that which would otherwise be required for multiple buildings. This consideration evolves from the diversity in load which is experienced when a group of buildings is interconnected to a common plant. Stated differently, the plant operates at a peak load which is less than the summation of individual building peaks. Centralization also allows for reduced redundancy of capacity.

o RECOVER VALUABLE FLOOR SPACE

Another consideration of dispatching major cooling and heating components to St. Joseph's Medical Center is the elimination of mechanical rooms within the Stamford Court Complex to house them. This freed space can be incorporated into the architectural layout of useful and rentable space. For existing buildings, removal of abandoned equipment permits conversion of these areas to other useful purposes.

o ENERGY EFFICIENCY OF DISTRICT ENERGY

Energy cost reduction of district energy is achieved through higher operating efficiencies and lower cost fuel than can be obtained by smaller dispersed systems.

Load diversity or load leveling is characteristic of district energy systems and occurs when the needs of many buildings are interconnected to a single loop. This phenomena permits the district energy plant to operate at reduced peaks and at longer sustained intervals which contributes to enhanced energy utilization. This enables equipment to function close to their design ratings.

A district energy plant consumes large quantities of fuel at a single location. This bulk demand enables operators to purchase fuel at a discount over individual customers which contributes to the lower cost.

This energy cost reduction is passed through to the connected customer who enjoys the rewards of improved energy utilization.

o OPERATING AND MAINTENANCE SAVINGS

Connected buildings benefit from an operations and maintenance perspective. Through an adoption of district cooling and heating, on-site expenditures for these services can be reduced. Without the need to operate chillers and boilers, operating staffs, budgets, utilities and service contracts are not required for this equipment. This is particularly important for this project which being comprised of several separate buildings, can significantly consolidate its operating staff through a district system. Since the work environment is safer having avoided on-site production, insurance premiums to protect employees and the public will be reduced.

o FLEXIBILITY FOR FUTURE INTERCONNECTION TO INNOVATIVE TECHNOLOGIES

Centralizing cooling and heating production facilitates future interconnection of the plant with other investment opportunities including cogeneration and thermal storage. These technologies are often more effective when applied to a large thermal production plant. This same rationale would apply to the interconnection of other developing energy centers to this project.

CAPITAL COST OF THE PROPOSED CONFIGURATION

The capital cost for the proposed system at the Strawberry Hill site is comprised of the equipment and components required for thermal production and distribution to prospective customers. The cost estimate coincides with the proposed implementation strategy by distributing costs over two phases. Phase 1 includes the installation of two 600 ton hi-efficiency chillers and hot water convertors and a distribution trunk line which will enable district service to St. Joseph Medical Center, the Stamford High School and Stamford Court Complex. Capital requirements for Phase 2 includes the incremental costs associated with the interconnection of additional customers including the Stamford Police Department, Hampshire House, 71 and 91 Fountain Terrace.

The capital cost is adjusted for the Phase 1 investment through the assumption of State assistance totaling $500,000 as it regards participation of the Stamford Court Complex.

Cost of the underground distribution system includes a four-pipe system for hot and chilled water, an allowance for service piping connections to customers and Btu metering equipment.

The capital cost estimate is presented in the following table:

* * * *

Table 3-2: Capital Cost Estimate Assuming a District Energy Plant at St. Joseph's Medical Center

* * * *

ECONOMIC ANALYSIS OF DISTRICT ENERGY SERVICE FOR THE PROPOSED CONFIGURATION

To justify the economics of implementing the system, the approach employed derives an annual cost to provide this service assuming sales to the selected customers. This cost is presented on a unit energy basis expressed in $/ton-hr for cooling and $/MMBtu for heating.

The cost categories which comprise the unit cooling and heating cost are equivalent to the considerations examined for individual customers in Section 2 and include a capital component, an energy component and an O&M component.

o CAPITAL COMPONENT

The capital component consists of the expenditures for the central energy plant at St. Joseph Medical Center and the distribution system. The entire cost is assumed to be financed. To annualize this cost, a capital recovery factor is applied based on 11% interest rate and a twenty year debt term.

o ENERGY COMPONENT

The energy component consists of the gas and electrical energy consumed for the chilled and hot water production. The energy costs reflect a reduction over that of an individual customer

Table 3-2

Stamford District Cooling and Heating Project

CAPITAL COST ESTIMATE ASSUMING ENERGY PLANT AT ST JOSEPH MEDICAL CENTER

Phase 1: Core Customers
Phase 2: Secondary Customers

ITEM DESCRIPTIONS — COST ESTIMATE

[--- Costs are in 1990 Dollars ---]

CENTRAL ENERGY PLANT AT ST JOSEPH MEDICAL CENTER

Item	Units	Number and Size Phase 1	Phase 2	Phase 3	Phase 4	Cost Phase 1	Cost Phase 2	Cost Phase 3	Cost Phase 4
*** Cooling Plant ***									
electric centrifugal chillers, cooling towers,pumps,piping,etc electric service upgrade	(ton)	(2)x600							
Cost						$1,040,000			
*** Heating Plant ***									
convertors,pumps,piping,etc	(mmbtuhr)	(2)x9.0	(1)x9.0						
Cost						$80,000	$28,000		
*** Building Upgrade ***									
Cost						$150,000			
CENTRAL PLANT SUBTOTAL (installed)						$1,270,000	$28,000		

DISTRICT PIPING DISTRIBUTION SYSTEM

Item	Size (in)	Location	Length in Trench Feet Phase 1	Phase 2	Phase 3	Phase 4	Cost Phase 1	Cost Phase 2	Cost Phase 3	Cost Phase 4
Transmission:										
cool	12	underground	2500	0	0	0	$637,500			
heat	8	underground	2500	0	0	0	$488,750			
Service Connections:										
	10	underground	200	0	0	0	$50,000			
	4	underground	0	600	0	0	$0	$102,000		
	3	underground	1000	1500	0	0	$85,000	$127,500		
Btu Meters:			6	5	0	0	$48,000	$40,000		
DISTRIBUTION SUBTOTAL (installed)							$1,309,250	$269,500		

	Phase 1	Phase 2	Phase 3	Phase 4
CENTRAL PLANT SUBTOTAL (installed)	$1,270,000	$28,000	$0	$0
DISTRIBUTION SUBTOTAL (installed)	$1,309,250	$269,500	$0	$0
Contingency	$258,000	$30,000	$0	$0
Engineering	$181,000	$21,000	$0	$0

TOTAL ESTIMATED COST

	Phase 1	Phase 2	Phase 3	Phase 4
Total Cost For Each Phase	$3,018,250	$348,500	$0	$0
Grant Application	$500,000			
Total Cost After Each Phase	$2,518,250	$2,866,750		

recognizing improved operating efficiency and bulk fuel purchases.

o O&M COMPONENT

An allowance is budgeted for manning, parts, service, raw materials (water, sewer, chemicals), insurance, taxes, etc. to operate the system. It should be noted that on a unit energy basis, O&M is less costly for a district energy system since operations are centralized and more efficiently performed.

o BREAKEVEN COMPUTATION AND CONCLUSIONS

The base case economic model is presented in the following tables for Phase 1 and 2 system configurations:

* * * *

Table 3-3: Estimated District Cooling and Heating Unit Cost Calculation - Phase 1 (Sensitivity Case: gas cost = 3.5 $/MMBtu)

Table 3-4: Estimated District Cooling and Heating Unit Cost Calculation - Phase 1 and 2 (Sensitivity Case: gas cost = 3.5 $/MMBtu)

* * * *

The approach calculates the required revenue to justify the system's implementation and establishes a unit cost based on anticipated energy sales. The model totals the three cost components (capital, energy and O&M) which must be recovered as required revenue and determines the breakeven unit cost.

