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Steamtown District Heating and Cooling Project
Scranton, Pennsylvania

FINAL REPORT

Prepared for

COMMUNITY CENTRAL ENERGY CORPORATION
and
U.S. DEPARTMENT OF ENERGY

Prepared by

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

April, 1990

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TABLE OF CONTENTS

Steamtown
District Heating and Cooling
Project

TABLE OF CONTENTS

TABLES

FIGURES

SECTION 1

Executive Summary

SECTION 1

EXECUTIVE SUMMARY

INTRODUCTION

This report summarizes the activities of a study intended to examine the feasibility of a district heating and cooling alternative for the Steamtown National Historic Site in Scranton, PA. The objective of the study was to investigate the import of steam from the existing district heating system in Scranton which is operated by the Community Central Energy Corporation and through the use of modern technology provide hot and chilled water to Steamtown for its internal heating and cooling requirements. Such a project would benefit Steamtown by introducing a clean technology, eliminating on-site fuel use, avoiding first costs for central heating and cooling plants and reducing operation and maintenance expenditures. For operators of the existing district heating system, this project represents an opportunity to expand their customer base and demonstrate new technologies.

The study was conducted by Joseph Technology Corporation, Inc. and performed for the Community Central Energy Corporation through a grant by the U. S. Department of Energy. Steamtown was represented by the National Park Service, the developers of the site.

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

Technical analysis of Steamtown 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 were shared with Steamtown representatives which indicated unit costs with on-site equipment in the approximate range of 11-16 $/MMBtu for heating and .4 -.7 $/tonhr for cooling.

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 sited a heating and cooling plant within the confines of a dedicated building (existing Gas Works Building). The plant would consist of steam to hot water heat exchangers to convert imported district steam 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 Steamtown.

A cost estimate was prepared to include plant and underground piping components. Three phases of growth were assumed for the system, each phase to be coordinated with the renovation of site buildings with the addition of new thermal capacity. The cost of the complete system after three phases of implementation is estimated at approximately $1,500,000.

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 approximately a 20% overall saving with district service.

ACTION PLAN

This study demonstrated the savings achievable through a district energy alternative to conventional on-site energy plants as would have been installed. The results of this study are preliminary. It remains to build on these results through detailed cost estimates suitable for defining a construction budget and commitments by CCEC and the National Park Service.

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 the complex of railroad age buildings being renovated as Steamtown.
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

Gas Works Building as well as the plant itself.

3. Attain customer commitment and contract to select a district energy alternative, revising analyses accordingly to justify this approach to his satisfaction.
4. Retain a general contractor to construct the system.

SECTION 2

Project Overview

SECTION 2

PROJECT OVERVIEW

OBJECTIVE

It is the purpose of this study to examine an alternative energy solution for the Steamtown National Historic Site in Scranton, PA, which is under development.

The Steamtown National Historic Site, as part of the U.S. Department of the Interior and the National Park Service, shall reinforce the importance of the railroad age to the region through preservation and rehabilitation of the former DL&W Railroad yard. The site shall contain a collection of steam locomotives and rolling stock, enabling visitors to view them in a period setting. The project involves the rehabilitation and construction of building structures to house the museums, visitor accommodations, maintenance shops, storage and office needs. The antiquated condition of existing building structures mandates extensive remodeling including the installation of new heating and cooling systems. Up to sixteen new boilers and chillers are tentatively planned for installation throughout Steamtown.

This study intends to investigate an alternative to this conventional design scenario through an application of district heating and cooling, which is a clean technology and an energy conservation measure characterized by centralized thermal production and distribution to individual buildings in the service area.

Scranton is home to a steam district heating system operated by the Community Central Energy Corporation (CCEC) which maintains a live steam line along Washington Avenue, the southeast property boundary of Steamtown. Refer to Figure 2-1 which locates Steamtown with respect to the existing district heating distribution system.

The objective is to construct a substation to import this steam and to serve as a central heating and cooling plant for Steamtown. Hot and chilled water would be exported from the substation to the facilities within the complex. This approach would derive energy savings and environmental advantages for Steamtown. On-site combustion of heating fuel would be avoided, providing a cleaner and safer museum environment. Since the inefficiencies of fuel combustion are eliminated, the system operates at higher efficiencies which saves energy. Centralization of cooling production localizes exposure to CFC's to a single location, reducing the risk of failures and environmental contamination associated with multiple plants. The overall reduction in fuel/energy consumption reduces the quantities of CO , NO and thermal pollution released to the atmosphere which contribute to ozone layer degradation and the "greenhouse" effect.

Although steam district heating has been established for many years in Scranton, application of modern hot water technology has not been introduced in Pennsylvania. It remains to build a demonstration project to essentially serve as an advertisement of this new innovation to the public and institutions throughout Pennsylvania. Since Steamtown has been highly promoted, this

EXISTING DISTRICT HEATING SYSTEM AND PROPOSED DEVELOPMENT SITE

project will share in the overall publicity, facilitating the dissemination of information to the public. The recent engineering achievements and modern products now available make hot and chilled water district systems a viable alternative to a highly competitive market where conventional technologies have been entrenched for many decades. District heating and cooling is applicable to many sites throughout Pennsylvania where thermal load density is sufficient to be economically attractive. By demonstrating this new technology in the highly visible setting of Steamtown, it is anticipated that in addition to its historical value, interested visitors will witness the advantages of hot water technology and contribute to its application elsewhere in Pennsylvania and the country.

DISTRICT SYSTEM TECHNOLOGY AND BENEFITS

SYSTEM FEATURES

District heating and cooling is the distribution of thermal energy (hot and chilled water for the proposed project) from a central source to multiple buildings in the surrounding area. The thermal energy is distributed through an underground piping system to a service connection at each building where it is used to heat and cool the building. The central plant consists of the equipment required to produce and distribute the thermal products and can be comprised of conventional boilers and chillers to more involved designs employing cogeneration technologies and thermal storage. In the strategy proposed for development of Steamtown, a district substation would be constructed, so named since production of hot water would rely on the supply of steam from the existing district heating system which supplies much of the downtown Scranton.

A major consideration which had stunted the proliferation of district systems was the cost and upkeep of underground piping systems. Modern designs and installation practices have alleviated this concern to a great extent. The underground piping system used for the cost estimate presented elsewhere in this study is of European design widely employed in hot water district heating applications. It consists of a thin wall carbon steel carrier surrounded by polyurethane insulation and encased with a polyethylene jacket. Piping system construction features shallow burial, reducing excavation work, and the probability of encountering interferences. Both considerations facilitate construction schedules and reduce cost. Advanced jointing techniques at the outer casing portrays excellent resistance to ground water infiltration, the major cause of piping failure. Once buried, maintenance costs are controlled since the piping system is equipped with an integral leak detection and alarm system which not only detects leakage, but enables operators to accurately locate the fault. With these features and attentive maintenance, these piping systems can last indefinitely.

SYSTEM BENEFITS

District heating and cooling systems must compete in this country with conventional technologies and demonstrate economic feasibility to warrant its consideration for installations. Modern district heating and cooling systems display technical advantages and environmental advantages which enable effective competition with conventional individual systems. Among these benefits is included:

- o Energy Conservation and Cost Reduction

  The primary benefit of a district heating and cooling system is fuel cost reduction since a central thermal plant operates more efficiently and can secure lower cost fuel over smaller individual systems. This energy cost reduction is passed through to all customers who enjoy the rewards of improved energy utilization.

  From the perspective of Steamtown, a useful form of energy (i.e., hot and chilled water) is imported and consumed. The inefficiencies associated with the conversion of non-renewable fuels to produce heat and then to generate steam or hot water are eliminated.

- o Utilize Alternate Fuel Supplies

  District heating and cooling are uniquely flexible with a constantly changing energy outlook. These systems readily adapt to alternate fuel supplies and can serve large urban centers without adverse environmental impact.

- o Environmental and Safety Considerations

  District energy is designated as a clean technology since heating and cooling production is removed to an off-site location which infers that the by-products of these processes are also removed from the site. Stack emissions from boilers are completely eliminated thereby fostering cleaner air and a healthier on-site environment. Without the need for boiler fuel, its storage and handling, the potential hazards of leakage, soil contamination, explosion, fire, etc., are not possible. Any hazardous chemicals used in the normal operation or maintenance of these systems need not be required nor stored on-site.

A serious topic of environmental importance regards reducing the presence of chlorofluorocarbons (CFC's) which have been linked to the degradation of the earth's ozone layer. Widely used as refrigerants in centrifugal chillers, a district cooling system which employs fewer operating chillers promotes the confinement and stricter control of these substances.

o Operating and Maintenance Savings

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

Central plants of the district system are maintained by a professional staff to insure efficient, reliable and safe operation which will be reflected in low cost energy production.

