

DOE/CE/2 6614--T1

DISTRICT COOLING AND HEATING DEVELOPMENT
IN
STAMFORD, CT

FINAL REPORT

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Prepared for:

THE STAMFORD PARTNERSHIP

Supported by:

THE UNITED STATE DEPARTMENT OF ENERGY

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DECEMBER, 1994

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ACKNOWLEDGEMENTS

This study was performed under the direction of and in close cooperation with Mr. David E. Anderson, President of the Stamford Partnership. The authors appreciate the suggestions and guidance of the DOE project manager, Mr. Floyd Collins.

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SUMMARY

This report summarizes the development options for introducing district cooling and heating in downtown Stamford, CT.

A district energy system as defined for the Stamford project is the production of chilled and hot 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 cogeneration as a means to encourage energy conservation and provide the city with an economic development tool.

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.

The purpose of the study was to identify a system configuration and pursue implementation of a district energy system. Analysis of the system configuration focused on selecting an arrangement which offered a realistic opportunity for implementation.

Several alternatives have been investigated as follows:

1. Construction of an 82 MW cogeneration plant and a district heating and cooling system to serve downtown buildings. Taking into account the low prices for electricity, it was determined that the development of such a plant at this time is unfeasible.
2. Construction of a small (4 MW) in-fence cogeneration plant combined with cooling and heating. The analysis has demonstrated that such a plant is feasible. The plant can be used for the Swiss Bank, Stamford Mall or on a smaller scale, for the University of Connecticut.
3. Construction of a district cooling and heating plant to supply (in the first development stage) the University of Connecticut, the Stamford Mall and the Swiss Bank. The plant can be located at the University of Connecticut site in

order to offer district energy to the Swiss Bank before the bank finalizes their plans for HVAC and energy supply systems. The University has sufficient space to house the district energy plant. By providing the space, the University will avoid the installation of new chillers, boilers, labor and maintenance expenses associated with the operation of their individual plant.

In order to minimize the risk and to reduce the initial capital investment, the plant should be sized to supply the Swiss Bank and the University peak loads. At the same time, the district energy plant will be supplying on an annual basis most of the loads while the Mall equipment will be supplying the peak load.

The economic analysis performed in this report have demonstrated that district cooling can be generated at 21¢/ton-hr, while the customers with electric chilling are presently paying 42¢/ton-hr. The profit will be further increased with the connection of additional customers located in close proximity to the proposed system. It is recommended securing the Swiss Bank's commitment to district energy as soon as possible in order to provide the Bank with the advantage of avoiding the installation of their individual plant. The Swiss Bank will then avoid a capital cost of about \$2.5 million for their own plant as well as labor and maintenance expenses.

The results of this study are preliminary. It remains to build on these results through detailed cost estimates and finalization of ownership, leasing and financial issues.

The following actions are recommended:

- Announce an intent to build a modern hot and chilled water district energy system to serve as a pilot project in downtown Stamford.
- Performed detailed cost estimates with sufficient accuracy to authorize a construction budget.
- Refine cost figures for each customer to achieve sufficient accuracy for committing to system interconnection.

- Develop cost estimates to permit customer facility to interconnect with the district energy system.
- Perform an economic analysis based on customer's current cost, customer's retrofit cost, and district energy cost. Accumulated savings should be presented as a payback to recover the cost of the retrofit.
- Prepare results of economic analysis and present to customers for review. Revise accordingly, seeking a letter of commitment to join the system.
- Finalize system ownership, financing and any leasing arrangements.
- Finalize interconnection agreements as district energy prices and contractual responsibilities are established.
- Retain a general contractor to construct the system.

SECTION 1

INTRODUCTION

1.1 Potential District Cooling and Heating Loads

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 chilled and hot 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 districts 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 7,000,000 sq. ft. of commercial space exists in the downtown area, housing among others, the headquarters of a number of the Fortune 500 companies (Figure 1-1). The downtown area is comprised of many newer buildings, but there exists a sufficient number of buildings with older

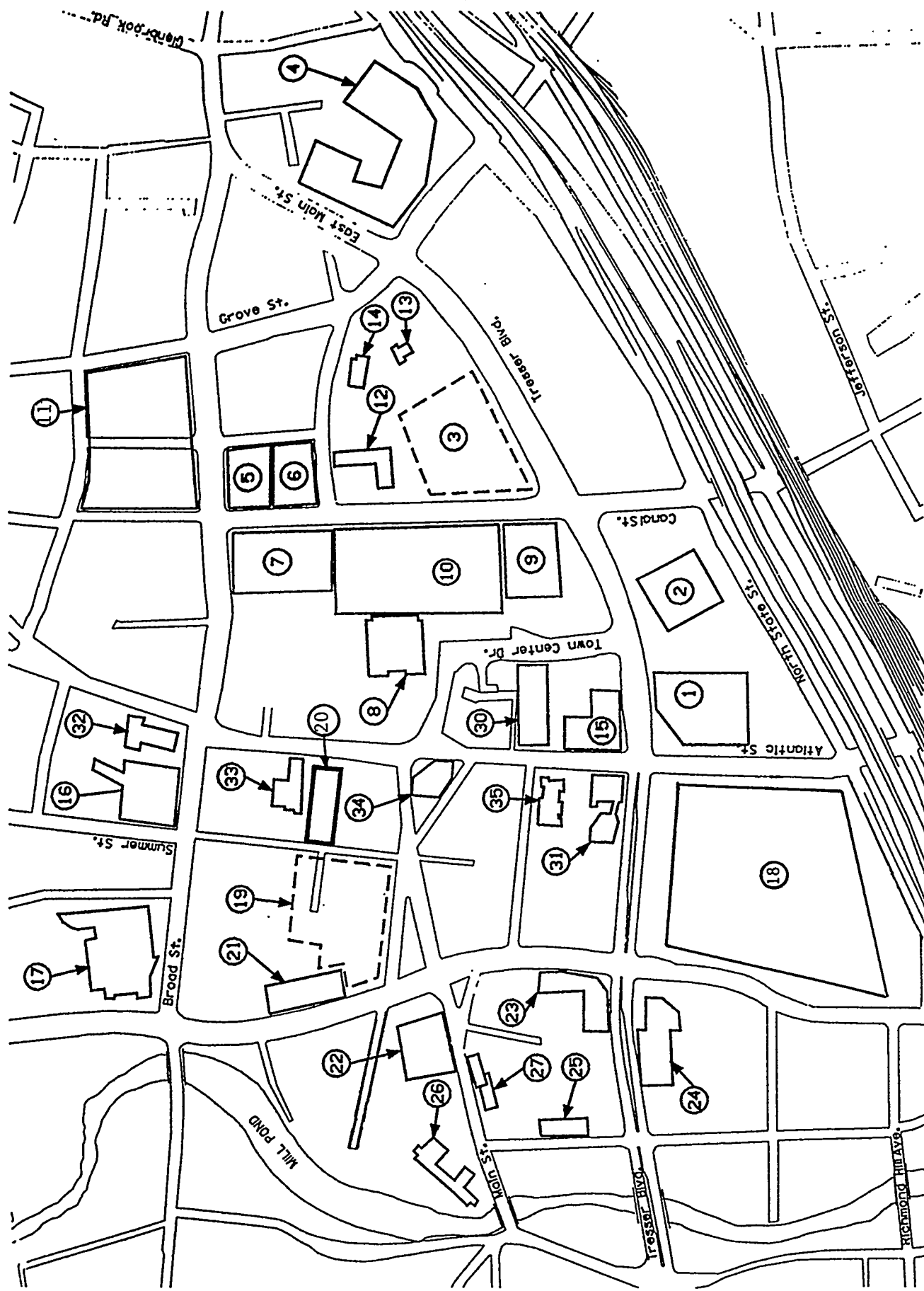


Figure 1-1 Downtown Stamford

equipment that would provide a sizable heating and cooling load (Table 1-1). Several very large buildings, such as the Stamford Town Center, are currently employing central chilled and hot water system. Recent developments, such as the Swiss Bank and the University of Connecticut, offer immediate district energy opportunities. 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 (Figure 1-2). 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 and Stamford High School are also located in the North District.

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 possess moderate heat load density.

1.2 Benefits of District Cooling and Heating to the Stamford Community

The implementation of district cooling and heating combined with cogeneration (DCH/C) shall produce several significant benefits for the City of Stamford and its residents. The benefits are classified as economic and environmental, and coincide with the objects of the recently emerged sustainable development efforts. The cost savings and energy conservation effects are directly related to the overall system efficiency. Cogeneration systems exhibit efficiencies as high as 80%, compared to the 33% average efficiency experienced by most utilities. The benefits are described below.