Results indicate a 20%-30% annualized cost savings with district energy service over the individual customer costs with on-site plants estimated in Section 2. This comparison is graphically presented in the following figures for cooling and heating:

Table 3-3

Stamford District Cooling and Heating Project

ESTIMATED DISTRICT COOLING AND HEATING UNIT COST CALCULATION

Energy Plant at St Joseph Phase 1: Core Customers		[---- COOLING ----]		[---- HEATING ----]		[--- TOTALS ---]	
Sensitivity Case: gas cost = 3.5 $/MMBtu							
--- THERMAL LOAD ESTIMATE ---							
Peak Load		1,250	tons	14.3	mmbtu/hr		
Annual Full Load Operating Hours		1,000	hr	1,700	hr		
Annual Load		1,250,000	ton-hr	24,310	mmbtu		
--- CAPITAL COST ---							
Capital Cost (See Table 3-2)						2,518,250	$
Capital Recovery Factor (assuming 11.0% interest, 20 yr. period)						12.6	%
Annual Capital Cost Component						316,200	$
--- ANNUAL OPERATIONS ---							
Energy Efficiency		0.80	kw/ton	80.0	eff-%		
Electric Consumption @	0.08 $/kw-hr	80,000	$	2,000	$		
Gas/Oil Consumption @	3.50 $/mmbtu	0	$	106,400	$		
DHC Pumping Electric @	0.08 $/kw-hr	10,500	$	3,400	$		
Subtotal (fuel)		90,500	$	111,800	$	202,300	$
Personnel						60,000	$
Replacement Parts/Service						25,000	$
Boiler Lease from St Joseph						30,000	$
Water,Sewer,Chemicals						10,000	$
Insurance,Taxes,Misc (1.5% of invest)						38,000	$
Loss of Rented Space -	20 $/sqft					0	$
Subtotal (non fuel)						163,000	$
--- DISTRICT COOLING AND HEATING COST CALCULATION ---							
Annual Capital Cost Component						316,200	$
Annual Fuel						202,300	$
Annual Non-fuel Operations						163,000	$
Annual Total Costs		408,900	$	272,600	$	681,500	$
Estimated Cost Apportionment		60%		40%			
Annual Cooling/Heating Load		1,250,000	ton-hrs	24,310	mmbtu	39,310	mmbtu
Unit Cooling/Heating Cost >>>>>>>>>>>>>>>>>>		0.33	$/ton-hr	11.21	$/mmbtu	17.34	$/mmbtu

Table 3-4

Stamford District Cooling and Heating Project

ESTIMATED DISTRICT COOLING AND HEATING UNIT COST CALCULATION

Energy Plant at St Joseph Phase 1+2: Core + Secondary Customers	[---- COOLING ----]		[---- HEATING ----]		[--- TOTALS ---]	
Sensitivity Case: gas cost = 3.5 $/MMBtu						
--- THERMAL LOAD ESTIMATE ---						
Peak Load	1,400	tons	24.0	mmbtu/hr		
Annual Full Load Operating Hours	1,000	hr	1,700	hr		
Annual Load	1,400,000	ton-hr	40,800	mmbtu		
--- CAPITAL COST ---						
Capital Cost (See Table 3-2)					2,866,750	$
Capital Recovery Factor (assuming 11.0% interest, 20 yr. period)					12.6	%
Annual Capital Cost Component					360,000	$
--- ANNUAL OPERATIONS ---						
Energy Efficiency	0.80	kw/ton	80.0	eff-%		
Electric Consumption @ 0.08 $/kw-hr	89,600	$	2,000	$		
Gas/Oil Consumption @ 3.50 $/mmbtu	0	$	178,500	$		
DHC Pumping Electric @ 0.08 $/kw-hr	11,700	$	5,700	$		
Subtotal (fuel)	101,300	$	186,200	$	287,500	$
Personnel					60,000	$
Replacement Parts/Service					25,000	$
Boiler Lease from St Joseph					30,000	$
Water,Sewer,Chemicals					10,000	$
Insurance,Taxes,Misc (1.5% of invest)					43,000	$
Loss of Rented Space - 20 $/sqft					0	$
Subtotal (non fuel)					168,000	$
--- DISTRICT COOLING AND HEATING COST CALCULATION ---						
Annual Capital Cost Component					360,000	$
Annual Fuel					287,500	$
Annual Non-fuel Operations					168,000	$
Annual Total Costs	407,800	$	407,800	$	815,500	$
Estimated Cost Apportionment	50%		50%			
Annual Cooling/Heating Load	1,400,000	ton-hrs	40,800	mmbtu	57,600	mmbtu
Unit Cooling/Heating Cost >>>>>>>>>>>>>>>>>>	0.29	$/ton-hr	9.99	$/mmbtu	14.16	$/mmbtu

* * * *

Figure 3-3: Comparison of Unit Energy Costs - Cooling

Figure 3-4: Comparison of Unit Energy Costs - Heating

* * * *

The economics of district energy systems generally improve as more customers saturate a given distribution system. This conclusion is affirmed in Figures 3-3 and 3-4 which indicates a reduced unit breakeven cost in Phase 2.

Sensitivity of the economics to the price of gas is presented in the following tables for Phase 1 and Phase 2 implementations.

* * * *

Table 3-5: Estimated District Cooling and Heating Unit Cost Calculation - Phase 1 (Sensitivity Case: gas cost = 4.0 $/MMBtu)

Table 3-6: Estimated District Cooling and Heating Unit Cost Calculation - Phase 1 and 2 (Sensitivity Case: gas cost = 4.0 $/MMBtu)

* * * *

The sensitivity of total district energy cost (cooling and heating) to the price of gas as well as a comparison to the total annual costs currently experienced by selected buildings for Phase 1 is indicated in the following figure:

* * * *

Figure 3-5: Comparison of Total Annual Cooling and Heating Costs and Potential Savings with District Energy

* * * *

The figure was prepared based on estimates of total current costs with on-site production plants as calculated in Tables 2-2 to 2-4; district energy costs were calculated in Tables 3-3 to 3-6. As indicated in Figure 3-5, overall cost savings are estimated at