- o Capital Cost and Installation Savings

  For new construction like Steamtown, a district heating and cooling system would enable the developer/owner to avoid the first costs associated with the installation of heating and cooling production equipment (i.e., boilers and chillers). For new construction, this also eliminates the mechanical rooms and the special design requirements to contain noise, smell, dirt, ventilation, loading and vibration which provides the architect more flexibility in his layout of available space.

- o Recover Valuable Floor Space

  Avoiding the installation of new on-site equipment frees floor space which can be incorporated into a layout of useful space.

SECTION 3

District Energy Market Analysis

SECTION 3

DISTRICT ENERGY MARKET ANALYSIS

MARKETING TO THE CUSTOMER

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 system, operations and ultimately profitability.

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

IDENTIFICATION OF THE MARKET

To assess the potential market for district energy in Steamtown, a survey of buildings and proposed renovation was conducted. The objective of the survey was to solicit information regarding the technical aspects of proposed heating and cooling systems, energy consumption and cost, and maintenance expenditures. This information was retained for subsequent analyses to determine the current cost to heat and cool each building.

The engineer's primary goal of the survey involves the collection of information which complements efforts to calculate annual heating and cooling loads, calculate costs with individual heating and cooling plants, and to identify the compatibility with a district energy system.

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 customer to the broad issues of introducing district energy to provide an economic incentive to the area. The interest displayed is vital to the success of the project.

DEVELOP ENERGY COSTS ASSUMING INDIVIDUAL ON-SITE PLANTS

An analysis was performed for selected buildings to determine prospective heating and cooling costs assuming that during renovation, individual plants were installed in each building as is done conventionally. These costs permit a means of comparison with district heating and cooling service.

The cost categories which comprise each building's cost with on-site equipment 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.

CAPITAL COMPONENT

The capital component includes the central equipment and related components which would be avoided in a district energy retrofit. Specific items include boilers, chillers, cooling towers, evaporator and condenser pumps and piping components, controls and installation. Rehabilitation work at Steamtown suggests additional cost avoidance since the structural and electrical work needed to house on-site equipment is eliminated. Structural items include foundations, noise isolation, ventilation, water and sewer penetrations, and framing.

The analysis calculates costs on an annual basis. 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.

ENERGY COMPONENT

The energy component consists of the energy cost for fuel and electricity for heating and cooling production within the building assuming on-site generation. 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 thermal loads directly as the amount of electricity or fuel consumed. This is further complicated for cooling since electric cooling is usually added to other electric auxiliaries and lighting in the building for billing purposes making it difficult to predict actual cooling cost and load.

O&M COMPONENT

The O&M component which is credited to on-site 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 heating and cooling equipment described previously. Specific items include operating labor, water treatment, electricity, 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, small 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 building were summated as indicated in Tables 3-1 to 3-10. Based on the estimated annual heating and cooling loads, a unit heating and cooling cost was determined by dividing total cost by the annual load.

Results indicate the unit cost to produce cooling with on-site chiller plants range from 0.40 - 0.70 $/ton-hr and to produce heating with on-site boiler plants, a range of 11-16 $/MMBtu.

Table 3-1

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Locomotive Shop	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE ---						
Peak Load	2.7	mmbtu/hr	0	tons		
Annual Load	4,590	mmbtu	0	ton-hr		
--- CAPITAL COST ---						
Capital Cost	96,789		0		96,789	$
Heat plant inc. 1x2.7 mmbtu/h boiler						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$12,200		$0		12,200	$
--- ANNUAL OPERATIONS ---						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	500	$	0	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	33,700	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$34,200		$0		34,200	$
Personnel					3,000	$
Replacement Parts/Service					807	$
Boiler Lease					0	$
Water,Sewer,Chemicals					403	$
Insurance,Taxes,Misc (1.0% of invest)					1,000	$
Loss of Rented Space - 5 $/sqft					2,500	$
Subtotal (non fuel)	$7,700		$0		7,700	$
Estimated Cost Apportionment	100.0%		0.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION ---						
Annual Capital Cost Component					12,200	$
Annual Fuel					34,200	$
Annual Non-fuel Operations					7,700	$
Annual Total Costs	54,100	$	0	$	54,100	$
Estimated Cost Apportionment	100.0%		0.0%			
Annual Heating/Cooling Load	4,590	mmbtu	0	ton-hrs	4,590	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>	11.79	$/mmbtu	0.00	$/ton-hr	11.79	$/mmbtu

Table 3-2

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Office/ Storage I	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE ---						
Peak Load	2.4	mmbtu/hr	132	tons		
Annual Load	4,080	mmbtu	79,200	ton-hr		
--- CAPITAL COST ---						
Capital Cost	86,034		158,400		244,434	$
Heat plant inc. 1x2.4 mmbtu/h boiler						
Cool Plant inc. 1x130 ton chiller (new)						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$10,800		$19,900		30,700	$
--- ANNUAL OPERATIONS ---						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	500	$	7,100	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	29,900	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$30,400		$7,100		37,500	$
Personnel					5,000	$
Replacement Parts/Service					3,357	$
Boiler Lease					0	$
Water,Sewer,Chemicals					1,018	$
Insurance,Taxes,Misc (1.0% of invest)					2,400	$
Loss of Rented Space - 5 $/sqft					5,000	$
Subtotal (non fuel)	$6,700		$10,100		16,800	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION ---						
Annual Capital Cost Component					30,700	$
Annual Fuel					37,500	$
Annual Non-fuel Operations					16,800	$
Annual Total Costs	47,900	$	37,100	$	85,000	$
Estimated Cost Apportionment	56.4%		43.6%			
Annual Heating/Cooling Load	4,080	mmbtu	79,200	ton-hrs	5,030	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>	11.74	$/mmbtu	0.47	$/ton-hr	16.90	$/mmbtu

Table 3-3

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Main of Way Building	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE						
Peak Load	0.8	mmbtu/hr	45	tons		
Annual Load	1,394	mmbtu	27,000	ton-hr		
--- CAPITAL COST						
Capital Cost	29,395		54,000		83,395	$
Heat plant inc. 1x.8 mmbtu/h boiler						
Cool Plant inc. 1x45 ton chiller						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$3,700		$6,800		10,500	$
--- ANNUAL OPERATIONS						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	500	$	2,400	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	10,200	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$10,700		$2,400		13,100	$
Personnel					1,000	$
Replacement Parts/Service					1,145	$
Boiler Lease					0	$
Water,Sewer,Chemicals					347	$
Insurance,Taxes,Misc (1.0% of invest)					800	$
Loss of Rented Space - 5 $/sqft					0	$
Subtotal (non fuel)	$1,300		$2,000		3,300	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION						
Annual Capital Cost Component					10,500	$
Annual Fuel					13,100	$
Annual Non-fuel Operations					3,300	$
Annual Total Costs	15,700	$	11,200	$	26,900	$
Estimated Cost Apportionment	58.4%		41.6%			
Annual Heating/Cooling Load	1,394	mmbtu	27,000	ton-hrs	1,718	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>>	11.26	$/mmbtu	0.41	$/ton-hr	15.66	$/mmbtu

Table 3-4

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Roundhouse	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE						
Peak Load	2.1	mmbtu/hr	175	tons		
Annual Load	3,587	mmbtu	105,000	ton-hr		
--- CAPITAL COST						
Capital Cost	75,639		210,000		285,639	$
Heat plant inc. 1x2.1 mmbtu/h boiler						
Cool Plant inc. 1x175 ton chiller						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$9,500		$26,400		35,900	$
--- ANNUAL OPERATIONS						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	500	$	9,500	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	26,300	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$26,800		$9,500		36,300	$
Personnel					5,000	$
Replacement Parts/Service					4,130	$
Boiler Lease					0	$
Water,Sewer,Chemicals					1,190	$
Insurance,Taxes,Misc (1.0% of invest)					2,900	$
Loss of Rented Space - 5 $/sqft					5,000	$
Subtotal (non fuel)	$7,300		$10,900		18,200	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION						
Annual Capital Cost Component					35,900	$
Annual Fuel					36,300	$
Annual Non-fuel Operations					18,200	$
Annual Total Costs	43,600	$	46,800	$	90,400	$
Estimated Cost Apportionment	48.2%		51.8%			
Annual Heating/Cooling Load	3,587	mmbtu	105,000	ton-hrs	4,847	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>	12.16	$/mmbtu	0.45	$/ton-hr	18.65	$/mmbtu