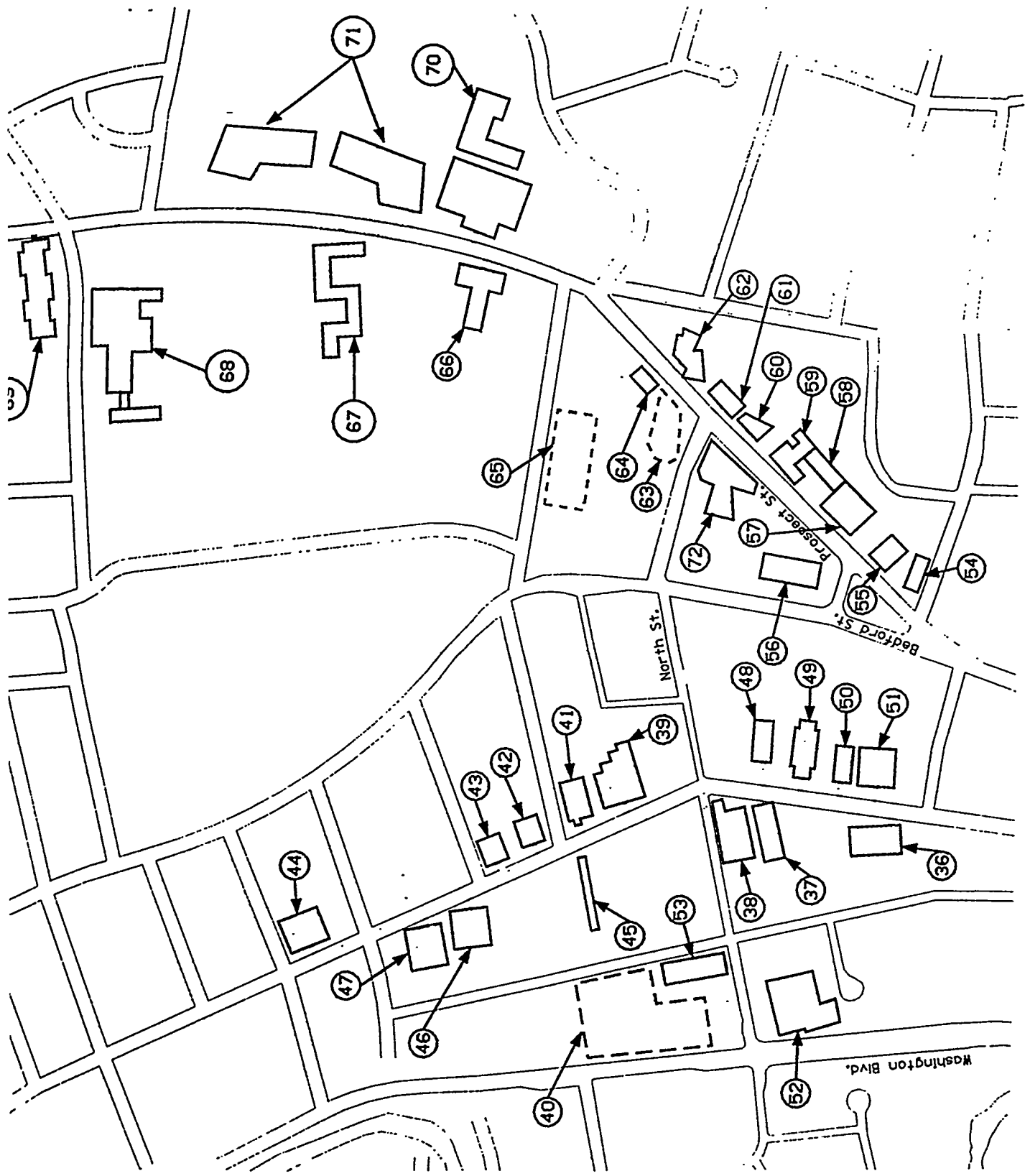


Figure 1-2 North District

Table 1 - 1
Peak Load - Downtown Stamford

No.	Building	Cooling Peak Load (Tons)	Heating Peak Load (MMBTU/hr)
1	Champion International	484	6.97
2	GTE Corporation	1600	8.23
3	Block 38	*1500	*20.00
4	General Reinsurance	1163	16.74
5	177 Broad Street	686	9.88
6	Apartments	139	2.00
7	Macy's	660	9.50
8	Sak's	660	9.50
9	Filienes	660	9.50
10	Stamford Town Center	1320	19.00
11	Avalon Apartments	1806	26.00
12	SNET	224	3.52
13	Bayview Towers	347	5.41
14	Fire Station	153	2.21
15	300 Atlantic Street	521	7.50
16	Caldor	262	3.75
17	University of Connecticut	*700	*5.60
18	Swiss Bank	*2400	15.00
20	Crown Theaters/100 Apts.	*190	*2.75
21	Stamford Associates	243	3.50
22	Norelco Building	298	5.18
23	Government Center	290	4.18
24	Advocate Building	278	4.03
25	Clinton Manor	271	3.97
26	Stamford Manor	722	10.45
27	Augustus Apartments	0	2.63
28	Old Government Center	401	5.78
29	Post Office	64	0.92
30	Office Building	87	1.25
31	Center for the Arts	278	4.68
32	Library	521	7.50
33	Palace Theater	278	4.07
34	Old Town Hall	78	1.12
35	R.C. Church	111	1.61
TOTAL		19,395	243.93

*Assumed based on building size

Table 1 - 2
Peak Loads - North District

No.	Building	Cooling Peak Load (Tons)	Heating Peak Load (MBtu/hr)
36	600 Summer Street	143	2.56
37	780 Summer Street	104	1.53
38	800 Summer Street	82	1.04
39	999 Summer Street	122	1.36
40	Proposed 303 Condos	526	7.58
41	1055 Summer Street	43	0.63
42	1111 Summer Street	139	2.26
43	1177 Summer Street	139	2.17
44	1575 Summer Street	115	1.65
45	1116 Summer Street	26	0.38
46	1250 Summer Street	61	0.88
47	1290 Summer Street	63	0.9
48	733 Summer Street	87	1.25
49	707 Summer Street	104	1.53
50	6741 Summer Street	26	0.38
51	595 Summer Street	69	1.18
52	Office (Ray Tiery)	313	4.59
53	North Star Condos	542	7.8
54	Unitarian Church	0	3.4
55	Park View Apts	117	1.67
56	1st Congregational Church	87	4.25
57	Town House Apts - 65	93	1.41
58	Town House Apts - 73	79	1.21
59	Town House Apts - 75	111	1.63
60	99 Prospect	139	2.02
61	111 Prospect	110	1.25
62	Stamford Savings	39	0.56
63	112 Prospect Street	43	0.63
64	Yeshiva Bais Bisyomin	8	0.11
65	Superior Court	*750	*10.00
66	Hayes House	332	4.79
67	70 Strawberry Hill	208	3.41
68	St. Joseph Medical Center	722	10.56
69	Regency Towers	226	3.25
70	Stamford High School	930	13.39
71	Fountain Terrance	757	10.92
72	100 Prospect Street	137	2.05
TOTAL		7592.00	116.18

Economic

The economic benefits offered by the development of DCH/C are widespread throughout the local economy. They include energy sustainability, new jobs, additional income, economic development, and lower energy costs.

Sustainability. "DCH/C is a key to ecological sustainability". The ecological strain produced by the exploding population growth that places enormous demands on our natural and environmental resources may be addressed through sustainable development. Energy is a primary force in economic development and DCH/C a key to ecological sustainability through its economic and environmental advantages.

Income. "An annual revenue in excess of \$3.5 million". DCH/C systems may generate significant income for the host cities, as well as states, through property taxes, property lease, franchise fees, and gross receipt taxes. Property tax on a \$100 million project alone may produce an annual income of \$2.6 million, based on the current tax assessment and rates. Property leasing fees for similar facilities range from \$600,000 to over \$800,000, while DCH franchise fees range from 4% to 5% of the capital cost of the distribution system or about \$250,000. The city of Stamford may realize a total annual revenue in excess of \$3.5 million from the implementation of DCH/C.

New Jobs. "The development of DCH/C creates 150 short-term and 40 long-term jobs". The initial development of DCH/C will create employment for both the short and long term. Typically, 40% to 60% of the total installed cost of the system reflects labor charges. The short term employment requirements are in excess of 150 positions related to the design and construction of the system for over one year. The number of required positions drops to a level necessary to sustain growth beyond the initial construction. Once the facility is complete, an additional 40 long-term jobs, relating to its operation and administration are created. Part of the salaries from these new jobs remain in the local economy producing a "multiplier effect".

Reduced Energy Costs. "Fuel price structuring is a key element to market share". DCH/C can more effectively contract lower cost fuel than individual

customers which results in savings. Large quantities of fuel in a single location produce a bulk demand, commanding a significant discount over individual customer rates.

Economic Development. "Lower cost energy will spur investment." DCH/C is an energy conservation measure noted for increased thermal efficiency that is reflected in energy savings to end-users. The potential savings from this system may provide a positive cash flow for most customers. Accumulated savings by individual and end-users can be directly reinvested into the community to upgrade living spaces, provide better tenant services or improve the properties' appearance. DCH/C is also credited with the reduction of operation and maintenance costs for heating and cooling systems in individual buildings.

Reduced energy costs provide an incentive for economic development. DCH/C offers developers and businesses the avoided capital cost of installing heating and cooling plants and lower energy costs.

Environmental

Although, economic issues dominate the development of DCH/C systems, a host of environmental advantages address the growing environmental concerns. These advantages include energy conservation, a cleaner environment through reduced and better controlled emissions, and reduced ozone-depleting CFC's.

Cleaner Environment. "DCH/C offers stricter emission control". DCH/C encourages improved environmental quality by replacing multiple point sources with a centralized source that exhibits rigorous maintenance and enhanced controllability. Air quality in downtown areas is improved since distributed heating plants in individual buildings are retired and replaced with an efficient central source. In addition, modern emission control equipment is more readily used in central facilities where the strict emission regulations are easier to enforce.

The gas turbines typically used for cogeneration are equipped with water injection at the combustor to reduce NO_x emissions to approximately 42 ppm. The hot exhaust train of each gas turbine includes a heat recovery steam generator to capture waste heat for DCH productions, while a Selective Catalytic Reactor (SCR)

further reduces NO_x to about 9 ppm. The stack height may range from 70 to 150 feet and will significantly enhance dispersion compared to the existing individual heating systems in downtown buildings. Modern stack designs alleviate aesthetic concerns.

An advantage often ignored involves the reduction of noise pollution, prevalent in congested downtown areas. A substantial part of the noise pollution is a result of cooling towers and other air-conditioning equipment.

Reduced CFC's and Chemical Pollution. "Containment of CFC's is a top environmental issue". By limiting the proliferation of fuel, refrigerants (CFC's) and chemicals in a central DCH/C facility, the potential hazards and accidental release of these materials into the environment is minimized. The development of district cooling systems are central in addressing the emerging importance of containment and reduction of CFC's into the atmosphere. Control facilities not only offer better control of refrigerants but are more apt to switch to alternative refrigerants.

SECTION 2

ASSESSMENT OF DISTRICT COOLING AND HEATING COMBINED WITH A LARGE COGENERATION PLANT

2.1 Objective

This section summarizes the preliminary assessment of constructing a cogeneration plant in the city of Stamford and a district heating and cooling system to serve the downtown Stamford buildings. This section addresses the preliminary layout, performance, cost, and issues concerning a cogeneration facility.

The success of any cogeneration system is determined by the energy cost savings for the participants. The cost savings is directly related to the overall system efficiency. It is this difference in efficiency as compared with conventional systems which makes cogeneration attractive. This superior efficiency, however, may be offset by a poor match between thermal and electric loads.

The development of a district heating and cooling system in concert with cogeneration provides tremendous flexibility in load matching. Thermal loads may be selected and incorporated in the system as required for optimal performance. In addition, the size of the cogeneration system is variable and dependent on available funding and institutional considerations.

The engineering and design of a cogeneration plant is probably the most straight forward aspect in the development process. The regulatory, legal, and rate aspects are not well defined and rapidly changing. This uncertainty coupled with utility issues, such as problems with interface and stand-by rates, may become a significant concern.

2.2 Plant Siting and Configuration

Plant siting may be addressed in two ways: by building a new structure to house the cogeneration plant, and by utilizing an existing building, such as the city's incinerator facility which is to be shut down shortly. The cogeneration plant siting requirements are presented in Figure 2-1 and Figure 2-2. A building with a single