Figure 3-3

COMPARISON OF UNIT ENERGY COSTS – COOLING

Stamford District Cooling and Heating Project

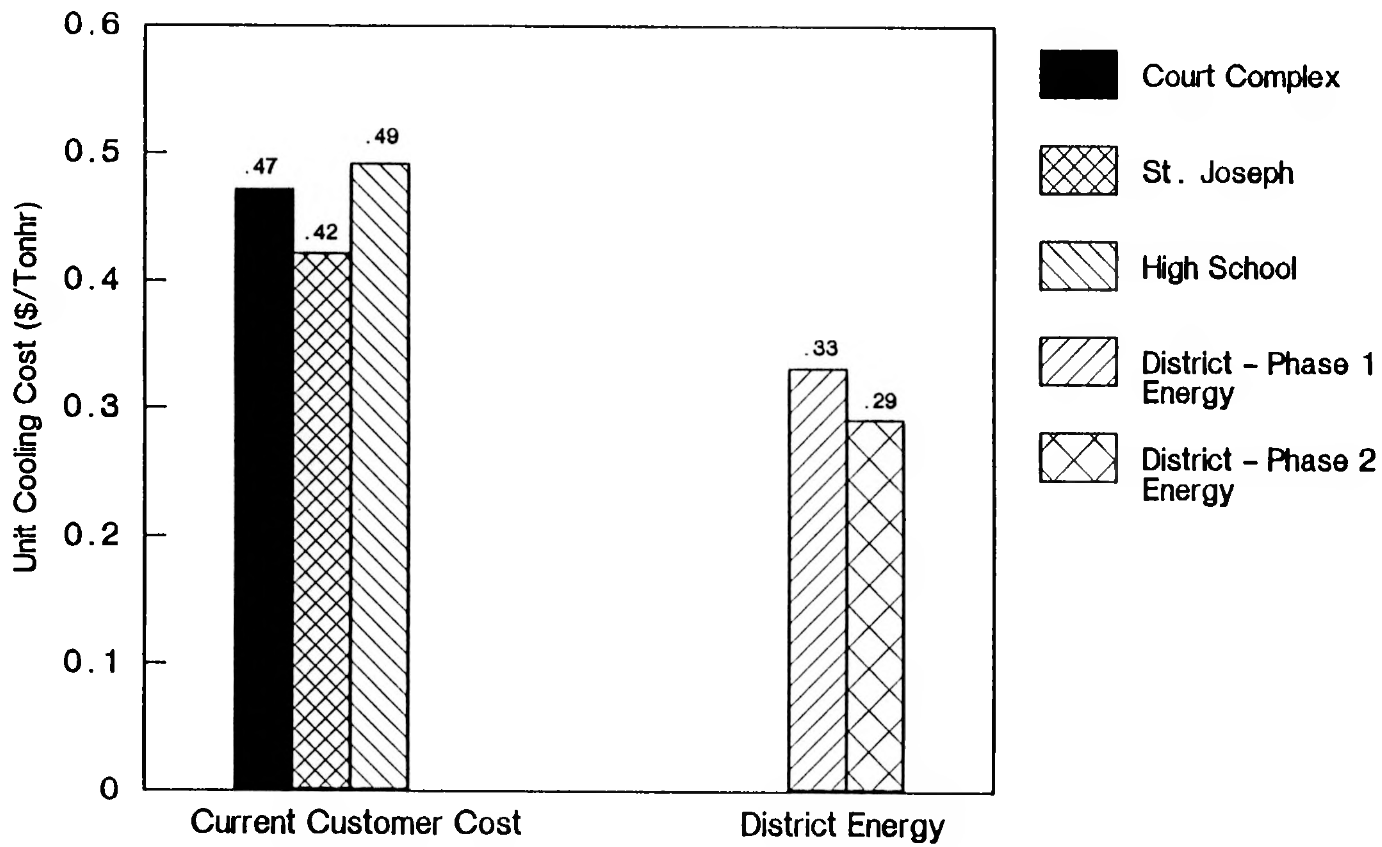


Figure 3-4

COMPARISON OF UNIT ENERGY COSTS – HEATING

Stamford District Cooling and Heating Project

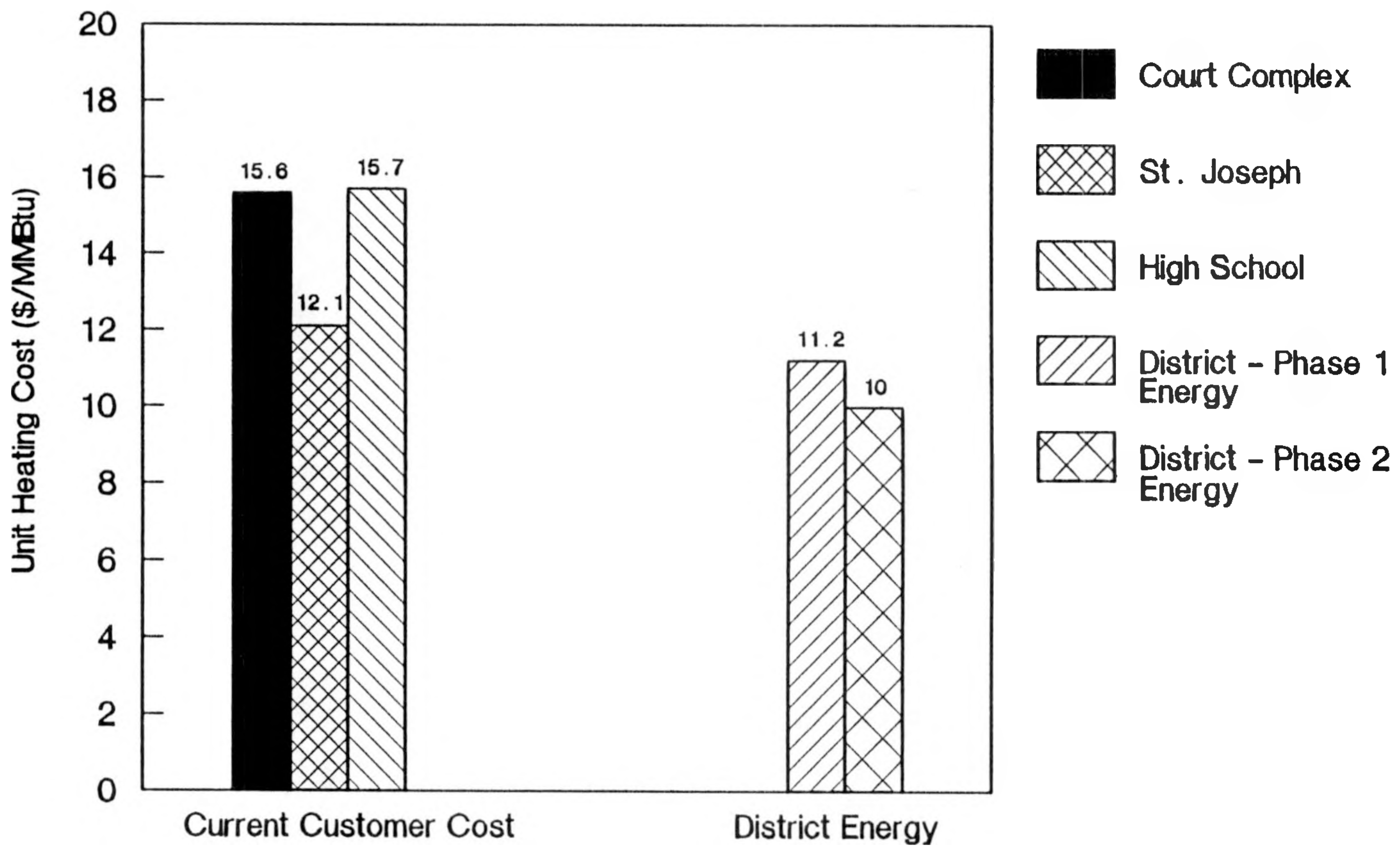


Table 3-5

Stamford District Cooling and Heating Project

ESTIMATED DISTRICT COOLING AND HEATING UNIT COST CALCULATION

****

Energy Plant at St Joseph
Phase 1: Core Customers [---- COOLING ----] [---- HEATING ----] [--- TOTALS ---]