Table 3-5

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Oil House	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE ---						
Peak Load	0.2	mmbtu/hr	13	tons		
Annual Load	340	mmbtu	7,800	ton-hr		
--- CAPITAL COST ---						
Capital Cost	7,170		15,600		22,770	$
Heat plant inc. 1x.2 mmbtu/h boiler						
Cool Plant inc. 1x13 ton chiller						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$900		$2,000		2,900	$
--- ANNUAL OPERATIONS ---						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	200	$	700	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	2,500	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$2,700		$700		3,400	$
Personnel					2,000	$
Replacement Parts/Service					80	$
Boiler Lease					0	$
Water,Sewer,Chemicals					35	$
Insurance,Taxes,Misc (1.0% of invest)					200	$
Loss of Rented Space - 5 $/sqft					2,000	$
Subtotal (non fuel)	$1,700		$2,600		4,300	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION ---						
Annual Capital Cost Component					2,900	$
Annual Fuel					3,400	$
Annual Non-fuel Operations					4,300	$
Annual Total Costs	5,300	$	5,300	$	10,600	$
Estimated Cost Apportionment	50.0%		50.0%			
Annual Heating/Cooling Load	340	mmbtu	7,800	ton-hrs	434	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>	15.59	$/mmbtu	0.68	$/ton-hr	24.45	$/mmbtu

Table 3-6

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Office/ Storage II	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE ---						
Peak Load	1.2	mmbtu/hr	65	tons		
Annual Load	2,040	mmbtu	39,000	ton-hr		
--- CAPITAL COST ---						
Capital Cost	43,017		78,000		121,017	$
Heat plant inc. 1x1.2 mmbtu/h boiler						
Cool Plant inc. 1x65 ton chiller						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$5,400		$9,800		15,200	$
--- ANNUAL OPERATIONS ---						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	500	$	3,500	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	15,000	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$15,500		$3,500		19,000	$
Personnel					3,000	$
Replacement Parts/Service					1,658	$
Boiler Lease					0	$
Water,Sewer,Chemicals					504	$
Insurance,Taxes,Misc (1.0% of invest)					1,200	$
Loss of Rented Space - 5 $/sqft					3,500	$
Subtotal (non fuel)	$4,000		$5,900		9,900	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION ---						
Annual Capital Cost Component					15,200	$
Annual Fuel					19,000	$
Annual Non-fuel Operations					9,900	$
Annual Total Costs	24,900	$	19,200	$	44,100	$
Estimated Cost Apportionment	56.5%		43.5%			
Annual Heating/Cooling Load	2,040	mmbtu	39,000	ton-hrs	2,508	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>	12.21	$/mmbtu	0.49	$/ton-hr	17.58	$/mmbtu

Table 3-7

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Signal Tower	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE						
Peak Load	0.2	mmbtu/hr	6	tons		
Annual Load	255	mmbtu	3,600	ton-hr		
--- CAPITAL COST						
Capital Cost	5,377		7,200		12,577	$
Heat plant inc. 1x.15 mmbtu/h boiler						
Cool Plant inc. 1x6 ton chiller						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$700		$900		1,600	$
--- ANNUAL OPERATIONS						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	200	$	300	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	1,900	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$2,100		$300		2,400	$
Personnel					2,000	$
Replacement Parts/Service					165	$
Boiler Lease					0	$
Water,Sewer,Chemicals					52	$
Insurance,Taxes,Misc (1.0% of invest)					100	$
Loss of Rented Space - 5 $/sqft					2,000	$
Subtotal (non fuel)	$1,700		$2,600		4,300	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION						
Annual Capital Cost Component					1,600	$
Annual Fuel					2,400	$
Annual Non-fuel Operations					4,300	$
Annual Total Costs	4,500	$	3,800	$	8,300	$
Estimated Cost Apportionment	54.2%		45.8%			
Annual Heating/Cooling Load	255	mmbtu	3,600	ton-hrs	298	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>>	17.65	$/mmbtu	1.06	$/ton-hr	27.83	$/mmbtu

Table 3-8

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Station/ Gift Shop	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE ---						
Peak Load	0.2	mmbtu/hr	17	tons		
Annual Load	408	mmbtu	10,200	ton-hr		
--- CAPITAL COST ---						
Capital Cost	8,603		20,400		29,003	$
Heat plant inc. 1x.24 mmbtu/h boiler						
Cool Plant inc. 1x17 ton chiller						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$1,100		$2,600		3,600	$
--- ANNUAL OPERATIONS ---						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	200	$	900	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	3,000	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$3,200		$900		4,100	$
Personnel					2,000	$
Replacement Parts/Service					412	$
Boiler Lease					0	$
Water,Sewer,Chemicals					121	$
Insurance,Taxes,Misc (1.0% of invest)					300	$
Loss of Rented Space - 5 $/sqft					3,500	$
Subtotal (non fuel)	$2,500		$3,800		6,300	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION ---						
Annual Capital Cost Component					3,600	$
Annual Fuel					4,100	$
Annual Non-fuel Operations					6,300	$
Annual Total Costs	6,800	$	7,200	$	14,000	$
Estimated Cost Apportionment	48.6%		51.4%			
Annual Heating/Cooling Load	408	mmbtu	10,200	ton-hrs	530	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>	16.67	$/mmbtu	0.71	$/ton-hr	26.40	$/mmbtu

Table 3-9

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Silk Mill	HEATING		COOLING		TOTALS	
--- THERMAL LOAD ESTIMATE						
Peak Load	2.0	mmbtu/hr	112	tons		
Annual Load	3,434	mmbtu	67,200	ton-hr		
--- CAPITAL COST						
Capital Cost	72,412		134,400		206,812	$
Heat plant inc. 1x2.0 mmbtu/h boiler						
Cool Plant inc. 1x110 ton chiller						
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$9,100		$16,900		26,000	$
--- ANNUAL OPERATIONS						
Energy Efficiency	75	eff-%	1.00	kw/ton		
Electric Consumption @ 0.09 $/kw-hr	500	$	6,000	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	25,200	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$25,700		$6,000		31,700	$
Personnel					4,000	$
Replacement Parts/Service					2,843	$
Boiler Lease					0	$
Water,Sewer,Chemicals					862	$
Insurance,Taxes,Misc (1.0% of invest)					2,100	$
Loss of Rented Space - 5 $/sqft					5,000	$
Subtotal (non fuel)	$5,900		$8,900		14,800	$
Estimated Cost Apportionment	40.0%		60.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION						
Annual Capital Cost Component					26,000	$
Annual Fuel					31,700	$
Annual Non-fuel Operations					14,800	$
Annual Total Costs	40,700	$	31,800	$	72,500	$
Estimated Cost Apportionment	56.1%		43.9%			
Annual Heating/Cooling Load	3,434	mmbtu	67,200	ton-hrs	4,240	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>	11.85	$/mmbtu	0.47	$/ton-hr	17.10	$/mmbtu

Table 3-10

Steamtown District Heating and Cooling Project

ESTIMATED HEATING AND COOLING COST WITH ON-SITE PRODUCTION PLANTS

Preliminary

Customer: Garage	[---- HEATING ----]		[---- COOLING ----]		[--- TOTALS ---]	
--- THERMAL LOAD ESTIMATE						
Peak Load	0.5	mmbtu/hr	0	tons		
Annual Load	884	mmbtu	0	ton-hr		
--- CAPITAL COST						
Capital Cost Heat plant inc. 1x.5 mmbtu/h boiler	18,641		0		18,641	$
Capital Recovery Factor (assuming 11.0% interest rate, and 20 yr. period)					12.6	%
Annual Capital Cost Component	$2,300		$0		2,300	$
--- ANNUAL OPERATIONS						
Energy Efficiency	75	eff-%	1.00	kW/ton		
Electric Consumption @ 0.09 $/kw-hr	200	$	0	$		
Gas/Oil Consumption @ 5.50 $/mmbtu	6,500	$	0	$		
DHC Pumping Electric @ 0.09 $/kw-hr	0	$	0	$		
Subtotal (fuel)	$6,700		$0		6,700	$
Personnel					1,000	$
Replacement Parts/Service					155	$
Boiler Lease					0	$
Water,Sewer,Chemicals					78	$
Insurance,Taxes,Misc (1.0% of invest)					200	$
Loss of Rented Space - 5 $/sqft					2,000	$
Subtotal (non fuel)	$3,400		$0		3,400	$
Estimated Cost Apportionment	100.0%		0.0%			
--- ON-SITE HEATING AND COOLING COST CALCULATION						
Annual Capital Cost Component					2,300	$
Annual Fuel					6,700	$
Annual Non-fuel Operations					3,400	$
Annual Total Costs	12,400	$	0	$	12,400	$
Estimated Cost Apportionment	100.0%		0.0%			
Annual Heating/Cooling Load	884	mmbtu	0	ton-hrs	884	mmbtu
Unit Heating/Cooling Cost >>>>>>>>>>>>>>>>>>>>	14.03	$/mmbtu	0.00	$/ton-hr	14.03	$/mmbtu

SECTION 4

District System Configuration

SECTION 4

DISTRICT SYSTEM CONFIGURATION

INTRODUCTION

The proposed project entails construction of a district energy substation for the purpose of importing steam from Scranton's district heating system to generate low temperature hot water for distribution to the various buildings in Steamtown. Installation of chillers at this same location is also planned to supply chilled water for cooling. Project planners for Steamtown have designated a building on site for this substation. This building, referred to as the "Gas Works Building", is adjacent to Washington Avenue where the steam supply header of the district heating system is located. The building would be available to CCEC by Steamtown for purposes of establishing an energy substation.