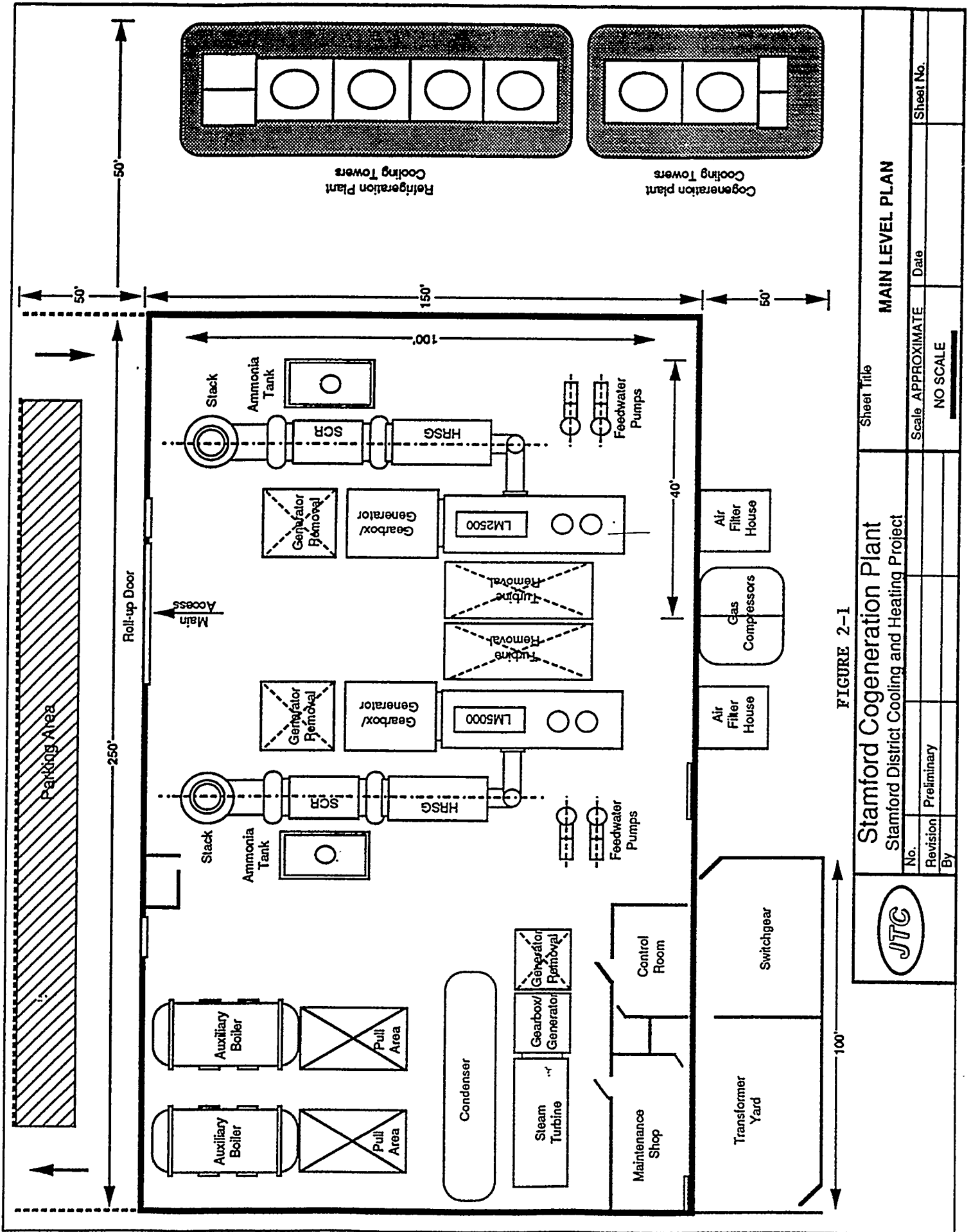


FIGURE 2-1

JTC		Stamford Cogeneration Plant		Stamford District Cooling and Heating Project		MAIN LEVEL PLAN	
No.	Revision	Scale	APPROXIMATE	Date	Sheet No.		
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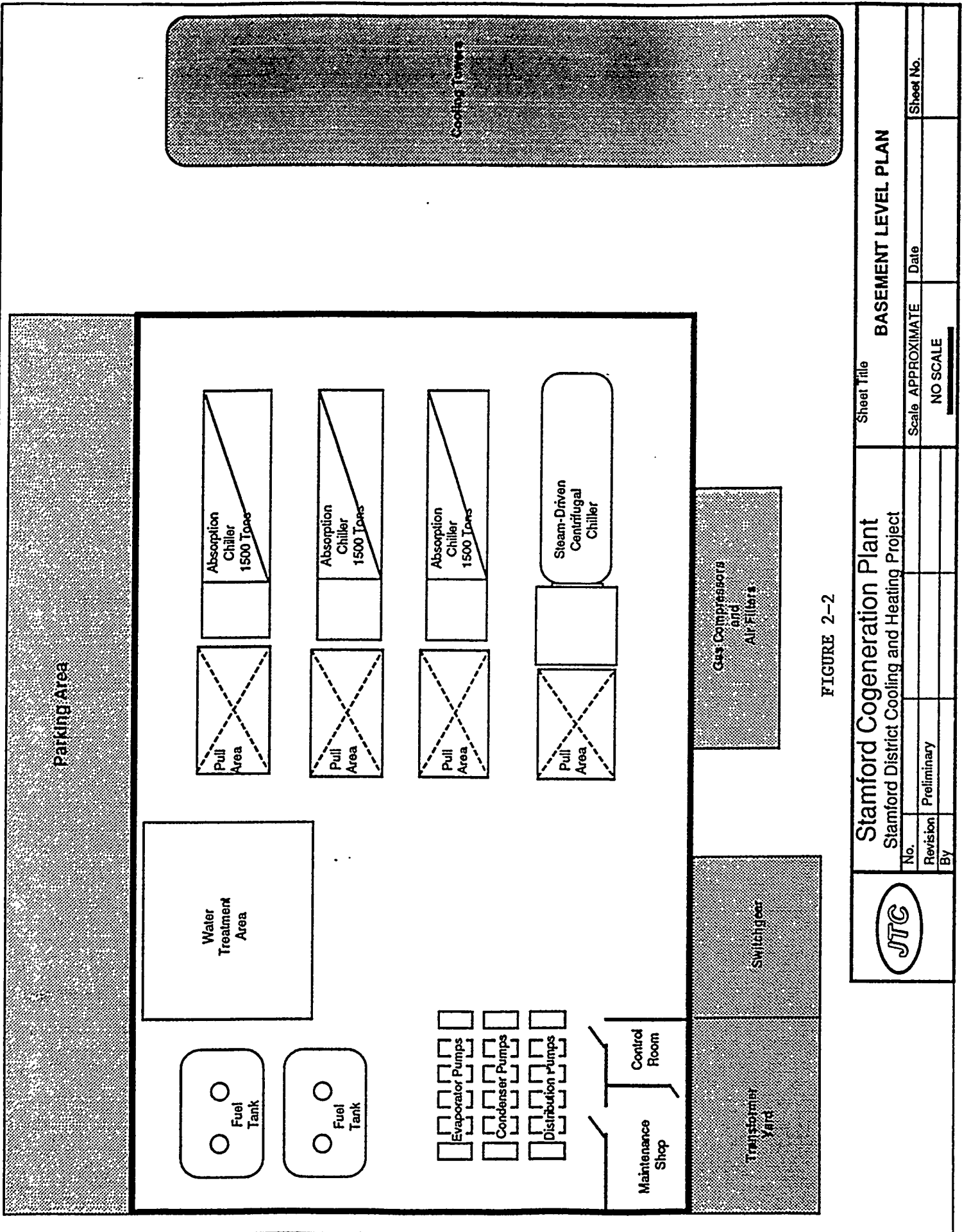



FIGURE 2-2

		Stamford Cogeneration Plant Stamford District Cooling and Heating Project		Sheet Title BASEMENT LEVEL PLAN	
		No.	Revision	Scale	NO SCALE
	Preliminary	APPROXIMATE		Date	Sheet No.
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floor and basement is the most typical configuration for this application. As indicated in Figure 2-1 the maximum building dimensions are 250'x150' on a 300' x 250' lot. The remaining lot space is utilized for equipment such as the cooling towers, air filters, switchgear, and uses such as transformer yard, and parking.

This layout may be adjusted to accommodate a smaller lot. The cooling towers may be installed on the roof and a second floor may be added.

The site should be in close proximity to the load location, downtown Stamford and offer the opportunity to build a central energy plant.

Discussions with vendors which package gas turbines for cogeneration applications were contacted to determine component sizing, performance criteria and cost as an initial step in this assessment. A combined cycle gas turbine cogeneration plant is recommended for the project, which would qualify under PURPA requirements for thermal utilization and efficiency. The plant consists of two gas turbines, a General Electric LM 2500 and a LM 5000, and a single steam turbine. Total plant capacity is estimated at 82 MW of electrical production at 59°F (ISO conditions). The gas turbines would be equipped with water injection at the combustor or dry NO_x burners to reduce NO_x emissions. The hot exhaust train of each gas turbine will include a HRSG (heat recovery steam generator) to capture waste heat for district cooling and heating production and a SCR (selective catalytic reactor) to reduce NO_x further to about 9 ppm. Stack height can range from 70 - 150 feet but will depend on the findings of a dispersion analysis.

The balance of plant will consist of equipment which supports the operation of the gas turbines and are required for district cooling and heating. District cooling equipment will include steam absorption chillers and a steam driven centrifugal chiller which will use steam generated in the HRSG's. The capacity of the cooling plant will be sized to supply a peak cooling load of 9400 Tons. The configuration assumes a hot water district heating system requiring steam to hot water converters for its production. Backup packaged steam boilers are estimated for period when a gas turbine is not operating. Heating equipment is sized to meet a peak demand of approximately 120 mmbtu/hr.

A preliminary layout of major equipment components is indicated on Figure 2-1 and 2-2. Primary components include the LM2500 and LM5000 gas turbines with SCR and HRSG, transformers/switchgear, steam turbine, condenser, cooling tower, gas compressors, fuel tanks, water treatment tanks, hot water backup boilers and ancillaries, and centrifugal and absorption chillers with cooling towers, pumps and auxiliaries. The turbines with their HRSG's and the auxiliary boilers are located on the main level of the plant. The chillers are located in the basement level of the plant along with the water treatment system, the fuel storage tanks, and the various pumps. The cooling towers, transformer yard/switchgear, gas compressors, and air filters are located on the outside of the structure. This layout is flexible and may change to suit land availability.

The maximum gas requirement for the LM 2500 and LM 5000 gas turbines is estimated at 700,000 mcf/h. Once the final gas requirement is determined, gas suppliers may be approached to determine the rates and to select the most favorable one. The available gas suppliers for Stamford are Yankeegas and TENNACO, along with the alternative of transportation gas.

2.3 Plant Performance and Cost Estimate

The heat balance of the proposed LM 2500 and LM 5000 gas turbine cogeneration plant was analyzed for the district cooling and heating system in Stamford. Three ambient temperature and district energy load conditions were defined to predict performance of the cogeneration plant. Three examples of potential operating conditions (included as heat and flow diagrams Figure 2-3 to 2-5) follow:

- a) Typical Summer Day - 90°F dry bulb, 75°F wet bulb, 85,000 #/hr steam extraction for district cooling and heating.
- b) Typical Winter Day - 30°F dry bulb, 30% R.H., 44,000 #/hr steam extraction for district cooling and heating.
- c) Typical Spring/Fall Day - 59°F dry bulb, 60% R. H., 13,000 #/hr. steam extraction for district cooling and heating.

These operating conditions were used to extrapolate other operating temperatures through a bin analysis of hourly temperature occurrence for the Stamford area to determine annual quantities including fuel consumption and electrical output. The