Sensitivity Case: gas cost = 4.0 $/MMBtu

****

		COOLING		HEATING		TOTALS	
--- THERMAL LOAD ESTIMATE ---							
Peak Load		1,250	tons	14.3	mmbtu/hr		
Annual Full Load Operating Hours		1,000	hr	1,700	hr		
Annual Load		1,250,000	ton-hr	24,310	mmbtu		
--- CAPITAL COST ---							
Capital Cost (See Table 3-2)						2,518,250	$
Capital Recovery Factor (assuming 11.0% interest, 20 yr. period)						12.6	%
Annual Capital Cost Component						316,200	$
--- ANNUAL OPERATIONS ---							
Energy Efficiency		0.80	kw/ton	80.0	eff-%		
Electric Consumption @	0.08 $/kw-hr	80,000	$	2,000	$		
Gas/Oil Consumption @	4.00 $/mmbtu	0	$	121,600	$		
DHC Pumping Electric @	0.08 $/kw-hr	10,500	$	3,400	$		
Subtotal (fuel)		90,500	$	127,000	$	217,500	$
Personnel						60,000	$
Replacement Parts/Service						25,000	$
Boiler Lease from St Joseph						30,000	$
Water,Sewer,Chemicals						10,000	$
Insurance,Taxes,Misc (1.5% of invest)						38,000	$
Loss of Rented Space -	20 $/sqft					0	$
Subtotal (non fuel)						163,000	$
--- DISTRICT COOLING AND HEATING COST CALCULATION ---							
Annual Capital Cost Component						316,200	$
Annual Fuel						217,500	$
Annual Non-fuel Operations						163,000	$
Annual Total Costs		418,000	$	278,700	$	696,700	$
Estimated Cost Apportionment		60%		40%			
Annual Cooling/Heating Load		1,250,000	ton-hrs	24,310	mmbtu	39,310	mmbtu
Unit Cooling/Heating Cost >>>>>>>>>>>>>>>>>>		0.33	$/ton-hr	11.46	$/mmbtu	17.72	$/mmbtu