Renovations and building construction within Steamtown is currently scheduled over a four year time period. To complement the construction stages of Steamtown, the substation will be of modular design, capable of expanding its capacity as required. To parallel this four year construction project, implementation of district energy is planned in three phases. This staged expansion of the substation and distribution system diffuses the impact of capital expenditures on the district energy system economics. As additional load is connected to the system, the larger revenue base contributes to offsetting additional capital investments in plant and piping, stabilizing the unit energy cost. The strategy also contributes to planning flexibility by shifting decision points regarding load and capacity to the future when plans are confirmed.

The three phases of expansion as each building is completed and opened for occupation are indicated in Figures 4-1 to 4-3. Also indicated is the proposed underground pipe routing which emanates from the substation to the various service connections. The proposed configuration for the district energy substation would consist of equipment and auxiliaries to support the export of hot and chilled water from the substation to the buildings of Steamtown (Figure 4-4).

PHASE I

The Phase I central system as illustrated in Figure 4-1 will supply heating and cooling to the Locomotive Machine Shop, Office/Storage Building I and the Maintenance-of-Way Building The peak heat load will be 5.92 MMBtu/hr with a peak cooling load of 177 tons.

The energy substation shall be located within the old Gas Works Building which is proximate to Washington Avenue and low pressure steam main of the Scranton district heating system.

To supply the heating load, two steam to hot water heat exchangers, each with a capacity of 5 MMBtu/hr, will be installed. Steam (5-10 psig) will be supplied to the heat exchangers from the existing Washington Avenue steam main by installing a short section of new underground steam piping to the substation as required. Other components to be installed include