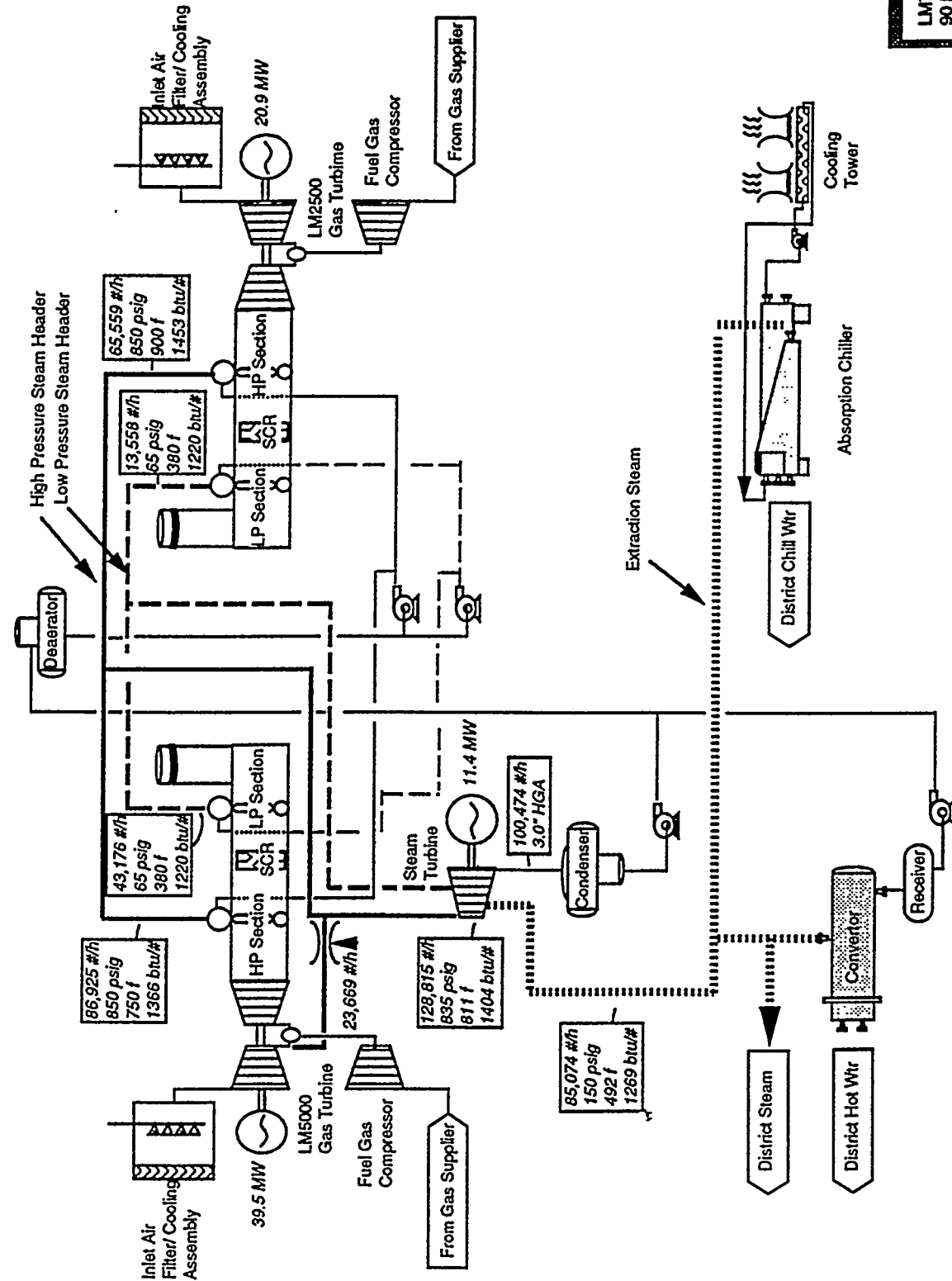



FIGURE 2-3

		Sheet Title HEAT & FLOW DIAGRAM - SUMMER DAY		Sheet No.	
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	Preliminary			Date	

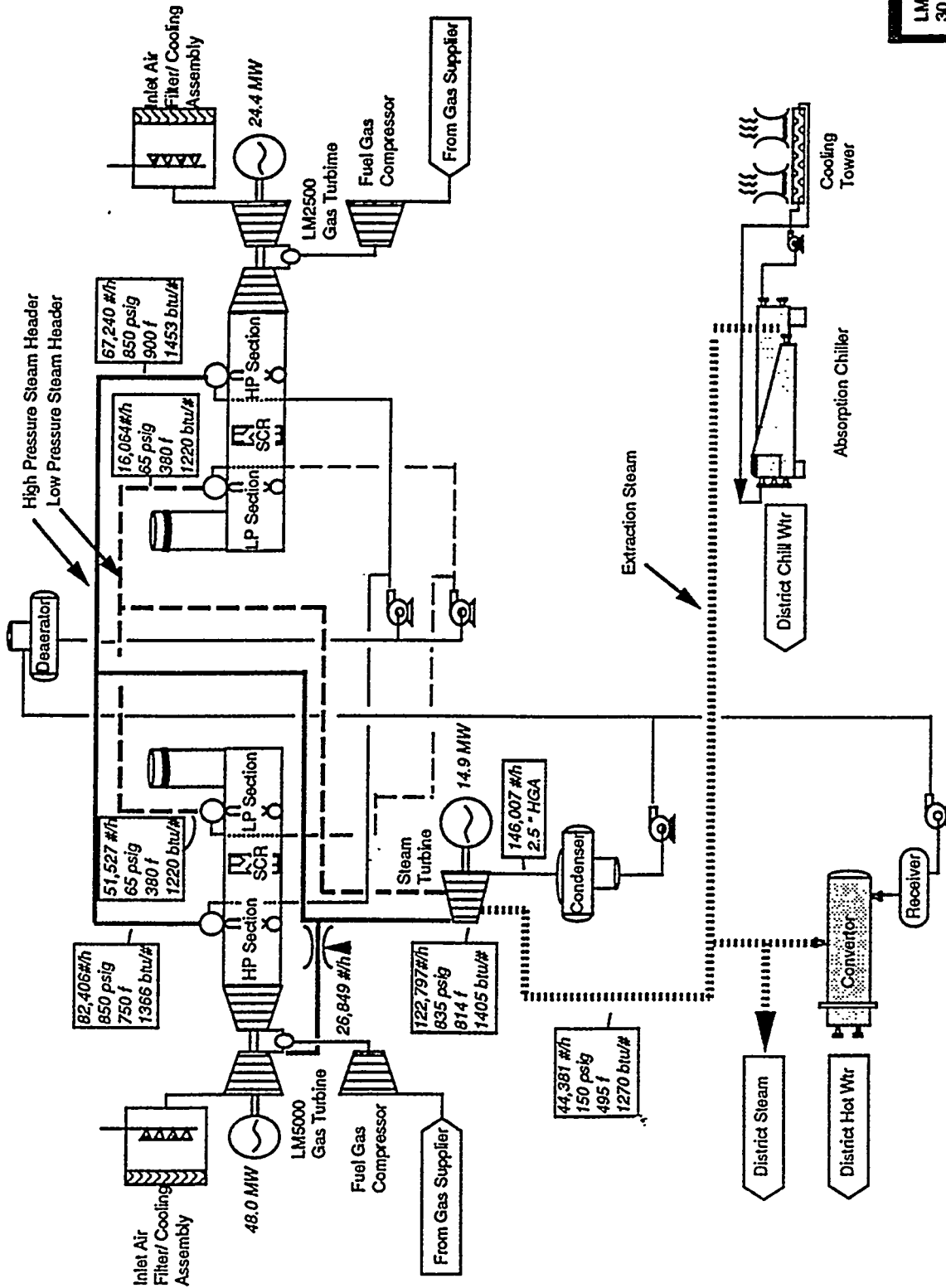

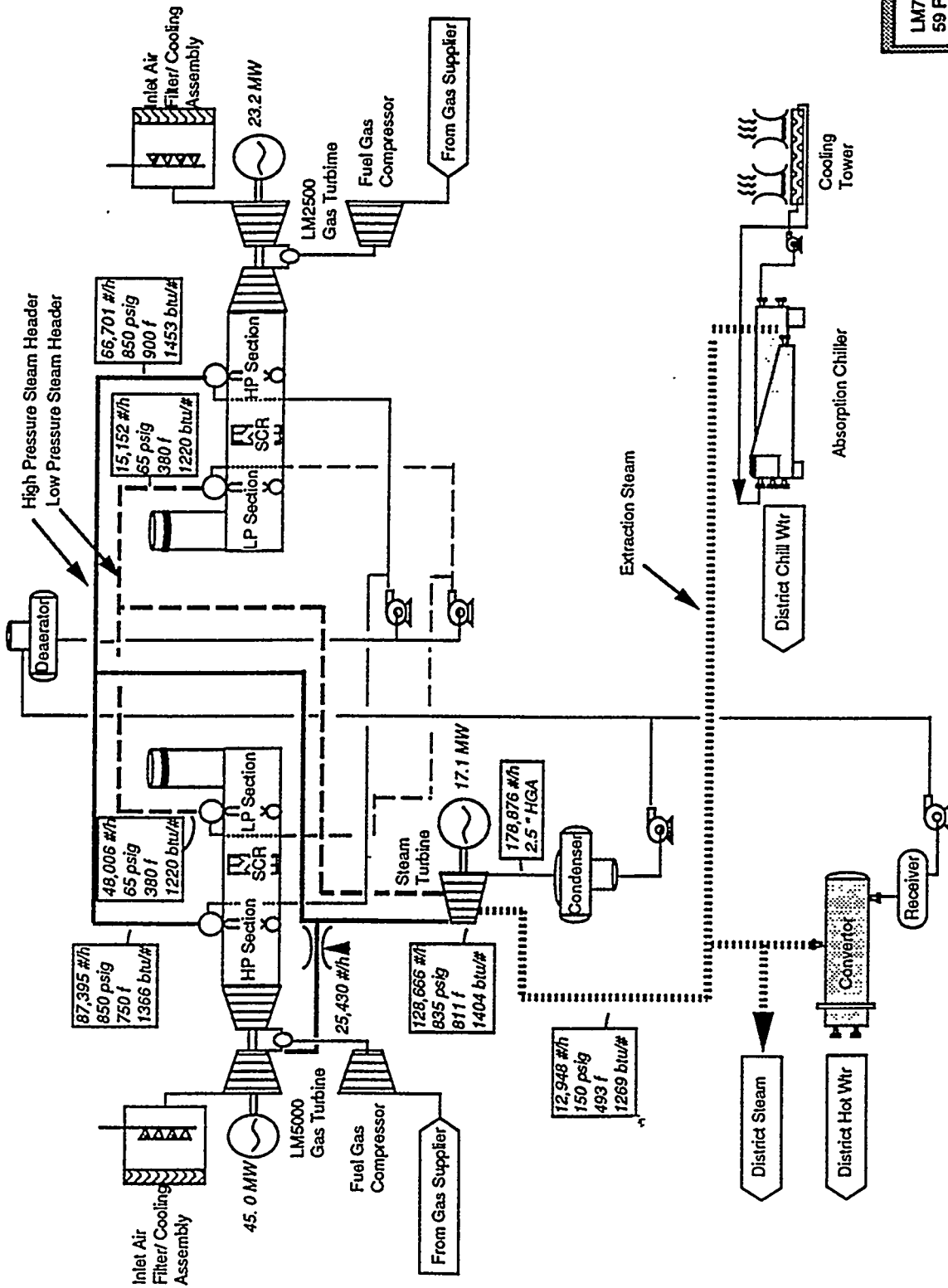


FIGURE 2-4

		Sheet Title HEAT & FLOW DIAGRAM - WINTER DAY		Sheet No.	
		Stamford Cogeneration Plant Stamford District Cooling and Heating Project		Scale NONE	
No.	Revision	Preliminary	Date	Date	
By					



LM7500 COMBINED CYCLE
59 F DB, 60 % RH
EVAP COOLED TO 52.5 F

FIGURE 2-5

		Stamford Cogeneration Plant Stamford District Cooling and Heating Project		Sheet Title HEAT & FLOW DIAGRAM - SPRING/FALL DAY
		No.	Revision	Scale
By	Preliminary	Date	Sheet No.	

results of this analysis is presented in Table 2-1. Note that the gas turbines shall be operating at their optimum rates and the steam extraction for district service will only affect the output of the steam turbine. Steam shall be utilized as needed, which determines the level of output for the steam turbine, which may range from no output to full output.

A preliminary cost estimate is presented in Table 2-2. It includes the cost for the cogeneration equipment, the heating and cooling equipment, the distribution network, the new building and other associated costs.

2.4 Permitting

The following discussion is presented as an introduction to permitting requirements. The discussion is not intended to be complete since the requirements for a project are dependent on the specific details and siting of the project.

Air

The Stamford Department of Environmental Protection, Air Management, Engineering and Enforcement Division, reviews construction of new sources of air emissions and issues permits for construction, installation or modification. This review is conducted for both attainment and non-attainment areas of the State as defined by the National Ambient Air Quality Standards (NAAQS). The city of Stamford is in non-attainment of national ambient air quality standards for CO (carbon monoxide) and TSP (total suspended particulate). The entire state is considered non-attainment for ozone. In accordance with the federal EPA policy, new sources can only be located in non-attainment areas if the emissions are offset by a reduction in emission of the same pollutants from other existing facilities in the same area. This is apparent since the efficient centralized facility will replace the emissions of the individual sources.