==

Table 3-6

Stamford District Cooling and Heating Project

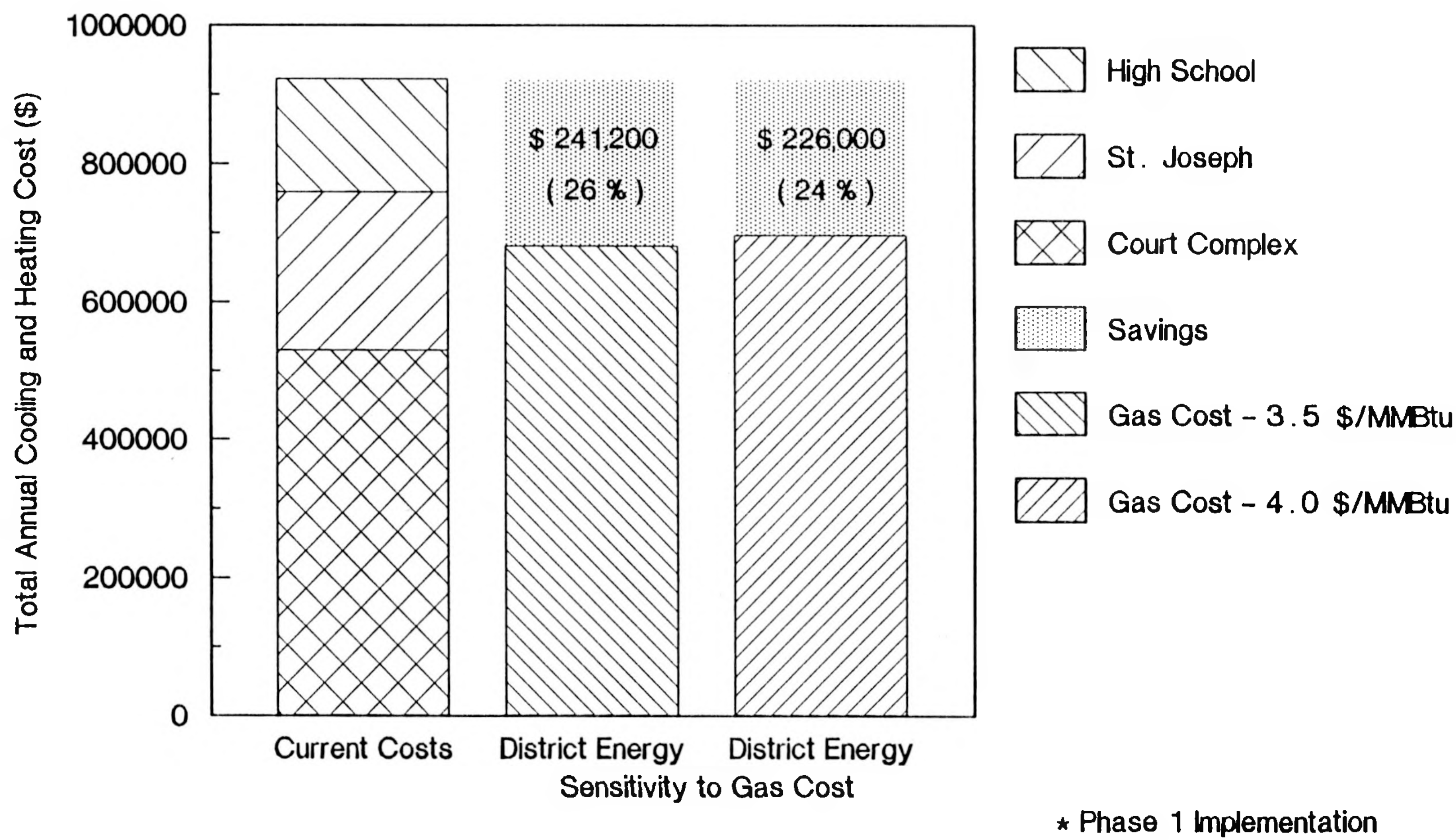
ESTIMATED DISTRICT COOLING AND HEATING UNIT COST CALCULATION

Energy Plant at St Joseph Phase 1+2: Core + Secondary Customers	[---- COOLING ----]		[---- HEATING ----]		[--- TOTALS ---]	
Sensitivity Case: gas cost = 4.0 $/MMBtu						
--- THERMAL LOAD ESTIMATE ---						
Peak Load	1,400	tons	24.0	mmbtu/hr		
Annual Full Load Operating Hours	1,000	hr	1,700	hr		
Annual Load	1,400,000	ton-hr	40,800	mmbtu		
--- CAPITAL COST ---						
Capital Cost (See Table 3-2)					2,866,750	$
Capital Recovery Factor (assuming 11.0% interest, 20 yr. period)					12.6	%
Annual Capital Cost Component					360,000	$
--- ANNUAL OPERATIONS ---						
Energy Efficiency	0.80	kw/ton	80.0	eff-%		
Electric Consumption @ 0.08 $/kw-hr	89,600	$	2,000	$		
Gas/Oil Consumption @ 4.00 $/mmbtu	0	$	204,000	$		
DHC Pumping Electric @ 0.08 $/kw-hr	11,700	$	5,700	$		
Subtotal (fuel)	101,300	$	211,700	$	313,000	$
Personnel					60,000	$
Replacement Parts/Service					25,000	$
Boiler Lease from St Joseph					30,000	$
Water,Sewer,Chemicals					10,000	$
Insurance,Taxes,Misc (1.5% of invest)					43,000	$
Loss of Rented Space - 20 $/sqft					0	$
Subtotal (non fuel)					168,000	$
--- DISTRICT COOLING AND HEATING COST CALCULATION ---						
Annual Capital Cost Component					360,000	$
Annual Fuel					313,000	$
Annual Non-fuel Operations					168,000	$
Annual Total Costs	420,500	$	420,500	$	841,000	$
Estimated Cost Apportionment	50%		50%			
Annual Cooling/Heating Load	1,400,000	ton-hrs	40,800	mmbtu	57,600	mmbtu
Unit Cooling/Heating Cost >>>>>>>>>>>>>>>>>>	0.30	$/ton-hr	10.31	$/mmbtu	14.60	$/mmbtu

Figure 3-5

COMPARISON OF TOTAL ANNUAL COOLING AND HEATING COSTS AND POTENTIAL SAVINGS WITH DISTRICT ENERGY

Stamford District Cooling and Heating Project



between 24 and 26% for the Phase 1 implementation strategy.

In the configuration presented in Figure 3-1, the distribution header is constructed in Phase 1 to serve the Court Complex. In Phase 2 without extending the distribution header, additional customers join the system to dilute the overall impact of the capital cost (expended in Phase 1) among a larger customer base reducing the unit cooling and heating cost. Since the system as configured is nominally economic, relying on assistance from the State and the participation of the several customers, this perspective of system growth and saturation to enhance viability must be reinforced after Phase 2. With future expansions and the incorporation of new and innovative heating and cooling plants, the system will achieve recognition as a leading alternative to secure the goal of the energy conscious. The Stamford Court Complex development represents an excellent opportunity to initiate this process since first cost savings will reduce project costs while lending public support to the DHC concept.

SECTION 4

Issues Supporting City Ownership

- Taking a Leadership Role
- Economic Development Opportunities
- Potential Revenue
- Environmental Partnership
- Utility Position
- Conclusions

SECTION 4

ISSUES SUPPORTING CITY OWNERSHIP

The primary issue which must be addressed to proceed with actual construction of this district energy system is probably typical of most projects where there has been no previous experience. That issue is ownership. Although there are several plausible alternatives including municipal, utility (gas, electric, water) and private entrepreneurs, the most probable is city ownership. The several reasons are discussed below and include:

- Taking a Leadership Role
- Economic Development Opportunities
- Revenue Potential
- Environmental Partnership
- Utility Position

TAKING A LEADERSHIP ROLE

Often the most difficult stage of implementing a district energy system is the initial increment. The project must develop the enthusiasm to generate the capital resources and the commitment of both system owners and customers. Although this first increment is nominally economic, it probably could not achieve the rates of return expected by a private developer. Construction of the selected configuration should be viewed as a first increment of a much larger and comprehensive program. Experience demonstrates that once established, a district energy system generally expands and becomes more profitable. One strategy addresses this issue by seeking city ownership of the system to fund and promote its growth. As the system expands, enriched by a widening customer base, other options gain in appeal. The City may retain ownership and interconnect the system with another municipal project, exemplified by refuse to energy plants, or, the City may opt to sell the system to a private developer for purposes of interconnecting the system to a cogeneration facility. With an expanded system,, the private developer's risk diminishes and he is more willing to invest in this venture which at the same time supplies low cost energy to the customer service area.

For a cogenerator to qualify his facility under federal regulations, an established thermal load must be identified. Having a district energy system in place represents an excellent opportunity for a developer to approach the Stamford system to the benefit of all parties. In any event, a larger system invites numerous opportunities to secure energy independence and flexibility which ultimately stabilizes energy cost in the community.

The objective is to initiate this process, to seek commitment and the resources required to construct the first increment of a city-wide district energy system. The City is the primary advocate which embodies the long-term objectives of its future. Recognizing energy cost stability as one element of a coordinated plan to secure its future, the City in this respect is a natural candidate to build, operate and own (at least initially) a district energy system.

ECONOMIC DEVELOPMENT OPPORTUNITIES

Although it is not currently among the major headlines as in past decades, energy related issues will once again emerge, menacing communities with higher cost and shortages. Energy independence will be a measure of a community's ability to effectively promote future growth opportunities. Stamford is in competition with other growth centers in the Northeast Corridor. District cooling and heating is a potential vehicle to secure future energy efficiency and a strengthened infrastructure to gear up for the next generation of growth. Just as current headlines center on high speed trains, more roads and housing, energy supply necessarily applies to long term planning strategies.

Through reduced energy related costs, district cooling and heating contributes to economic development opportunities by easing strained operating budgets of existing citizens and providing an incentive to outside parties seeking a Stamford location. Implementation of a system would lead to long term stability for Stamford and be a major contributor in keeping jobs and revenues supporting self-sufficiency.

The potential savings of enhanced energy utilization would provide an immediate positive cash flow for most customers. This concept applies to all segments of the community including public and private housing, businesses, institutions and government. Accumulated savings by individual properties could be directly reinvested into the building to upgrade living spaces, provide better services to the tenants and improve exterior appearance.

The introduction of a district energy system would place a brake on escalating costs of operation and maintenance experienced by everyone in the community. Subsidized and public housing projects for low income and elderly would surely benefit from such a project. Lower energy costs significantly contribute to retaining affordable housing.

The cost savings would be an incentive to those businesses considering leaving the area. They would remain in the community and serve as anchors to attract new businesses and other concerns to facilitate growth plans. Reduced energy costs has a ripple effect throughout the community and serves as an incentive for investment on the part of the private sector and the financial community. District energy offers varied and real opportunities for developers and investors to realize increased returns from their investments.

District energy implies the stabilization of future energy costs which has a beneficial impact on growth. Since a large central plant can adapt to a broader mix of fuels than individual systems and purchase greater quantities, future supplies of fuel are more assured, at better prices. If customers are confident of predictable energy costs, they will be more inclined to stay or join the community for the long term.

POTENTIAL REVENUE

Should the City decide to accept the responsibilities of constructing and owning a district energy system, it represents an opportunity to create a source of income for the City from the sale of chilled and hot water. As the system expands, other opportunities may develop such as interconnecting a refuse to energy plant to the district energy system. The district system would complement the refuse to energy plant by increasing the energy efficiency of the plant through the effective use of lower grade heat which would have been otherwise rejected.

The market value of the system increases significantly as it expands such that if the City sells the system to a developer, this too will be profitable venture.

ENVIRONMENTAL PARTNERSHIP

The City in its efforts to keep Stamford clean, control pollution, and reduce exposure to hazardous materials would be well served by a district energy system. By consolidating the number of thermal production plants as implied by district energy, several important objectives are accomplished.