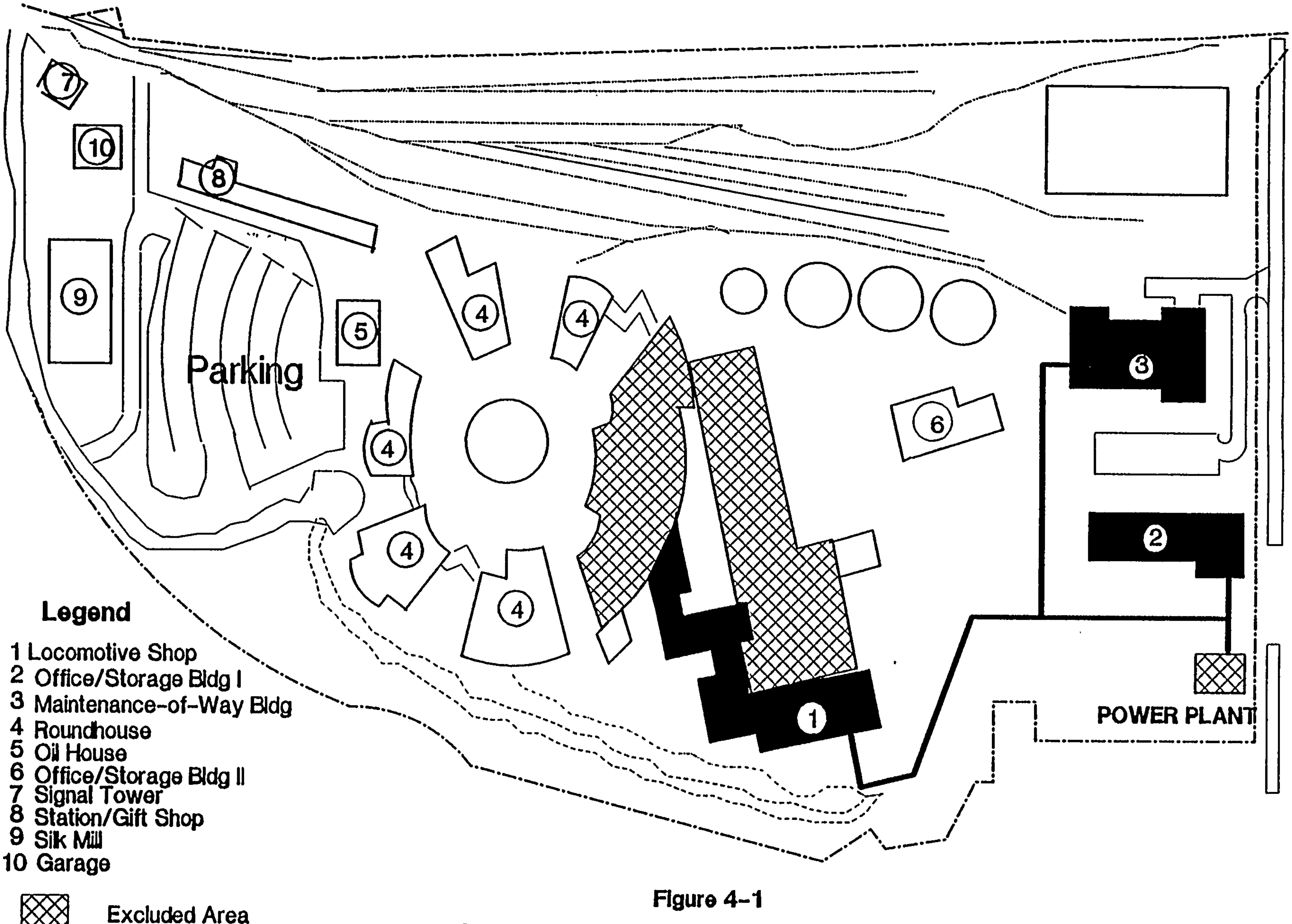


Figure 4-1
Steamtown District Heating and Cooling Project
PHASE I IMPLEMENTATION

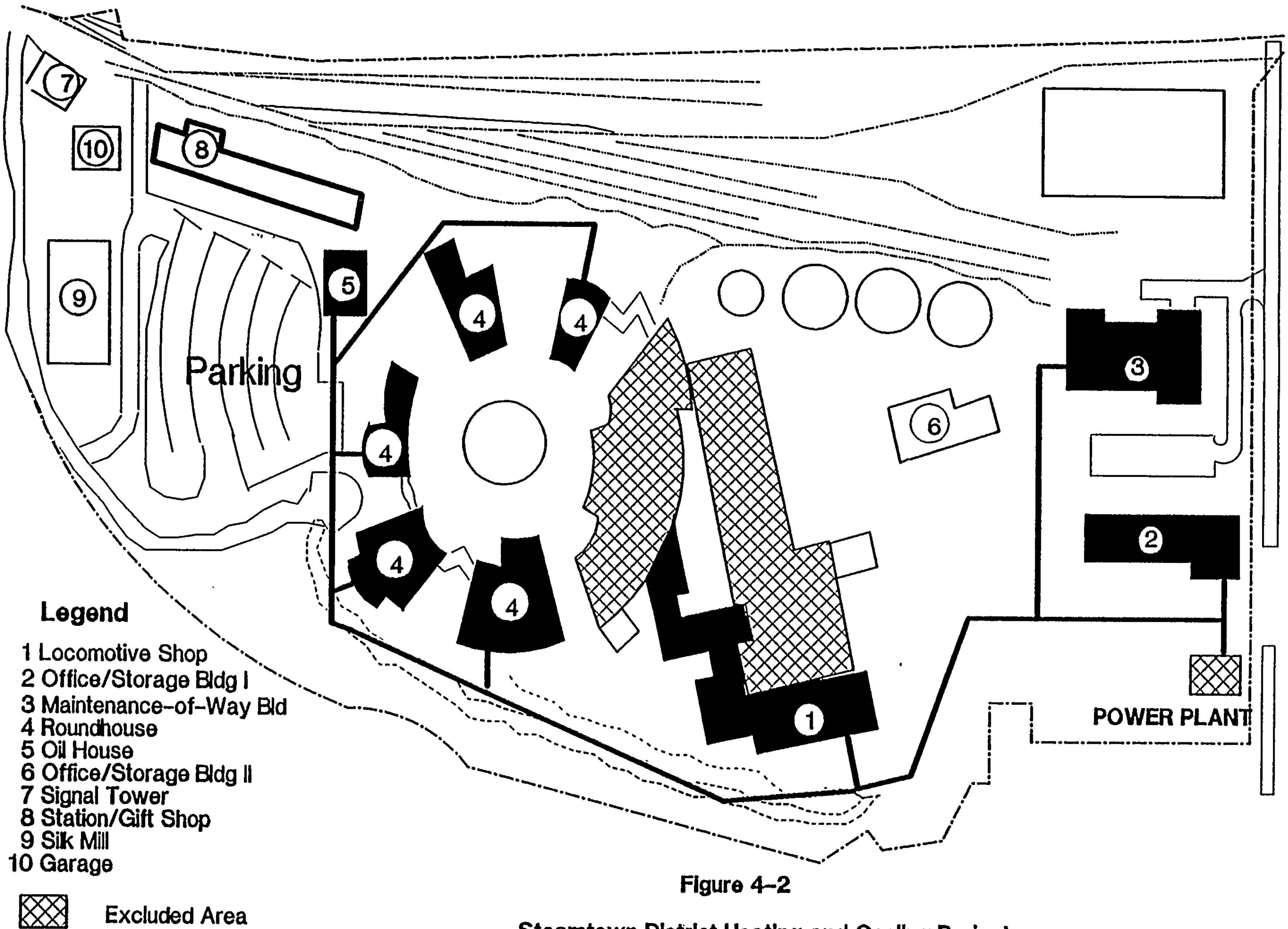


Figure 4–2

Steamtown District Heating and Cooling Project
PHASE I+II IMPLEMENTATION

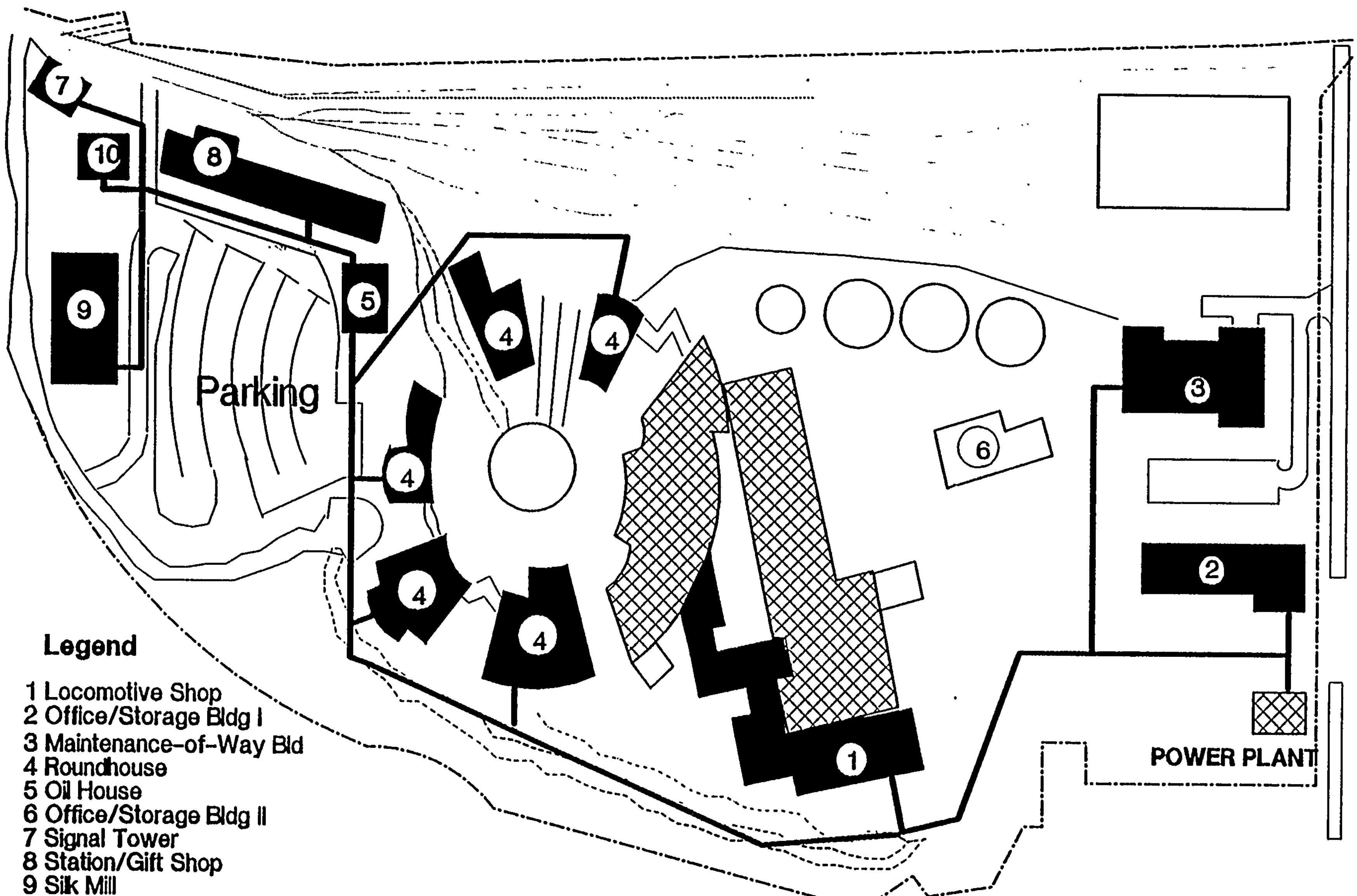
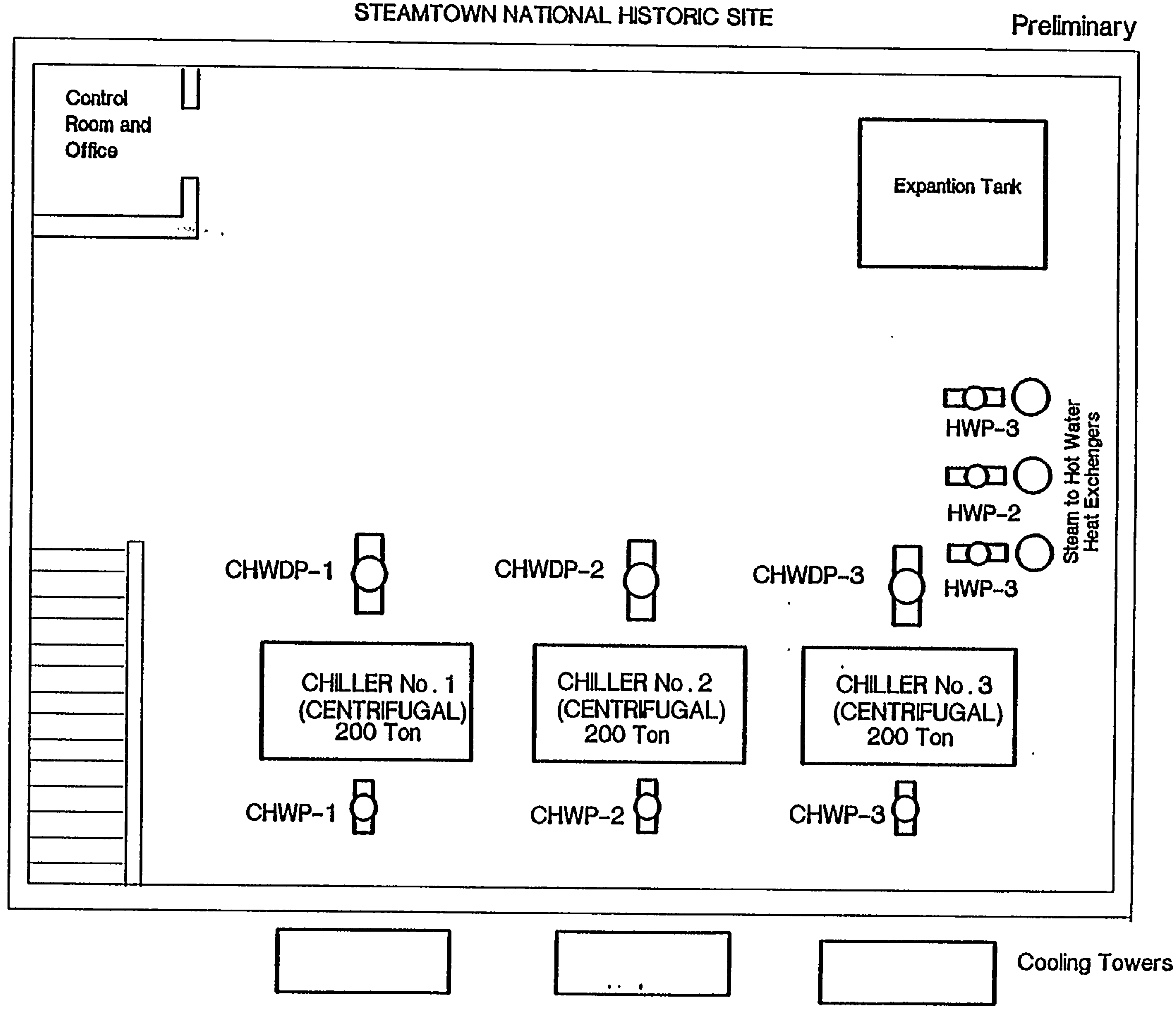