Air quality modeling will be required and conform to NAAQS, prevention of significant deterioration (PSD) and ambient air levels (AAL) in addition to the application. After review by the Division, a public hearing is generally held.

Table 2-1

Preliminary Heat Balance for the Stamford Cogeneration Plant

Stamford District Cooling and Heating Project

Capacity Factor	AMBIENT		COGEN PLANT INPUT						COGEN PLANT OUTPUT					
	Outdoor Temp (F)	Temp Occurrence HOURS/YR	Fuel			TOTAL (MMBTU)	Electric			Electric			District	
			LM2500 (MMBTU)	LM5000 (MMBTU)	AUXILIARY (MMBTU)		AUXILIARY (MWH)	LM2500 (MWH)	LM5000 (MWH)	STM TURBINE (MWH)	Heat Load (MMBTU)	Cool Load (TONHR)		
1.0	-18	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	-13	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	-8	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	-3	1	262	463	725	725	3	25	49	3	74	157	937	0
1.0	2	8	2076	3689	5765	5765	21	198	391	47	614	1157	7496	0
1.0	7	35	9005	16060	25064	25064	94	864	1711	278	2760	4647	32795	0
1.0	12	83	21167	37895	59062	59062	224	2048	4052	818	6693	10033	77771	0
1.0	17	169	42719	76773	119492	119492	460	4161	8226	1952	13878	18419	158353	0
1.0	22	279	69896	126105	196002	196002	764	6847	13524	3632	23240	27091	261423	0
1.0	27	453	112469	203715	316184	316184	1244	11071	21839	6466	38131	38602	424461	0
1.0	32	697	171481	311847	483328	483328	1916	16943	33375	10671	59073	51108	653089	0
1.0	37	842	205261	374796	580057	580057	2310	20337	39991	13580	71598	51731	788954	0
1.0	42	829	200228	367113	567340	567340	2265	19872	38999	13869	70475	41078	776773	0
1.0	47	771	184485	339664	524149	524149	2092	18321	35873	13195	65297	29039	722427	0
1.0	52	751	178011	329135	507145	507145	2019	17670	34509	12978	63138	19358	703687	0
1.0	57	780	183130	340060	523190	523190	2072	18149	35342	13440	64859	10834	730860	0
1.0	62	827	192305	358658	550963	550963	2165	19005	36891	14028	67758	5588	774899	0
1.0	67	865	199196	373159	572355	572355	2225	19607	37924	14252	69558	5845	2799926	0
1.0	72	791	180376	339426	519802	519802	1994	17661	34024	12477	62169	5345	5592442	0
1.0	77	402	90766	171582	262349	262349	990	8829	16934	5971	30744	2716	4383116	0
1.0	82	133	29731	56463	86194	86194	319	2869	5476	1824	9850	899	1959948	0
1.0	87	35	7745	14779	22524	22524	81	740	1405	433	2497	236	649937	0
1.0	92	8	1752	3360	5112	5112	18	166	313	86	547	54	179223	0
1.0	97	1	217	418	634	634	2	20	38	9	65	7	26236	0
1.0	102	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0	TOTALS	8760	2082277	3845160	5927437	5927437	23279	205401	400886	140010	723019	323943	21704753	0
0.9		8760	1874050	3460644	5334693	5334693	22688	184861	360797	126009	650717	323943	21704753	0

Table 2-2
Cogeneration Plant Cost Estimate

<i>Cogeneration Plant</i>	\$65,000,000
LM7500 Steam injected gas turbine	
Steam turbine generator	
HRSR, SCR, cooling tower	
Gas booster system, fuel storage	
Associated equipment	
<i>Heating Plant</i>	\$2,500,000
Boilers	
HW converters, piping	
Associated equipment	
<i>Cooling Plant</i>	\$5,500,000
Absorption/Centrifugal Chillers	
Cooling towers, condenser	
Pumps, piping	
Associated equipment	
<i>New Building</i>	\$3,500,000
<i>Distribution Network</i>	\$4,500,000
Piping, valves	
Btu meters	
Associated equipment	
<i>SUBTOTAL</i>	\$81,000,000
Contingency	\$8,000,000
Engineering	\$2,500,000
Legal & Financial Fees	\$2,500,000
Project Management Fee	\$4,000,000
Developer Fee	\$3,000,000
Working Capital	\$500,000
Interest During Construction	\$4,000,000
<i>TOTAL</i>	\$105,500,000

Water

The Department of Environmental Management has primary responsibility concerning the discharge of pollutants into State waters. Orders of approval are generally required to construct waste water treatment systems to ensure that any discharges will meet the established criteria.

Utility Interconnection

The procedure necessary to interconnect a cogeneration plant to the utility distribution system must not interfere with the operations of the utility or any of its customers. The cogeneration plant must have a circuit breaker accessible to the utility to enable isolation of the cogeneration plant from the utility's system. The utility reserves the right to refuse to interconnect or to discontinue an interconnection if the cogeneration plant causes interference with their electrical distribution. Once the project is sufficiently advanced, the utility will issue a "Request for a Service Investigation" which authorizes engineering time to assess the project from the utility's prospective and the services they will perform.

2.5 Economics

The breakeven cost of electricity, cooling and heating has been developed (Table 2-3). The information presented in Table 2-3 clearly demonstrates that the electric revenue is the major component supporting the feasibility of the project. Discussion with the electric utility has indicated that at the present time the electric sales will not be able to support this project.

2.6 Conclusion

The initial assessment was performed for an 82 MW cogeneration plant which was intended to export electricity, heating and cooling energy. Taking into account the low prices for electricity any further development of the 82 MW plant at this time was found unfeasible.

Table 2-3
Breakeven Cost for the 82 MW Cogeneration Plant

Costs	Ref. Data	Annual Cost	% of Cost
<i>CAPITAL COMPONENT</i>			
Capital Cost of Project	\$105,500,000		
Fixed Charge Rate	0.12	\$12,660,000	39%
<i>O & M COST</i>			
Percent of Capital Cost	2.50%	\$2,638,000	8%
<i>FUEL COST</i>			
Capacity Factor	0.9		
Fuel Quantity (MMBtu)	4,876,000		
Unit Fuel Cost (\$/mmbtu)	3.5		
Gas Turbine Fuel Cost		\$17,066,000	53%
<i>Total Annual Cost</i>		\$32,364,000	100%

Revenue	Ref. Data	Annual Sales	% of Sales
<i>HEAT GENERATION</i>			
Quantity (MMBtu)	240,000		
Unit Heat Cost (\$/MMBtu)	8		
Heat Sales		\$1,920,000	6%
<i>COOLING GENERATION</i>			
Quantity (Ton hrs.)	9,400,000		
Unit Cooling Cost (¢/ton-hr)	28		
Cooling Sales		\$2,632,000	8%
<i>ELECTRIC GENERATION</i>			
Quantity (MWHR)	616,261		
Unit Electric Cost (\$/MWHR)	45.13	\$27,812,000	86%
<i>Total Annual Revenue</i>		\$32,364,000	100%

SECTION 3

ASSESSMENT OF DISTRICT COOLING AND HEATING COMBINED WITH AN IN-FENCE COGENERATION PLANT

3.1 Objective

The development of the 82 MW cogeneration plant which was intended to export electricity, heating and cooling energy was found unfeasible at this time. Therefore an option of a small in-fence cogeneration plant combined with a district heating and cooling system has been developed. This scenario does not mean the export of electricity from the cogeneration plant but suggests to use all power generated to drive electric chillers and run an electric boiler.

The development of a district heating and cooling system in combination with cogeneration provides flexibility in load matching. Thermal loads may be selected and incorporated in the system as required for optimal performance. A number of buildings in the downtown of Stamford was identified to be served by the proposed DHC cogeneration plant. It should be noted that all customers are mostly office buildings which defines the profiles of their heating and cooling loads. The peak heating load for selected buildings was estimated at 130 MMBtu/hr and peak cooling load - at 9,000 tons. These loads will be supplied from the plant which has to be built in the adjacent area to a major customer.

3.2 Plant Configuration

The plant will consist of a gas turbine unit including a heat recovery steam generator (HRSG) with supplemental firing, a gas fired boiler(s) to supply peaking loads and an electric boiler. The plant will also include two types of chillers to supply cooling loads - electricity driven (thereafter "electric") and absorption chillers (thereafter "thermal"). The flow diagram of the plant is shown in Figure 3-1. The HRSG, electric and peaking boilers will be connected to the common steam header. The steam from the header will pass through a heat

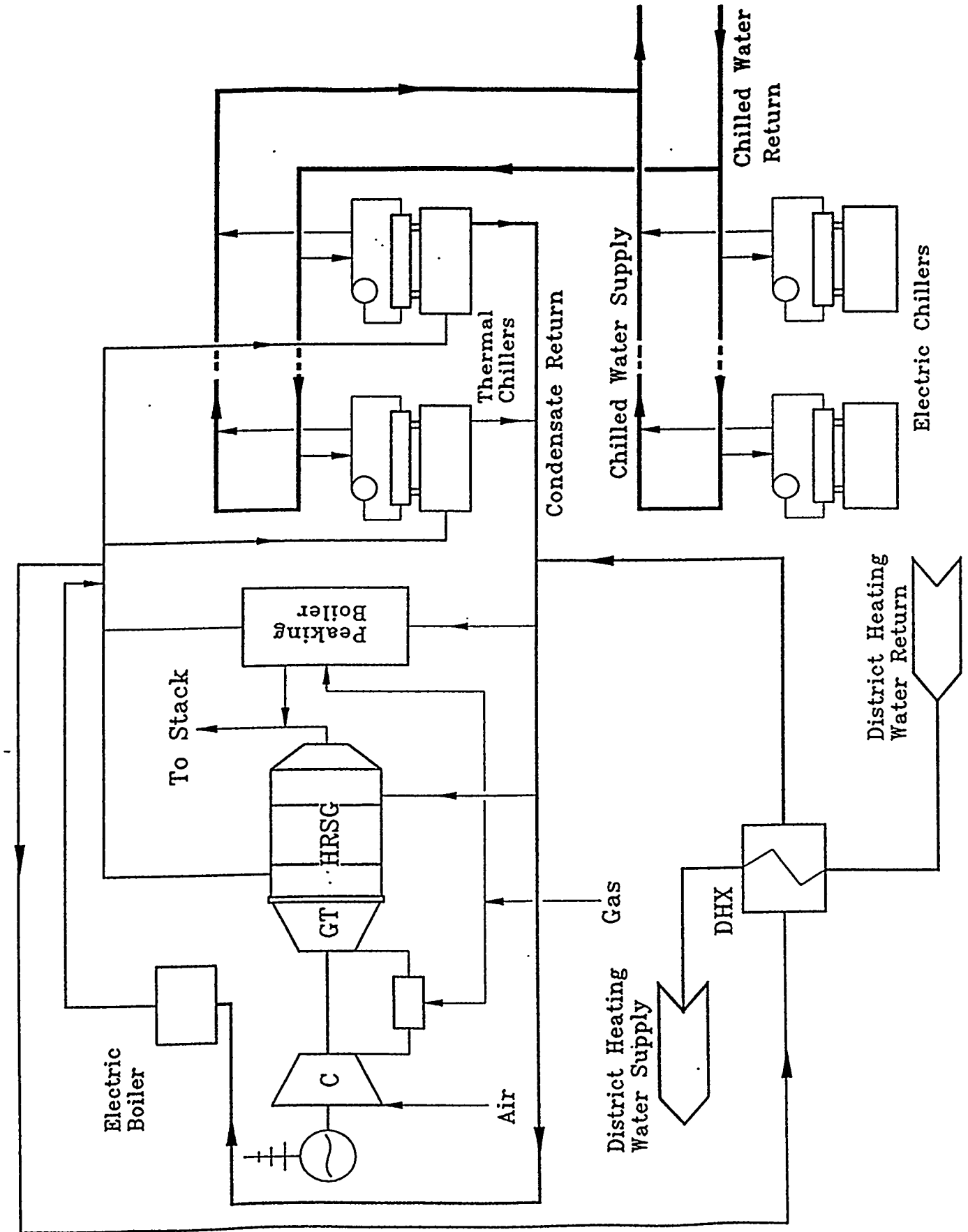


Figure 3-1 Cogeneration DHC System Flow Diagram

exchanger to heat a district heating water and, also will be delivered to the absorption chillers installed at the plant.