Centralization confines the fuel supply and hazardous working fluids to a single location. Examples include fuel oil, natural gas, chemicals, refrigerants (CFC's) which all damage the environment if not properly handled. Centralizing these materials simply reduces the probability of accidental releases.

Centralized energy production facilities are more energy efficient since they are constructed to industrial standards which are more adapt to monitor the control pollution emissions. Energy production is more efficient suggesting that more useful energy is produced while less air and thermal pollution is released to the atmosphere. Similarly, efficiency corresponds to reduced fuel consumption which conserves natural resources and reduces the dependence on foreign fuel supplies.

Only the public body can practically orchestrate programs which reflect the environmental concerns which everyone shares.

UTILITY POSITION

The local electric utility, Northeast Utilities (NU), who also provided financial resources for this study were approached with preliminary results to solicit their interest in owning the district energy system. They concluded that due to potential regulatory barriers to having equity ownership and risks associated with constructing the system that they could not currently undertake this responsibility. Part of their response includes:

"NU is a registered holding company and, as such, is subject to strict control by the Securities and Exchange Commission (SEC) under the Public Utilities Holding Company Act (PUHCA) of 1935. PUHCA allows the SEC to limit the types, geographic location, and financial structure of businesses in which NU may participate. Specifically, NU can only invest in a business that is reasonably incidental or economically necessary or appropriate to our integrated public utility system. The proposed Stamford DHC system does not include any equipment which can be utilized for the production of electricity and there are only limited arguments for its impact on the conservation of electric energy and management of electric load. Therefore, at this time, it appears unlikely that NU could define sufficient linkages between the proposed DHC business and its electric energy business to obtain the SEC approval necessary to allow NU to invest in the Stamford DHC system."

Although NU found the system as configured to be nominally economic, uncertainty regarding municipal financing, state grants, energy plant leasing arrangements and prospects for building development in this area also weighed heavily in their decision not to initiate the project at this time.

CONCLUSIONS

In the context of the previous discussion, it appears evident that district energy systems are best served through community commitment as suggested by the potential benefits of a system. It requires the resolve of its citizens to implement the system and nurture its success. Although the long term benefits are clear, it takes the vision of today's community to dedicate the resources for future aspirations and opportunities. Although private development of such systems should be pursued as in Stamford, the role of the city and its citizens are invaluable for actual implementation.

APPENDIX A

Potential District Energy Projects Overview

- Introduction
- Downtown Stamford
- North District
- South District
- Conclusions

APPENDIX A

POTENTIAL DISTRICT ENERGY PROJECTS OVERVIEW

INTRODUCTION

As part of the preliminary work to locate a potential project, time was spent performing an overall survey of buildings/ locations in Stamford.

A district heating and cooling system involves the establishment of a central energy plant and the distribution of a cooling and heating product through underground pipes to customer facilities in a surrounding service area. To properly estimate the size and cost of the central energy plant and associated distribution system, an evaluation of the thermal load in the candidate service areas must be conducted. The load assessment must also recognize the ability of individual customers to effectively utilize the products, which are hot and chilled water for the proposed system.

Several technical parameters are analyzed when selecting a prospective site. They include thermal load and its density which is a measure of the magnitude of peak heating/cooling demand over a specified land area. High load density, as exemplified in an urban center, enables construction of a central energy plant and underground distribution system in an economically feasible manner. This analysis attempts to maximize revenues by limiting distribution lengths and related costs.

Another important factor which contributes to economic implementation of the project is the cost to retrofit existing building heating and cooling systems to accept district energy. As part of this task, types of building heating and cooling systems are verified to determine the level of compatibility.

Based on these criteria, several areas in the greater Stamford area were included in the study of possible district energy projects:

DOWNTOWN STAMFORD

The Downtown Stamford area has undergone a commercial renaissance in the past 15 years. Approximately 13,000,000 sq. ft. of commercial space exists in the downtown area housing, among others, the headquarters of a number of the Fortune 500 companies. The downtown area is comprised of many newer buildings, but there exists a sufficient number of buildings with older equipment that would provide a sizable heating and cooling load. Several very large buildings, such as General Reinsurance and the Stamford Towne Center, are currently employing a hot water heating system and chilled water cooling system. In addition, the development of Block 38 can be coordinated with a district energy system, reaping substantial capital savings for the development.

NORTH DISTRICT

The area directly north of the downtown area is composed of residential and commercial buildings. Two major streets have been shown to be good candidates for district energy: Prospect - Strawberry Hill Avenue and Summer Street. Both have high heating and cooling loads and buildings which can be readily adaptable to district energy. There are several development projects slated for the north district, including construction of a courthouse complex on the site of the old court buildings. St. Joseph's Medical Center is located in the northern portion of the North District. The location and size of the Medical Center and surrounding land make it a likely choice for a central energy plant.

SOUTH DISTRICT

The area directly below I-95 is composed mostly of industrial buildings, with some office and condominium development along the harbor. The area possesses moderate heat load density. Of particular interest is the city operated refuse facility which is also located near the harbor, implying its employment in a district energy project.