Figure 4–3

Steamtown District Heating and Cooling Project
PHASE I+II+III IMPLEMENTATION

FIGURE 4–4 – ENERGY SUBSTATION

DISTRICT HEATING AND COOLING SYSTEM
STEAMTOWN NATIONAL HISTORIC SITE



distribution pumps, electrical service and wiring, controls, instrumentation and steam, condensate drainage and hot water piping, valves and fittings.

Chilled water will be supplied to Steamtown from a new 200 ton capacity chiller also located in the energy substation. Associated components include a cooling tower, circulation and condenser pumps, electrical service and wiring, controls, instrumentation and chilled water and condenser piping, valves and fittings.

PHASE I + II

Phase II expansion, illustrated in Figure 4-2, increases the system heating load to 8.23 MMBtu/hr and the cooling load to 365 tons by interconnecting Roundhouse and Oil House. This will be achieved by installation of an additional 200 ton centrifugal chiller in the energy substation.

PHASE I + II + III

Further expansion of the service area illustrated in Figure 4-3 includes the Office/Storage II, Signal Tower, Station/Gift Shop, Silk Mill and Garage. The cumulative heating load of the system is 12.4 MMBtu/hr, and the cooling load is 565 tons. To satisfy these demands one additional 5 MMBtu/hr heat exchanger and one 200 ton centrifugal chiller will be installed at the energy substation.

THERMAL LOAD

Heating and cooling loads anticipated for the three phases of project implementation are summarized in Table 4-1.

Table 4-1

Steamtown District Heating and Cooling Project

CUSTOMER HEATING AND COOLING LOADS

		Heating Loads						Cooling Loads					
		Phase 1		Phase 2		Phase 3		Phase 1		Phase 2		Phase 3	
	CUSTOMER NAME	Peak (mmb/h)	Annual (mmbtu)	Peak (mmb/h)	Annual (mmbtu)	Peak (mmb/h)	Annual (mmbtu)	Peak (tons)	Annual (tonhr)	Peak (tons)	Annual (tonhr)	Peak (tons)	Annual (tonhr)
1	Locomotive Shop	2.70	4590					0					
2	Office/Storage I	2.40	4080					132	79200				
3	Main of Way Bldg	0.82	1394					45	27000				
4	Roundhouse			2.11	3587					175	105000		
5	Oil House			0.20	340					13	7800		
6	Office/Storage II					1.20	2040					65	39000
7	Signal Tower					0.15	255					6	3600
8	Station/Gift Shop					0.24	408					17	10200
9	Silk Mill					2.02	3434					112	67200
10	Garage					0.52	884					0	0
	TOTAL CUSTOMER THERMAL LOAD												
	Total for each Phase	5.92	10064	2.31	3927	4.13	7021	177	106200	188	112800	200	120000
	System Total after each Phase	5.92	10064	8.23	13991	12.36	21012	177	106200	365	219000	565	339000

Full Load Heating Hours 1700
Full Load Cooling Hours 600

CAPITAL COST OF ALTERNATIVE OPTIONS

The capital cost for the system is comprised of the equipment and component required for the thermal production and distribution to prospective customers in Steamtown. The cost estimate coincides with the proposed implementation strategy by distributing costs over three phases. Cost of the underground distribution system includes a four-pipe system for hot and chilled water.

Three options are considered for the production of chilled water for the system. A more detailed description of cooling technology options is presented in Appendix A. All three options include heating service utilizing steam to hot water convertors recognizing the available steam supply from the existing district heating system in Scranton. The three options include:

* * * *

Option 1: <u>District Energy from the Gas House with Hot Water Convertors and Electric Chillers</u>

Cooling production assumes the installation of hi-efficiency centrifugal chiller. Overall cooling system performance including chillers and auxiliaries is assumed at 0.8 kw/ton. The capital cost for Option 1 is presented in Table 4-2.

Option 2: <u>District Energy from the Gas House with Hot Water Convertors and Steam Absorption Chillers</u>

Cooling production assumes the installation of single-stage absorption chillers utilizing the available low pressure district steam. Overall cooling system performance is estimated at 18 lb. steam/ton hr. The capital cost for Option 2 is presented in Table 4-3.

Table 4-2

Steamtown District Heating and Cooling Project

DISTRICT ENERGY SYSTEM CAPITAL COST ESTIMATE

Option 1: District Energy from the Gas House with Hot Water Convertors & Electric Chillers

Cost Basis Year 1990

Preliminary

*** ITEM DESCRIPTIONS *** / *** COST ESTIMATE ***

CENTRAL PLANT AT GAS HOUSE

	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	(ton)	(1)x200	(1)x200	(1)x200		$100,000	$100,000	$100,000	
electric service upgrade						$50,000			
*** Heating Plant ***									
hw convertors,pumps,piping,etc	(mmbtu/h)	(2)x5.0		(1)x5.0		$115,000		$65,000	
CENTRAL PLANT SUBTOTAL (installed)						$265,000	$100,000	$165,000	

DISTRICT PIPING DISTRIBUTION SYSTEM

	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:										
hot wtr	6	underground	600	0	0	0	$72,780	$0	$0	$0
hot wtr	4	underground	500	500	0	0	$45,400	$45,400	$0	$0
hot wtr	3	underground	0	600	0	0	$0	$47,640	$0	$0
hot wtr	2	underground	300	300	830	0	$18,600	$18,600	$51,460	$0
							$136,780	$111,640	$51,460	$0
chil wtr	8	underground	600	0	0	0	$52,140	$0	$0	$0
chil wtr	6	underground	500	1100	0	0	$40,000	$88,000	$0	$0
chil wtr	4	underground	0	0	870	0	$0	$0	$53,070	$0
chil wtr	2	underground	300	300	260	0	$12,900	$12,900	$11,180	$0
							$105,040	$100,900	$64,250	$0
DISTRIBUTION SUBTOTAL (installed)							$241,820	$425,080	$115,710	$0

	Phase 1	Phase 2	Phase 3	Phase 4
CENTRAL PLANT SUBTOTAL (installed)	$265,000	$100,000	$165,000	$0
DISTRIBUTION SUBTOTAL (installed)	$241,820	$425,080	$115,710	$0
Contingency	$51,000	$53,000	$28,000	$0
TOTAL ESTIMATED COST	$557,820	$578,080	$308,710	$0

Table 4-3

Steamtown District Heating and Cooling Project

DISTRICT ENERGY SYSTEM CAPITAL COST ESTIMATE

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers

Cost Basis Year 1990

Preliminary

*** ITEM DESCRIPTIONS *** / *** COST ESTIMATE ***

CENTRAL PLANT AT GAS HOUSE

	Units	Number and Size Phase 1	Number and Size Phase 2	Number and Size Phase 3	Number and Size Phase 4	Cost Phase 1	Cost Phase 2	Cost Phase 3	Cost Phase 4
*** Cooling Plant *** steam absorption chillers, cooling towers, pumps, piping, etc	(ton)	(1)x200	(1)x200	(1)x200		$150,000	$150,000	$150,000	
*** Heating Plant *** hw convertors, pumps, piping, etc	(mmbtu/h)	(2)x5.0		(1)x5.0		$115,000		$65,000	
CENTRAL PLANT SUBTOTAL (installed)						$265,000	$150,000	$215,000	