The plant is intended to operate as follows.

During the summer:

- gas turbine electric output will be used to drive electric chillers to supply base and peak cooling loads;
- gas turbine heat output (HRSG) is used by thermal chillers to supply peak cooling load;
- electric boiler uses the excess of electric generation and produces heat to supply domestic hot water load;
- gas fired boiler is used to supply peak cooling load.

During the winter:

- gas turbine heat output (HRSG) is used to supply base heating load;
- gas turbine electric generation is used by electric chillers to supply base cooling load;
- the excess of electric generation is directed to electric boiler to supply heating load;
- gas fired boiler is used to supply peak heating load.

3.3 Performance Analysis

The annual heating and cooling loads duration is shown in Figure 3-2. This figure also demonstrates the load supply by different components of the power plant - gas turbine unit, electric boiler and gas fired peaking boiler. The duration curve shown in Figure 3-2 represents the annual load profile. Similar curves were built for every month and monthly quantities supplied by different plant components have been determined. The heating load supply on monthly basis is presented in Figure 3-3. The cooling load supply is shown in Figure 3-4. It should be noted that cooling loads are mostly supplied by the electric chillers, while the thermal chillers are used to supply peaks only. This requires installation of the sufficient thermal chiller capacity despite the relatively short time of full utilization.

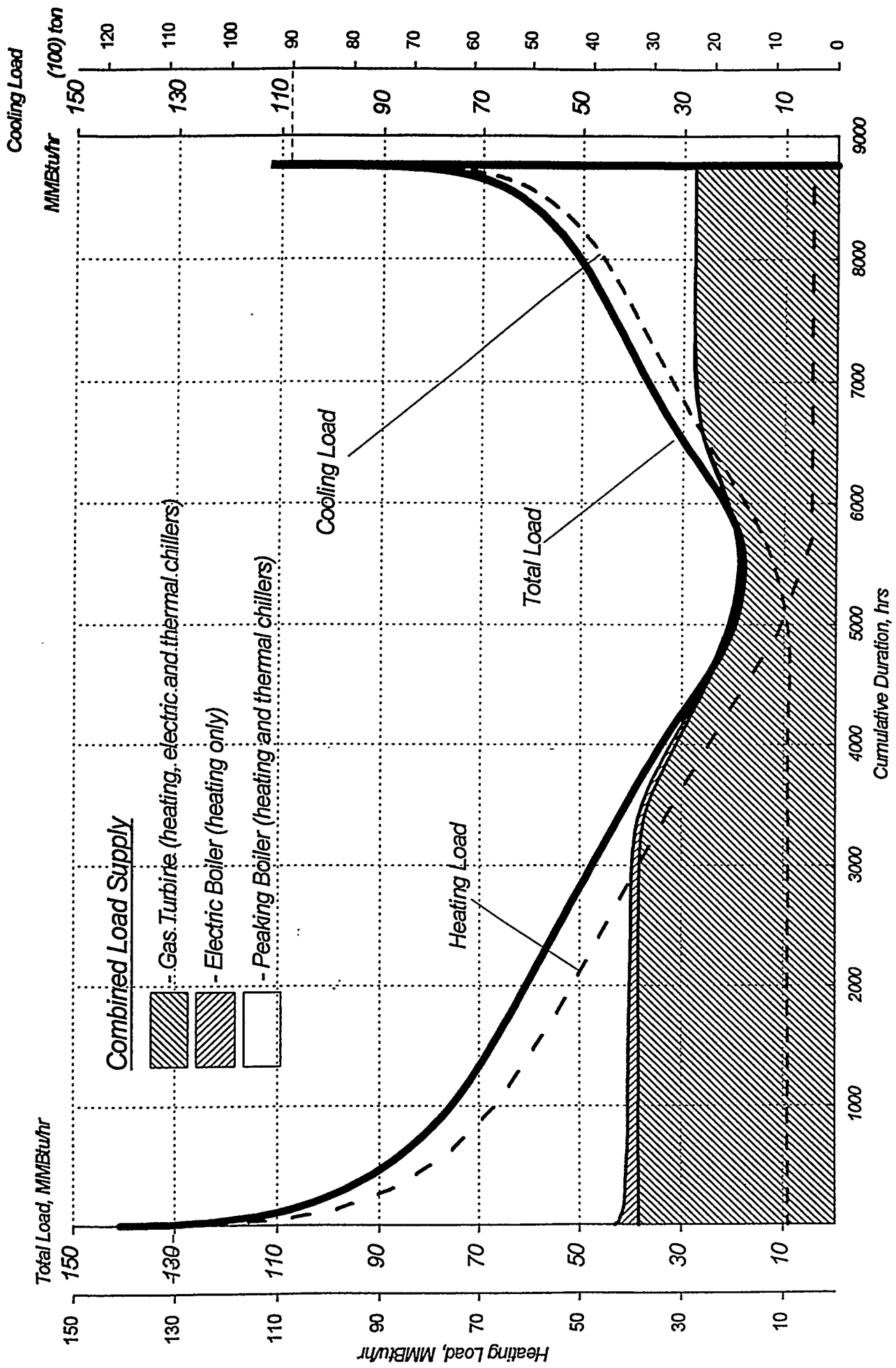


Figure 3-2 Heating and Cooling Annual Loads. Downtown Stamford, CT.