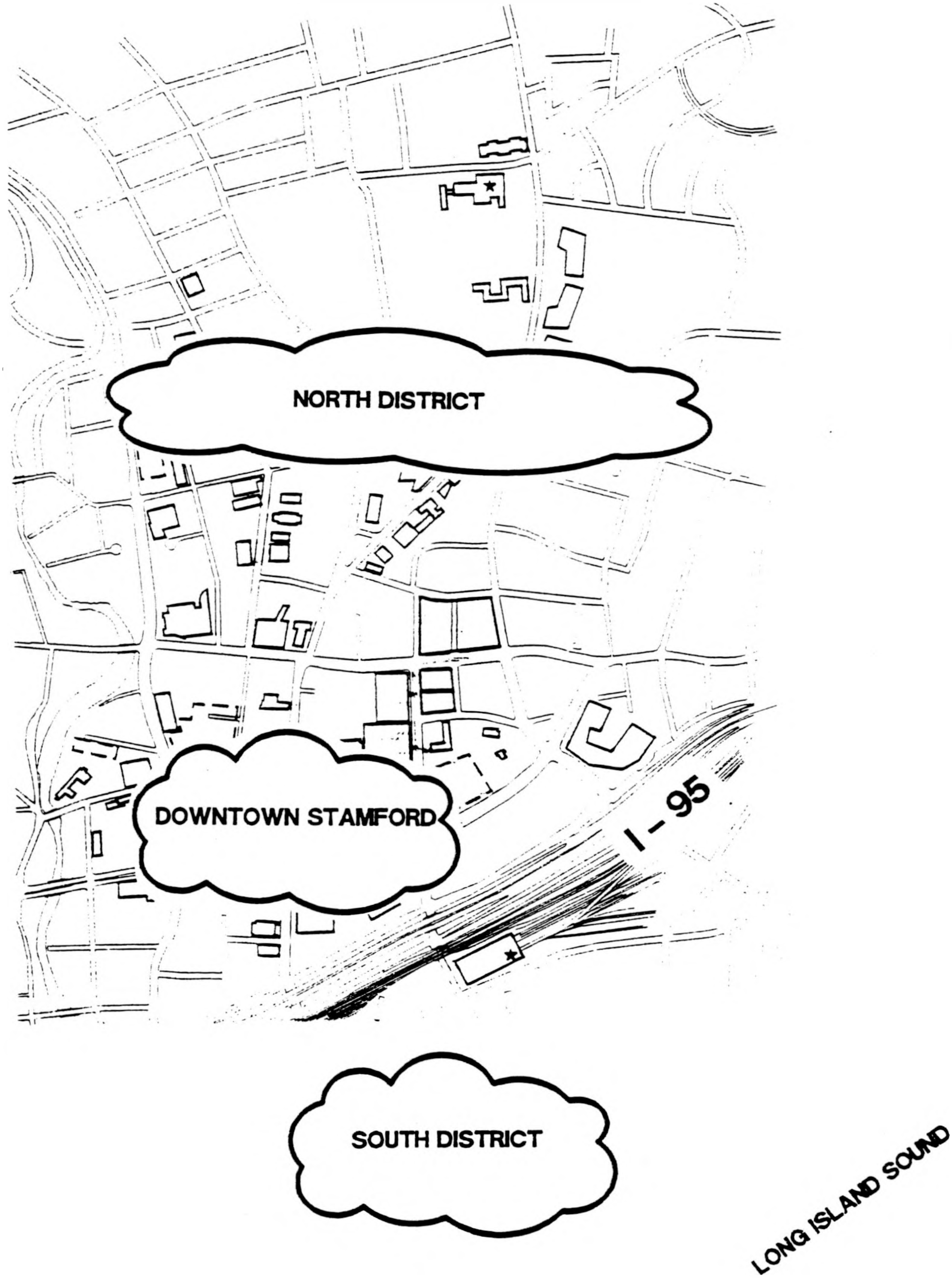
CONCLUSIONS

All three regions within Stamford are indicated in Figure A-1. The project selected for detailed assessment was sited within the Strawberry Hill area of Stamford which was addressed in the survey of the "North District". Notable criteria include high thermal load density, excess thermal capacity at St. Joseph Medical Center and retrofit compatibility. Other non-technical issues include public support of the project and the presence of both city and state buildings in the immediate vicinity of St. Joseph Medical Center. The selection criteria and a more fully described configuration is presented in the main body of the report.

Figure A-1

OVERALL SERVICE AREA OPPORTUNITIES

Stamford District Cooling and Heating Project



APPENDIX B

District Cooling Technology Options

- Application of Cooling Technology Options in Stamford
- Technology Options
- Hi- Efficiency Electric Chillers
- Absorption Chillers
- Free Chilling
- Cool Storage
- Cooling Transport Mediums

APPENDIX B

DISTRICT COOLING TECHNOLOGY OPTIONS

APPLICATION OF COOLING TECHNOLOGY OPTIONS IN STAMFORD

The selected configuration includes buildings in the vicinity of St. Joseph Medical Center which was designated as the central energy plant for the system. Application of cooling options were deemed dependent on the several criteria which shaped the project and affected the prospects of actual implementation.

- o To successfully develop a district energy system in Stamford for which there is no previous experience, the system in the initial stage would be modestly sized with a correspondingly modest capital budget.
- o In addition to being economic, the system had to be very reliable, inferring the use of market-proven products to demonstrate the overall advantages of district energy. After establishing a continuous operating record, the potential for growth and application of other technology options would be significantly improved.
- o The configuration selected for this first increment system, designated St. Joseph Medical Center as the location for the central energy plant. Consequently, available land area is restricted, limiting the application of cool technology options (e.g., chilled water storage).
- o The configuration is viewed as a first increment, intended to be a pilot project geared for expansion as enthusiasm for the system grows. It is thought that at this later date

when an independent energy plant serves the system, may be a more opportune environment to apply some of the technology options which will further enhance system performance. It can be easily envisioned that such a plant could be a gas turbine, waste to energy or some other form of cogeneration facility. These facilities are better candidates for adapting absorption and storage technologies, for example, to improve overall performance than the smaller conventional plant at St. Joseph Medical Center.

Recognizing these criteria, it was deemed appropriate to install only hi-efficiency centrifugal chillers for purposes of enhancing district cooling opportunities in Stamford. These chillers provide an energy conserving benefit to the system without adding substantially to the cost of the system. In the following paragraphs, a discussion of cooling technology options which appear to offer economic incentives for more flexible energy plants as planned for an expanded system in Stamford are reviewed.

TECHNOLOGY OPTIONS

The continuing increase in electrical demand on utilities and the corresponding increase in usage rates has stimulated a surge in renewed interest in more energy-efficient cooling systems, such as district energy systems. A number of technology alternatives are available which improve the economics of such systems and are related to the production and distribution aspects of the system. These options are discussed below and then reviewed as it applies to practical implementation for the configuration selected in Stamford.

HI-EFFICIENCY ELECTRIC CHILLERS. These are market available with energy consumption ratings in the range of 0.55 to 0.6 kw/ton. They are electric centrifugal machines and resemble other more commonly available machines typified by higher electric consumption ratings of 0.7 kw/ton. Open-drive models are flexible with respect to the driver which may include an electric motor, steam turbine or reciprocating engine.

ABSORPTION CHILLERS. A range of products are available utilizing low and high pressure steam or direct-fired models recovering waste heat (from cogeneration) or deriving heat from the combustion of conventional fuels like natural gas. Proper dispatch of this equipment can alleviate electrical demand during peak cooling periods. Absorption machinery substitutes electricity with conventional fuels (e.g., refuse, gas and oil) when demand and cost for these commodities are at their lowest levels during the summer. Absorption technology contributes to the levelization of demand versus energy supply.

FREE CHILLING. Manufacturers of compression-type chillers generally offer a free cooling option which enables the production of chilled water without operating the compressor. Such an option is used during cold winter months when air temperature is low and cooling tower water temperature is sufficiently low to drive the cycle. Another approach more suited to district energy systems is use of river water, where temperatures drop to the thirties during the winter. Typically, a heat exchanger is installed whereby chilled water is produced by using the river water as the cooling medium.

COOL STORAGE. Cool storage involves the production and storage of cooling capacity during non-peak hours to meet the following day's cooling requirements.

Thermal storage systems modify a cooling system's daily chiller load profile by shifting chilled water generation to off-peak hours to take advantage of lower electrical rates and demand charges. Thermal storage systems can be designed for partial or full storage capability wherein all or part of the peak hours load demand is generated during the longer off-peak hours. Operating costs are reduced and installed refrigeration capacity can be significantly lowered.

o Chilled Water Storage

In chilled water storage, water is chilled to 38 to 42 F at night and stored in a large tank. The system's advantage is that conventional water chilling equipment is required which operate at higher efficiency than those options which store ice. The primary disadvantage is that the size of the tank can be prohibitive depending on siting restrictions.

o Ice Storage

In ice storage, the tank volume required is only 15% to 20% of a chilled water tank. An examination of the relative costs of ice storage systems versus comparable water storage systems usually indicates than an ice storage system costs less than water storage. This is due mainly to the considerably reduced storage requirements. However, ice storage has the disadvantage that lower evaporator temperatures (and proportionally more electrical energy) are required to achieve freezing.