DISTRICT PIPING DISTRIBUTION SYSTEM

	Size (in)	Location	Length in Trench Feet Phase 1	Length in Trench Feet Phase 2	Length in Trench Feet Phase 3	Length in Trench Feet Phase 4	Cost Phase 1	Cost Phase 2	Cost Phase 3	Cost Phase 4
Transmission:										
hot wtr	6	underground	600	0	0	0	$72,780	$0	$0	$0
hot wtr	4	underground	500	500	0	0	$45,400	$45,400	$0	$0
hot wtr	3	underground	0	600	0	0	$0	$47,640	$0	$0
hot wtr	2	underground	300	300	830	0	$18,600	$18,600	$51,460	$0
							$136,780	$111,640	$51,460	$0
chil wtr	8	underground	600	0	0	0	$52,140	$0	$0	$0
chil wtr	6	underground	500	1100	0	0	$40,000	$88,000	$0	$0
chil wtr	4	underground	0	0	870	0	$0	$0	$53,070	$0
chil wtr	2	underground	300	300	260	0	$12,900	$12,900	$11,180	$0
							$105,040	$100,900	$64,250	$0
DISTRIBUTION SUBTOTAL (installed)							$241,820	$425,080	$115,710	$0

	Phase 1	Phase 2	Phase 3	Phase 4
CENTRAL PLANT SUBTOTAL (installed)	$265,000	$150,000	$215,000	$0
DISTRIBUTION SUBTOTAL (installed)	$241,820	$425,080	$115,710	$0
Contingency	$51,000	$58,000	$33,000	$0
TOTAL ESTIMATED COST	$557,820	$633,080	$363,710	$0

Option 3: <u>District Energy from the Gas House with Hot Water Convertors, Electric Chillers and Ice Storage</u>

Cooling production assumes the installation of a hi-efficiency centrifugal chiller, operating with a glycol solution to enable ice production. The configuration assumes partial storage such that on a peak cooling day, 40% of the total load is carried by the chiller and 60% by thawing the ice storage over a 10 hour period. The system evaluated consists of 21 storage vessels with a total capacity of approximately 3200 ton hrs. The tanks are installed in Phase II and III, having installed a 200 ton chiller in Phase I. Glycol is circulated between the chiller and the coils which are submerged in each tank. A heat exchanger is preferable to isolate the glycol loop from the chilled water distribution system which interconnects Steamtown buildings. The objective of the configuration is to reduce the demand component of the electric bill (estimated at 4.3 $/kw) by shifting cooling production to off-peak periods. The analysis reflects lower electrical cost by averaging the cost of electricity recognizing the mix of cooing related equipment including chiller operation both on and off-peak and chilled water pumping. The capital cost for Option 3 is presented in Table 4-4.

* * * *

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Economic analyses for the three options are grouped in the following tables:

* * * *

Option 1: District Energy from the Gas House with Hot Water Convertors and Electric Chillers

Table 4-5a: Input Data (5% escalation)

Table 4-5b: 20 Year Analysis (5% escalation)
Table 4-5c: Input Data (0% escalation)
Table 4-5d: 20 Year Analysis (0% escalation)

* * * *

Option 2: District Energy from the Gas House with Hot Water Convertors and Absorption Chillers

Table 4-6a: Input Data (5% escalation)
Table 4-6b: 20 Year Analysis (5% escalation)
Table 4-6c: Input Data (0% escalation)
Table 4-6d: 20 Year Analysis (0% escalation)

* * * *

Option 3: District Energy from the Gas House with Hot Water Convertors, Electric Chillers and Ice Storage

Table 4-7a: Input Data (5% escalation)
Table 4-7b: 20 Year Analysis (5% escalation)
Table 4-7C: Input Data (0% escalation)
Table 4-7d: 20 Year Analysis (0% escalation)

* * * *

Input data tables list the annual quantities, costs, financing parameters and relate expenses required for the analyses. Annual quantities pertinent to the analyses include heating and cooling sales, and steam and electric consumption. The capital costs presented in Tables 4-2 to 4-4 are summarized by phase for each selected option. Financing for this cost is amortized over 20 years with a 11% interest rate and 100% debt.

The economic model uses the required revenue approach, i.e., it totals the expenses anticipated for the system and determines the unit cost based on the anticipated energy sales. The three cost categories which must be recovered through district cooling sales include capital recovery charges, energy charges and O&M charges. Unit cost is expressed as $/MMBtu/hr for heating and ($/ton-hr.) for cooling. The economic analysis summates the three

Table 4-4

Steamtown District Heating and Cooling Project

DISTRICT ENERGY SYSTEM CAPITAL COST ESTIMATE

Option 3: District Energy from the Gas House
with Hot Water Convertors , Electric Chillers & Ice Storage

Cost Basis Year 1990

Preliminary

*** ITEM DESCRIPTIONS *** / *** COST ESTIMATE ***

CENTRAL PLANT AT GAS HOUSE

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	(ton)	(1)x200				$150,000			
electric service upgrade						$50,000			
ice storage tanks	(tonhr)		(15)x150	(7)x150			$225,000	$105,000	
*** Heating Plant ***									
hw convertors,pumps,piping,etc	(mmbtu/h)	(2)x5.0		(1)x5.0		$115,000		$65,000	
CENTRAL PLANT SUBTOTAL (installed)						$315,000	$225,000	$170,000	

DISTRICT PIPING DISTRIBUTION SYSTEM

	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:										
hot wtr	6	underground	600	0	0	0	$72,780	$0	$0	$0
hot wtr	4	underground	500	500	0	0	$45,400	$45,400	$0	$0
hot wtr	3	underground	0	600	0	0	$0	$47,640	$0	$0
hot wtr	2	underground	300	300	830	0	$18,600	$18,600	$51,460	$0
							$136,780	$111,640	$51,460	$0
chil wtr	8	underground	600	0	0	0	$52,140	$0	$0	$0
chil wtr	6	underground	500	1100	0	0	$40,000	$88,000	$0	$0
chil wtr	4	underground	0	0	870	0	$0	$0	$53,070	$0
chil wtr	2	underground	300	300	260	0	$12,900	$12,900	$11,180	$0
							$105,040	$100,900	$64,250	$0
DISTRIBUTION SUBTOTAL (installed)							$241,820	$425,080	$115,710	$0

	Phase 1	Phase 2	Phase 3	Phase 4
CENTRAL PLANT SUBTOTAL (installed)	$315,000	$225,000	$170,000	$0
DISTRIBUTION SUBTOTAL (installed)	$241,820	$425,080	$115,710	$0
Contingency	$56,000	$65,000	$29,000	$0
TOTAL ESTIMATED COST	$612,820	$715,080	$314,710	$0

Table 4-5a

Steamtown District Heating and Cooling Project

INPUT DATA FOR ECONOMIC ANALYSIS

Preliminary

Option 1: District Energy from the Gas House
with Hot Water Convertors & Electric Chillers

COST BASIS YEAR — All Costs Presented in this Table are 1990 dollars

	Project Parameters	Phase 1 1990	Phase 2 1991	Phase 3 1992	Phase 4 1993
ANNUAL QUANTITIES (Totaled)					
Heating Sales (mmbtu)		10064	10064	13991	21012
Cooling Sales (tonhr)		106200	106200	219000	339000
Steam for Heating (mlbs)		10064	10064	13991	21012
Steam for Cooling (mlbs)		0	0	0	0
Elec for Heating (mwhr)		7714	7714	21447	44362
Elec for Cooling (mwhr)		89848	89848	195359	314177
Labor Force (men)		0	0	0	0
CAPITAL COST (by phase)					
Plant ($1000)		265	0	100	165
Piping ($1000)		242	0	425	116
Contingency ($1000)		51	0	53	28
Total ($1000)		558	0	578	309
FINANCING					
Interest Rate (%)	11%				
Term (Yrs)	20				
Percent Financed	100%				
UNIT ENERGY COSTS					
Ave Electric Cost ($/kwhr)		0.085	0.085	0.085	0.085
Steam Cost ($/mlb)	5.00				
Heating Price ($/mmbtu)	NA				
Cooling Price ($/tonhr)	NA				
OTHER ANNUAL EXPENSES					
Average Labor ($/manyr)		$0	$0	$0	$0
Administration ($/yr)		$0	$0	$0	$0
Maintenance (% of investment)	2%				
Taxes/Insurance (% of invest)	0%				
Chiller Lease ($/yr)		$0	$0	$0	$0
MISCELLANEOUS					
Escalation	5%				