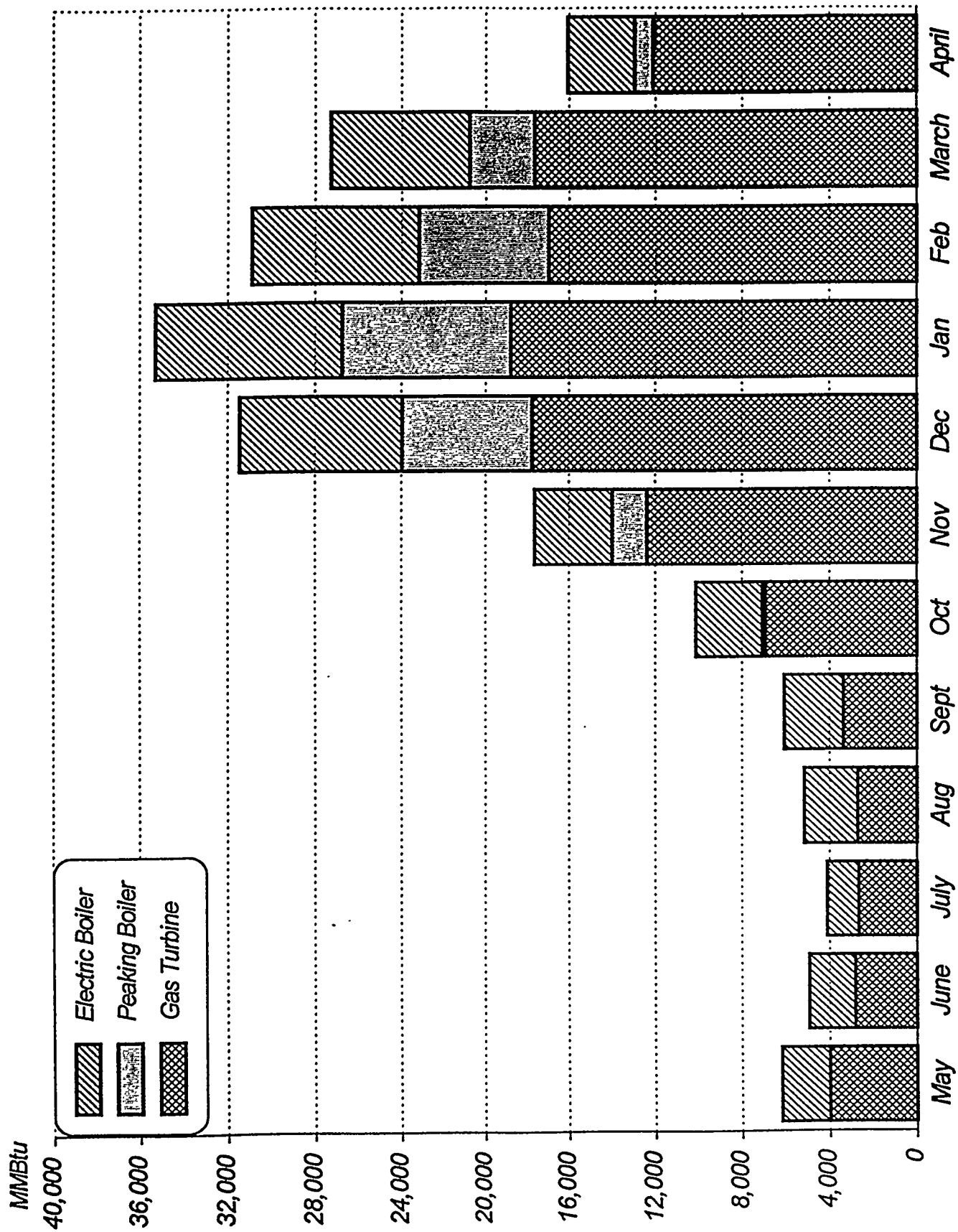


Figure 3-3 Heating Load Supply

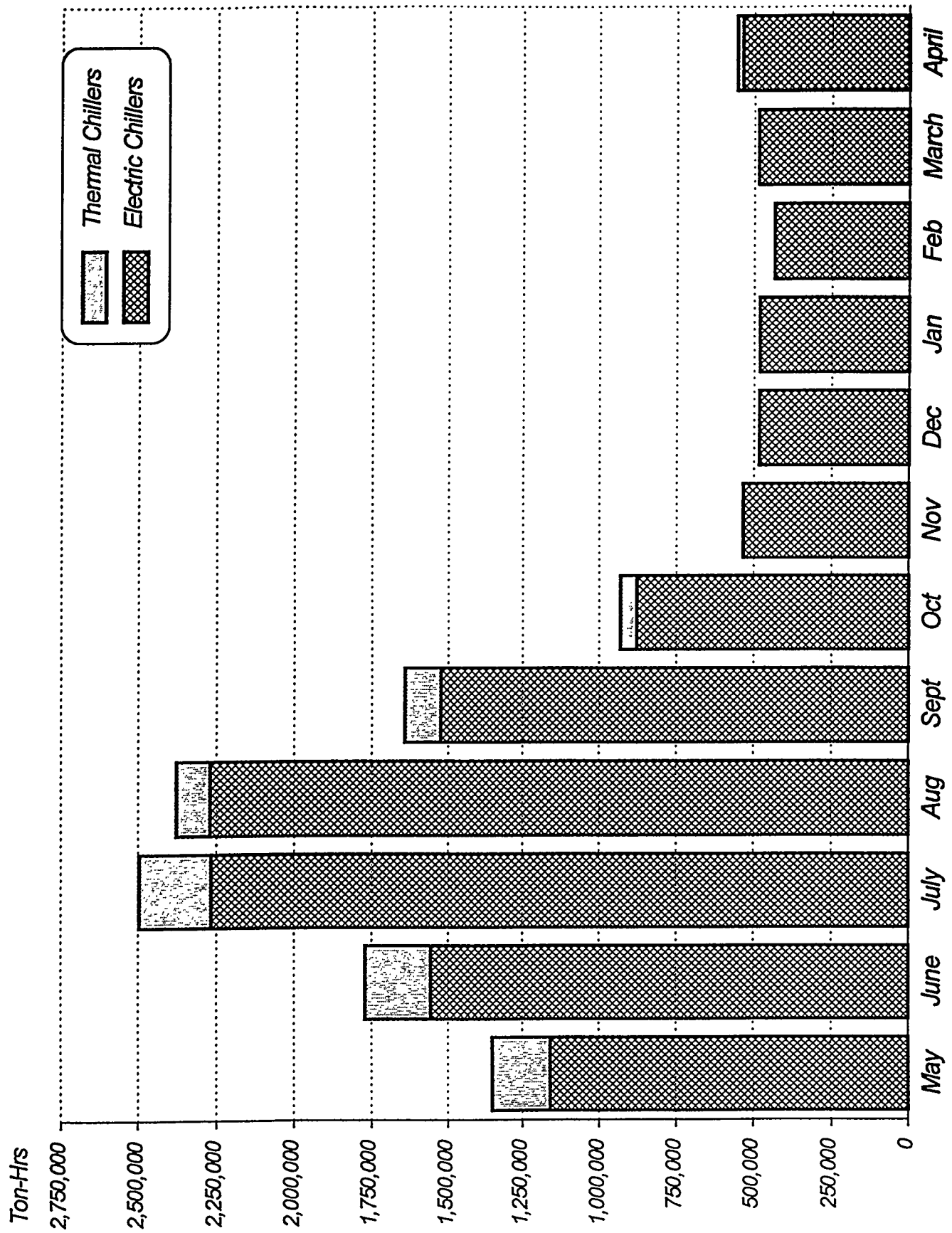


Figure 3-4 Cooling Load Supply

The preliminary performance analysis of the Cogeneration/ DHC system has been performed and it is presented in Table 3-1. The analysis was done based on the monthly quantities of the heating and cooling loads obtained from the monthly load duration curves. The capacity factor of the gas turbine unit was introduced to the analysis to reach the maximum flexibility in allocation the loads supply. It was assumed that all electricity generated at the plant would be used to drive electric chillers and run the electric boiler. No export of electricity was allowed. Thus, the electric generation was first allocated to the electric chillers. The excess generation, especially in the winter when cooling demand is insubstantial, was used in the electric boiler to supply heating load. Thermal chillers were used to supply the peak cooling load. The required installed capacities have also been estimated in this analysis. Using a typical heat rate for gas turbine units of this size, the fuel input to the gas turbine was determined. The gas fired boiler fuel efficiency was assumed 75% and fuel input to the peaking boiler was also estimated. The total annual fuel input to the plant was estimated at 403,076 MMBtu per year.

3.4 Cost Estimates

Based on the capacities required the preliminary cost estimate was performed. The backup capacities were assumed the size of the largest unit out of service. The size of the peaking boiler was estimated with taking into account that HRSG has supplemental firing. The price assumptions used in the estimate and a capital cost estimate for the plant are presented in Table 3-2.

Annual heating and cooling production cost is defined as the summation of three cost components: a) fuel, b) operations and maintenance (O&M) and c) capital component. The capital component is equivalent to the replacement cost of the power plant. To annualize this cost, amortization of this amount over the 20 year life of the plant was taken. The annual cost was then divided by the annual Btu's and Ton-hrs produced by the plant. The O&M cost was assumed 3% of the capital investment. Each cost component was totaled on an annual basis and then divided by the annual heat and cooling production to provide a unit heating cost. Results of this assessment are indicated in Table 3-3.

Table 3-1
Performance of the Cogeneration/ DHC System

Month	Total Heat Supply	Heating Peak	Total Cooling Supply	Cooling Peak	Electricity to		Heat Supply from		Cooling Supply from		Heat Rejected	Required Capacity		Gas Turb. Capacity Factor				
	MMBtu	MMBtu/hr	ton-hrs	ton	Lighting	Chillers	El. Boiler	Gas Turb.	Electr. Bir	Peak Bir		Eltr. Chlrs	G.T.		Pk. Bir	Electr. Bir	Peak Bir	Therm. Ch.
						kWh	MMBtu	MMBtu	ton-hrs	ton-hrs	MMBtu	MMBtu/hr	ton	MMBtu	MMBtu/hr	ton		
May	3,872	44.10	1,348,054	7,014	0	1,158,559	629,441	3,765	2,148	29	1,158,559	5,233	184,262	2,070	6	56	4,274	
June	2,830	44.10	1,770,114	7,991	0	1,556,195	603,805	2,817	2,061	3	1,556,195	4,627	209,292	2,050	8	64	4,551	
July	2,679	22.48	2,497,381	9,004	0	2,267,868	417,734	2,679	1,426	0	2,267,868	4,829	224,686	1,426	10	50	4,827	
August	2,730	22.48	2,377,668	7,991	0	2,269,976	702,024	2,730	2,396	0	2,269,976	4,200	103,492	2,396	11	39	3,351	
September	3,305	44.10	1,641,523	7,014	0	1,524,079	783,121	3,264	2,673	2	1,524,079	4,312	113,132	2,633	9	54	3,314	
October	6,987	65.72	932,160	6,037	0	878,561	902,239	5,636	3,079	572	878,561	2,224	51,375	2,421	6	68	2,731	
November	13,812	87.33	535,036	4,082	0	532,887	1,053,313	8,210	3,595	3,682	532,887	67	2,081	1,675	5	71	1,270	
December	26,205	119.76	481,971	1,151	0	481,971	2,192,829	16,029	7,484	5,323	481,971	0	0	2,632	10	69	0	
January	30,224	130.56	480,542	1,151	0	480,542	2,491,358	18,555	8,503	5,509	480,542	0	0	2,342	11	68	0	
February	26,200	108.95	434,444	1,036	0	434,444	2,253,556	16,729	7,691	4,183	434,444	0	0	2,404	11	77	0	
March	22,330	108.95	485,460	2,857	0	485,460	1,892,140	14,440	6,458	3,529	485,460	0	0	2,097	9	77	0	
April	12,453	87.33	556,483	4,226	0	537,308	902,692	7,707	3,081	2,940	537,308	382	18,793	1,275	5	73	3,131	
Totals (Maxes)	153,509	130.56	13,540,935	9,004	0	12,607,948	14,824,252	102,561	50,595	25,772	12,607,948	25,874	907,113	25,420	11	77	5,000	0.78

Design Temp - Dry (Winter) 6
 Peak Heat Load, MMBtu/hr 130
 % of Peak as Base Heat 4%
 Base Heat Load, MMBtu/hr 4.72
 Breakeven Heat Temp 55
 Peak Cooling Load, ton 6
 % of Peak as Base Cooling 130
 Base Cooling Load, ton 1000
 Breakeven Cooling Temp 75%
 Heat Rate, Btu/kWh 13,000
 Peaking Boiler Efficiency 75%
 GT Output, kW 4,000
 Heat, MMBtu/hr 28
 Heat Output w/ Suppl. Firing, MMBtu/hr 52

Table 3-2
Capital Cost Estimate

<i>Price Assumptions</i>	
Gas Turbine Package, \$/kW	1200
Steam Boiler, \$/BHP	800
Electric Boiler, \$/MMBtu/hr	8000
Electric Chiller, \$/ton	700
Thermal Chiller, \$/ton	1000
Gas Fuel, \$/MMBtu	4
Gas Turbine Package includes HRSG w/ supplementary firing	

<i>Required Minimum Installed Capacities</i>	<i>Preliminary Price</i>	
		BHP
Gas Turbine Package, kW	4,000	\$4,800,000
<i>HRSG with Supplementary Firing - total 52 MMBtu/hr - included in Gas Turbine Package</i>		
Peaking Boiler(s), MMBtu/hr	77	2300 \$1,840,000
Electric Boiler, MMBtu/hr	11	\$91,578
Electric Chillers, tons	4,000	\$2,800,000
Thermal Chillers, tons	5,000	\$5,000,000
<i>Backup Capacities</i>		
Boiler	23	770 \$616,000
Electric Chillers, tons	1,000	\$700,000
Thermal Chillers, tons	1,000	\$1,000,000
Total Cost		\$16,847,578
Annual Fuel, MMBtu	403,076	\$1,612,306

Table 3-3.
Unit Cost of Heat and Cooling for the Cogeneration Plant

Peak Heating Load, MMBtu/hr 130.0
Peak Cooling Load, ton 9,000

Total Useful Heat Produced, MMBtu 153,509
Total Useful Chilling Produced, ton hrs 13,540,935

<i>Annual Expenditures for the Cogeneration Plant</i>	<i>Miscellaneous</i>	<i>Item or Cost Description</i>	<i>Total Annual Cost (\$)</i>	<i>Heat Cost (\$/MMBtu)</i>	<i>Cooling Cost (\$/ton hr)</i>
FUEL		(MMBtu)			
Annual Fuel Usage					
Gas	(ccf) 4,030,765	403,076	\$1,612,306		
CAPITAL COMPONENT					
<i>Capital Cost of the Plant</i>	\$16,847,578				
Annual Capital Component (assuming 10% interest rate, 20 years)			\$1,978,910		
MAINTENANCE/OPERATIONS (NON-FUEL)					
O&M Costs (3% of Capital Investment)			\$505,427		
TOTAL ANNUAL COST			\$4,096,643	\$7.00	\$0.223

A total annual composite cost of \$4,096,643 or a unit cost of heat - \$7.00/MMBtu, and cooling - 22.3¢/ton-hr was estimated for the cost to supply heat and cooling from the power plant. This cost includes fuel, capital and O&M.

3.5 Conclusion

The proposed concept outlines the development of an in-fence cogeneration DHC system. No sales of electricity is required. The DHC plant heating and cooling costs compare favorably to individual costs of heating and cooling in the buildings. The concept can be used for the Swiss Bank, Stamford Mall or on a smaller scale for the University of Connecticut.

SECTION 4

FIRST PHASE OF DISTRICT COOLING AND HEATING SYSTEM DEVELOPMENT

4.1 Objective

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.

Developers of the central energy plant should first seek existing or new facilities with sufficient space to house the district energy plant.

From an institutional perspective the service area should be comprised of participants who will anchor the system, encouraging the success of the project. To a varying degree, all these criteria are satisfied in the proposed development described below.

4.2 System Description

There are presently a number of downtown developments which offer a good opportunity for the start of the first phase district energy system. These developments include the renovation of the former Bloomingdale's building into the University of Connecticut and the proposed construction of the Swiss Bank building.

It is proposed beginning the development of the district cooling and heating system with three customers: the Stamford Town Center (Mall), installed chiller capacity 1,320 tons and heating capacity 19 MMBTU/yr.; University of Connecticut with a

capacity of new chillers to be installed of 700 tons and boiler of 5.6 MMBtu/hr; and the Swiss Bank with a capacity of new chillers to be installed of 2,400 tons and heating capacity of 15 MMBtu/yr (Figure 4-1).