There are several popular systems available on the market for thermal storage of ice. One broadly adapted technology is referred to as static ice building which implies that as ice is formed, it is stored directly on the evaporator surface submerged in the storage vessel. Static systems pump refrigerant or brine through coils which freezes the surrounding water. Within this category of ice builders, several product lines have been developed. They include ice coil, brine coil, ice containers, and phase change systems. The second category has been termed dynamic ice building. The primary distinction is that after a thin film of ice has been formed on the evaporator surface, it is discharged to a separate storage vessel. By removing the ice from the evaporator, suction pressure depression of the refrigerant is minimized, thereby maintaining compressor efficiencies. A brief description of popular systems follow:

o Brine Coil System

The Brine Coil System (similar to the system offered by Calmac) includes a modular, insulated polyethylene tank containing a spiral-wound plastic tube heat exchanger surrounded with water. At night, a 75 percent water - 25 percent glycol solution from a standard packaged air conditioning chiller circulates through the heat exchanger and extracts heat until eventually all the water in the tank is frozen solid. The ice is built uniformly throughout the tank by closely spaced counter flow heat exchanger tubes. Water does not become surrounded by ice during the freezing process as in other static ice builders and can move freely as ice forms, preventing stress or damage to the tank.

During the day, the glycol solution is cooled by the ice bank from 52 F to 34 F. A temperature modulating valve set at 42-44 F in a bypass loop around the ice bank permits a sufficient quantity of 52 F fluid to bypass the ice bank, mix with 34 F fluid and achieve the desired 42-44 F temperature. The 42-44 F fluid enters the building distribution system, where it cools air from 75 F to 55 F. The fluid leaves the building system at 60 F, enters the chiller and is cooled to 52 F.

o Ice Coil System

The system (similar to the system offered by Baltimore Aircoil) consists of an ice chiller thermal storage unit, a refrigeration system, and chilled water pump. The ice chiller unit consists of a multiple tube serpentine coil submerged in an insulated tank of water. Both the coil and tank are of steel construction, galvanized for corrosion protection.

When no comfort cooling load exists, usually at night, the refrigeration system operates to build ice on the outside of the coil. This refrigeration can be provided by circulating a cold ethylene glycol solution inside the ice chiller coil or by feeding refrigerant directly into the coil. To ensure a uniform build of ice, the water is agitated by air bubbles from a low pressure distribution system located beneath the coil. When the ice has reached design thickness, an ice inventory control sends a signal to turn off the refrigeration system.

When chilled water is required for comfort cooling the chilled water pump is started, and the meltdown cycle begins. Warm return water from the building cooling coil circulates through the ice chiller and is cooled by the melting ice. During the cycle, the tank water is also agitated to provide uniform ice melting and a constant ice water supply temperature of 34 F or less. This design utilizes ice water directly as the cooling medium which is different to the other designs that use ice for storage but circulate a glycol solution throughout the entire building cooling loop.

o Containerized Ice System

The system (similar to the system offered by Reaction Thermal Systems) consists of many individual water-filled plastic containers which are stacked within a storage tank. A brine solution (antifreeze) is pumped through the storage tank which circulates through the voids which exist between individual containers. During night "off-peak" hours, chilled brine is circulated through the storage tank until individual containers are frozen solid. During peak cooling periods, the same brine solution is cooled by passing through the ice bank and used to replace or supplement the building's chillers. A standard packaged chiller suitable for low temperature brine production is used for the ice building system.

o Phase Change Materials

There are two materials on the market that enhance the phase change process that ordinarily occurs in a change of state between water and ice. These two phase change materials are:

eutectic salts and gas hydrates.

Eutectic salts are mixtures of inorganic salts, water, and additives. Gas hydrates are produced by mixing gas with water. Both of these materials work by raising the temperature at which water will change into a solid state. They have the advantage of a freeze point of 47 or 48 degrees, which reduces chiller energy requirements. Theoretically, phase change materials provide an optimal storage medium for cooling purposes.

Phase change materials also provide most of the storage space advantages associated with ice storage systems. By freezing and melting at 47 or 48 degrees, the phase change materials can be easily used in conventional chilled water systems with centrifugal or reciprocating chillers. The storage tank can be placed above or below grade. In addition, there are less increased power penalties (kW/ton) when phase change materials are used for cool storage because evaporative temperatures remain the same as for conventional chilled water production.

Reportedly, gas hydrates (which are currently still in the development stage for large, commercial-type installations) have some advantages over eutectic salts. Gas hydrates have high latent heat values. This translates into size and weight advantages. Gas hydrates will require only 1/2 to 1/3 the space and will be approximately 1/2 the weight of the equivalent eutectic salt system.

o Ice-Harvesting (Dynamic) System

The fully factory packaged self-contained harvesting ice generator/chillers (similar to units offered by Turbo Refrigeration Company) are expansion refrigeration systems whose evaporator consists of multiple vertical plates. The evaporator is mounted above a water/ice storage tank. Water is pumped from the storage tank at low head and distributed over the plates where it flows in a thin film down the plates and returns to the storage tank by gravity. If the water is warm, the unit functions as a chiller. If the water temperature is low, some of the water is frozen on the plates into sheets about 3/16 to 1/4 inch thick.

Periodically the ice is released from 1/12 of the plates by reversing the refrigerant flow to these plates. By not allowing the ice to build up, heat transfer is kept high; therefore, suction pressures are kept high. In the ice generation mode the unit operates at .95 kW/ton. In the chilling mode the unit operates at .70 kW/ton. The ice stored in the tank is approximately palm sized, having a great contact area between the ice and the returned chilled water.

The compressors are direct drive, open reciprocating. Heat rejection is accomplished with evaporative condensers. The control system is a microprocessor, controlling ice build time to 20 minutes and harvest time to 30 seconds. The ice inventory is controlled by electronic level indicators. When the ice is stored in the tank, it is deposited in gravel-like layers with a void ratio of 45 percent. The electronic level control system senses ice level and de-energizes the compressors and auxiliaries when the ice level fully fills the storage tank.

COOLING TRANSPORT MEDIUM

The medium of cooling is typically chilled water, which is transported through a piping distribution system to connect customers. Designing the piping network requires a comprehensive study of the service area load potential with emphasis on those buildings which are likely to be connected to the system, as well as planned future development areas. The distribution network is best planned for phased implementation to serve the relatively assured existing and future loads.

The capital cost for the piping network represents a major portion of the investment cost for a district cooing system. Therefore, it is imperative that the piping cost be controlled to have an economically viable district cooling system. There are several innovative methods to reduce the piping cost by reducing the pipe size while transporting sufficient capacity.

One means is to increase the temperature difference between supply and return lines. The usual practice is to design the pipe size based on a temperature difference of approximately 15 Fahrenheit degrees. Recently, with advanced equipment that can efficiently produce chilled water near the freezing point, it is possible to have a temperature difference of 25 to 28 Fahrenheit degrees. The larger the temperature difference between the supply and return lines, the smaller the distribution pipes and therefore, the lower the capital investment cost.

The other means is to use ice-water slurry as the medium of transport. Chilled water is the usual medium of transport to customers for cooling purposes. An innovative method is to use ice-water slurry. As a result, the supply temperature is 32 F. The temperature difference between the supply and return lines approaches 28 Fahrenheit degrees, as compared to the conventional piping design with a temperature difference of 15 Fahrenheit degrees. Due to this higher temperature difference, smaller pipe sizes can be used, resulting in a lower capital investment cost.