The DCH plant can be located at the University site. This will permit the offering of district cooling and heating to the Swiss Bank before the bank finalizes their plans for HVAC and energy supply systems. In order to minimize the risk and to reduce the initial capital investment the DCH plant should be sized to supply the University and Swiss Bank peak loads. At the same time, the DCH plant will supply on an annual basis most of the cooling load while the mall chillers will be supplying the peak load.

Coincident with the above developments, existing court buildings which face Hoyt Street will be replaced shortly with a new and large 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. These and other customers can be interconnected in order to enhance the system economics for the first phase development.

The prospective customers for the first phase of the development are within a half mile distance, making the system compact. Their close proximity will reduce the percentage that the underground piping system will cost with respect to the total budget.

The first phase would witness construction of a four-pipe underground distribution system for district cooling and heating.

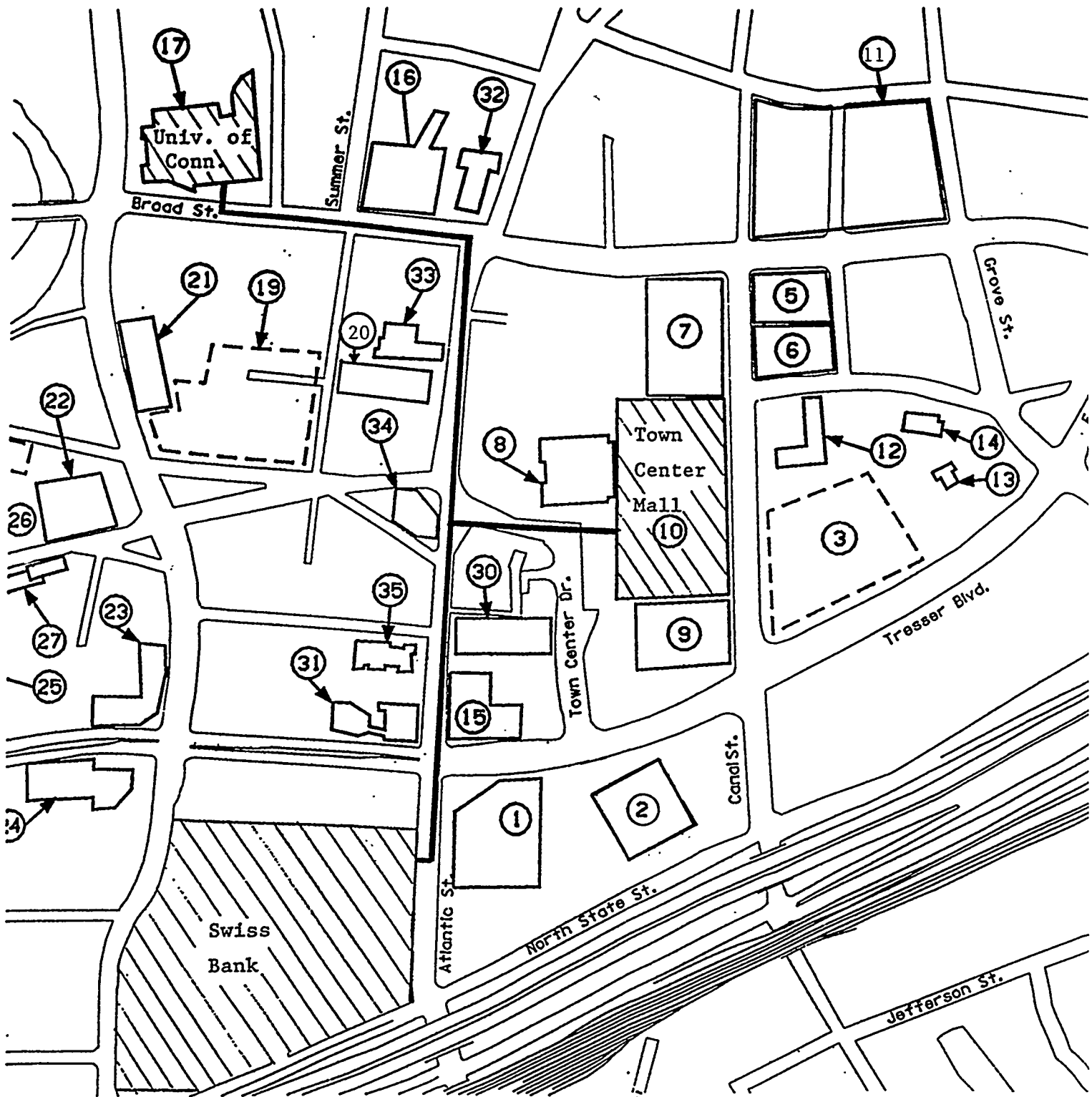


Figure 4-1 First Phase of the District Cooling/heating System in
 Stamford, CT
 4-3

4.3 Advantages of District Cooling and Heating Supply

A district energy alternative reduces the first costs associated with the installation of cooling and heating plant for new customers, such as the Swiss Bank. This cost savings 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 example, it is estimated that the Swiss bank will avoid capital investments of about \$2.5million.

For existing buildings, (such as the Stamford Town Center), central plant upgrading due to age or unreliable equipment can be avoided. A district energy retrofit does not involve the installation of high maintenance items (e.g. chillers, cooling towers, boilers) and provide years of service.

Another consideration of dispatching major cooling and heating components to a central plant is the elimination of mechanical rooms within the customer' facilities. 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.

Connected buildings benefit from an operation 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. Since the work environment is safer having avoided on-site production, insurance premiums to protect employees and the public will be reduced.

Centralization of cooling and heating production enables reduction in 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 buildings peaks. Centralization also allows for reduced redundancy of capacity.

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

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.

4.4 Present Cost of Cooling Individual Customers

By interconnecting to the district cooling and heating system the customer could recognize numerous advantages:

- reduction in the cost of energy;
- elimination of expenses associated with the ownership of on-site chillers and boilers;
- savings in space (at the cost of \$18-20/ft²);
- avoidance of problems associated with compliance with environmental regulation.

To provide quantitative insight as to the comparative economic benefits of DCH versus the present cooling and heating systems in Stamford, individual energy costs must be developed as a means of comparison. The comparison is based upon costs

the refrigerant and lithium bromide as the absorbent. This type of design boasts improved efficiency through a two-stage vapor generation process. Refrigerant vapor generation is substantially increased as compared to a single-stage type absorber with no additional energy consumption.

The system also includes a distribution trunk line which will enable district service to the Stamford Mall and Swiss Bank. Capital requirements for the next phase will include the incremental costs associated with the installation of new chillers and interconnection of additional customers. The major piping trunk installed in Phase I will have enough capacity to supply additional load.

Unit gas consumption is specified as 11.7 MBtu/ton-hr, and Yankeegas Rate Schedule 27 (summer rate) is used for the analysis. Computation of the unit cooling cost for such a facility is summarized in Table 4-2. The table incorporates the three components of capital, fuel and operations/maintenance. The economic analysis presented in Table 4-2 demonstrates that the chilled water plant can generate district cooling at 21¢/ton-hr, while the customers with electric chilling are presently paying 42¢/ton-hr.

4.6 Conclusion

The analysis of the development of the first phase district energy system demonstrated the feasibility of this project.

Table 4-2
Chilled Water Production Cost at the Proposed New System with a
2 - Stage Gas Chillers

OPTION PARAMETERS	
Chiller Drive	Direct Fired
Chiller Type	2 Stage Absorption
Peak Cooling Load (Tons)	4,800
Annual Cooling Load (TON-HR)	7,680,000
Chiller Fuel Type	Natural Gas
Auxiliaries Fuel Type	Electric

FUEL COMPONENT	
Chiller Gas Consumption (MBTU/TON-HR)	11.7
Aux Electric Consumption (KW/TON)	0.1
Chiller Gas Consumption (MMBTU)	89,856
Aux Electric Consumption (KWHR)	768,000
Average Unit Gas Cost, Rate 27 (\$/MMBTU)	2.83
Average Unit Electric Cost (\$/KWHR)	0.102
Gas Cost (\$)	254,292
Electric Cost (\$)	78,336
ANNUAL FUEL COST (\$)	332,628

O & M COMPONENT	
Labor	\$150,000
Administrative	\$50,000
Service, Parts and Supplies	\$75,000
Chemicals, Water and Sewer	\$35,000
Insurance/Taxes (3.5% of Capital)	\$235,000
ANNUAL O & M	\$545,000

TOTAL PRODUCTION COST	
ANNUAL CAPITAL	\$737,000
ANNUAL FUEL	\$332,628
ANNUAL O & M	\$545,000
TOTAL ANNUAL COST	\$1,614,628
Annual Cooling Load (TON-HR)	7,680,000
UNIT COOLING COST (\$/TON-HR)	0.21

CAPITAL COST COMPONENT	
Primary Mechanical Equipment	
Chiller, Control Panel	\$2,160,000
Chiller Pumps	\$1,000,000
Cooling Tower, Condenser Pumps	\$410,000
Mechanical Installation & Piping	\$800,000
Instrumentation & Control	\$170,000
Electrical	\$100,000
Bldg. Enclosure & Foundation	\$400,000
Subtotal	\$4,140,000
Engineering	\$300,000
Contingency	\$350,000
TOTAL COST AT PLANT BOUNDARY.....	\$4,790,000
Chilled Water Piping	\$2,000,000
TOTAL COST	\$6,790,000
Interest Rate	10%
Term (years)	25
Capital Recovery Factor	0.110
ANNUAL CAPITAL COST	\$737,000

SECTION 5

DEVELOPMENT STRATEGY, OWNERSHIP AND MARKETING

5.1 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. As the system expands, enriched by a widening customer base 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 developed. 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. Recognizing energy cost stability and economic developing, the city is the primary advocate which embodies the long-term objectives of its future.

5.2 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 buildings 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, business, 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 have 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 system 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.

5.3 Potential Revenue

Should the district cooling and heating be developed, it will represent an opportunity to create a source of income for the city from the district energy system. As the system expands, other opportunities may develop such as interconnection to a large or in-fence cogeneration facility. These alternatives provide the plant with revenue potential through the sale of hot/chilled water and/or electricity. Increased operating efficiency of the plant achieved through linkage to a district energy system implies that the heat used to produce these useful energy products is not directly rejected to the surrounding reducing thermal pollution having a beneficial impact to the environment.

The market value for the district energy system increases significantly as it expands.

5.4 Environmental Improvement

The city of Stamford in its efforts keep 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 efficiency 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.

5.5 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. There are several ownership alternatives including municipal, electric utility, gas utility and private entrepreneurs. It appears evident that the district energy system is 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. The city of Stamford fully supports the development of the system although presently it has decided not to act as the system developer.

The increased competition between gas and electricity utilities offers unique opportunities to the owners of DCH systems. These are as follow:

- Retention of customers;
- Acquisition of new customers;
- Investment opportunities;
- Start unregulated business;
- DSM opportunities;
- Public Service Commission Support;
- Positive public image;

The experience has demonstrated that in order for an electric or gas utility to become a developer of a DCH system, aggressive marketing by the competing utility or a private developer is required. The involvement of a private developer in the development of a new DCH system is unlikely particularly if the system is not combined with cogeneration.

5.6 Marketing

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 energy 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 help, to move the project forward. 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 shown strong interest in 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. 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 if district energy does not become available.

Customer Survey of the Energy Market

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.

Develop Customer's Current Cooling and Heating Cost

An analysis has to be 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 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.

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 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. To present the capital components on an annual basis a capital recovery factor is applied to the total cost.

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.

Operations and Maintenance Component

The operations and maintenance (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.