Table 4-5b

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 1: District Energy from the Gas House
with Hot Water Convertors & Electric Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	106200	106200	219000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	7714	7714	21447	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	89848	89848	195359	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.25	5.51	5.79	6.08	6.38	6.70	7.04	7.39	7.76
Ave Electric ($/kwhr)	0.085	0.089	0.094	0.098	0.103	0.108	0.114	0.120	0.126	0.132
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	558	0	637	358	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	106	109	183	258	265	271	278	286	293	302
Cooling Sales	34	34	90	127	130	134	137	141	145	149
E. EXPENSES ($1000)										
Steam	50	53	77	122	128	134	141	148	155	163
Electric	8	9	20	35	37	39	41	43	45	47
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	11	12	25	33	35	37	39	41	43	45
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	70	73	122	190	200	210	220	231	243	255
F. DEBT SERVICE ($1000)										
Principal	9	10	21	28	32	35	39	43	48	53
Interest	61	60	129	167	163	160	156	152	147	142
Total Debt Service	70	70	150	195	195	195	195	195	195	195
Funds for Debt Service	70	70	150	195	195	195	195	195	195	195
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	70	70	150	195	195	195	195	195	195	195
Interest	(61)	(60)	(129)	(167)	(163)	(160)	(156)	(152)	(147)	(142)
Principal	(9)	(10)	(21)	(28)	(32)	(35)	(39)	(43)	(48)	(53)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)	NA									
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	10.56	10.82	13.05	12.29	12.59	12.91	13.24	13.60	13.97	14.35
(Capital Component)	5.29	5.29	7.19	6.22	6.22	6.22	6.22	6.22	6.22	6.22
(Energy Component)	4.43	4.65	4.67	5.00	5.25	5.52	5.79	6.08	6.39	6.70
(Nonfuel Component)	0.84	0.88	1.20	1.07	1.12	1.18	1.23	1.30	1.36	1.43
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.32	0.32	0.41	0.38	0.38	0.39	0.40	0.42	0.43	0.44
(Capital Component)	0.16	0.16	0.23	0.19	0.19	0.19	0.19	0.19	0.19	0.19
(Energy Component)	0.13	0.14	0.15	0.15	0.16	0.17	0.18	0.19	0.19	0.20
(Nonfuel Component)	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-5b

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 1: District Energy from the Gas House
with Hot Water Convertors & Electric Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	339000	339000	339000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	44362	44362	44362	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	314177	314177	314177	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	8.14	8.55	8.98	9.43	9.90	10.39	10.91	11.46	12.03	12.63
Ave Electric ($/kwhr)	0.138	0.145	0.153	0.160	0.168	0.177	0.186	0.195	0.205	0.215
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	0	0	0	0	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	310	319	329	338	349	360	371	383	396	409
Cooling Sales	153	157	162	167	172	177	183	189	195	201
E. EXPENSES ($1000)										
Steam	171	180	189	198	208	218	229	241	253	265
Electric	50	52	55	57	60	63	67	70	73	77
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	47	49	52	54	57	60	63	66	70	73
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	268	281	295	310	326	342	359	377	396	416
F. DEBT SERVICE ($1000)										
Principal	59	66	73	81	90	100	111	123	136	151
Interest	136	129	122	114	105	95	84	72	59	44
Total Debt Service	195	195	195	195	195	195	195	195	195	195
Funds for Debt Service	195	195	195	195	195	195	195	195	195	195
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	195	195	195	195	195	195	195	195	195	195
Interest	(136)	(129)	(122)	(114)	(105)	(95)	(84)	(72)	(59)	(44)
Principal	(59)	(66)	(73)	(81)	(90)	(100)	(111)	(123)	(136)	(151)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)										
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	14.76	15.19	15.63	16.11	16.60	17.12	17.66	18.24	18.84	19.47
(Capital Component)	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22
(Energy Component)	7.04	7.39	7.76	8.15	8.56	8.98	9.43	9.91	10.40	10.92
(Nonfuel Component)	1.50	1.58	1.65	1.74	1.82	1.92	2.01	2.11	2.22	2.33
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.45	0.46	0.48	0.49	0.51	0.52	0.54	0.56	0.58	0.59
(Capital Component)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
(Energy Component)	0.21	0.23	0.24	0.25	0.26	0.27	0.29	0.30	0.32	0.33
(Nonfuel Component)	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-5c

Steamtown District Heating and Cooling Project

INPUT DATA FOR ECONOMIC ANALYSIS

Preliminary

****

Option 1: District Energy from the Gas House
with Hot Water Convertors & Electric Chillers

****

COST BASIS YEAR — All Costs Presented in this Table are 1990 dollars

	Project Parameters	Phase 1 1990	Phase 2 1991	Phase 3 1992	Phase 4 1993
ANNUAL QUANTITIES (Totaled)					
Heating Sales (mmbtu)		10064	10064	13991	21012
Cooling Sales (tonhr)		106200	106200	219000	339000
Steam for Heating (mlbs)		10064	10064	13991	21012
Steam for Cooling (mlbs)		0	0	0	0
Elec for Heating (mwhr)		7714	7714	21447	44362
Elec for Cooling (mwhr)		89848	89848	195359	314177
Labor Force (men)		0	0	0	0
CAPITAL COST (by phase)					
Plant ($1000)		265	0	100	165
Piping ($1000)		242	0	425	116
Contingency ($1000)		51	0	53	28
Total ($1000)		558	0	578	309
FINANCING					
Interest Rate (%)	11%				
Term (Yrs)	20				
Percent Financed	100%				
UNIT ENERGY COSTS					
Ave Electric Cost ($/kwhr)		0.085	0.085	0.085	0.085
Steam Cost ($/mlb)	5.00				
Heating Price ($/mmbtu)	NA				
Cooling Price ($/tonhr)	NA				
OTHER ANNUAL EXPENSES					
Average Labor ($/manyr)		$0	$0	$0	$0
Administration ($/yr)		$0	$0	$0	$0
Maintenance (% of investment)	2%				
Taxes/Insurance (% of invest)	0%				
Chiller Lease ($/yr)		$0	$0	$0	$0
MISCELLANEOUS					
Escalation	0%				

Table 4-5d

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 1: District Energy from the Gas House
with Hot Water Convertors & Electric Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	106200	106200	219000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	7714	7714	21447	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	89848	89848	195359	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ave Electric ($/kwhr)	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	558	0	578	309	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	106	106	170	232	232	232	232	232	232	232
Cooling Sales	34	34	84	114	114	114	114	114	114	114
E. EXPENSES ($1000)										
Steam	50	50	70	105	105	105	105	105	105	105
Electric	8	8	18	30	30	30	30	30	30	30
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	11	11	23	29	29	29	29	29	29	29
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	70	70	111	164	164	164	164	164	164	164
F. DEBT SERVICE ($1000)										
Principal	9	10	20	27	30	33	37	41	45	50
Interest	61	60	123	155	152	149	145	141	136	132
Total Debt Service	70	70	143	181	181	181	181	181	181	181
Funds for Debt Service	70	70	143	181	181	181	181	181	181	181
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	70	70	143	181	181	181	181	181	181	181
Interest	(61)	(60)	(123)	(155)	(152)	(149)	(145)	(141)	(136)	(132)
Principal	(9)	(10)	(20)	(27)	(30)	(33)	(37)	(41)	(45)	(50)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)	NA									
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	10.56	10.56	12.15	11.03	11.03	11.03	11.03	11.03	11.03	11.03
(Capital Component)	5.29	5.29	6.83	5.79	5.79	5.79	5.79	5.79	5.79	5.79
(Energy Component)	4.43	4.43	4.23	4.32	4.32	4.32	4.32	4.32	4.32	4.32
(Nonfuel Component)	0.84	0.84	1.09	0.92	0.92	0.92	0.92	0.92	0.92	0.92
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.32	0.32	0.38	0.34	0.34	0.34	0.34	0.34	0.34	0.34
(Capital Component)	0.16	0.16	0.21	0.18	0.18	0.18	0.18	0.18	0.18	0.18
(Energy Component)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
(Nonfuel Component)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-5d

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 1: District Energy from the Gas House
with Hot Water Convertors & Electric Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	339000	339000	339000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	44362	44362	44362	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	314177	314177	314177	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ave Electric ($/kwhr)	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	0	0	0	0	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	232	232	232	232	232	232	232	232	232	232
Cooling Sales	114	114	114	114	114	114	114	114	114	114
E. EXPENSES ($1000)										
Steam	105	105	105	105	105	105	105	105	105	105
Electric	30	30	30	30	30	30	30	30	30	30
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	29	29	29	29	29	29	29	29	29	29
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	164	164	164	164	164	164	164	164	164	164
F. DEBT SERVICE ($1000)										
Principal	55	62	68	76	84	93	104	115	128	142
Interest	126	120	113	106	97	88	78	66	54	40
Total Debt Service	181	181	181	181	181	181	181	181	181	181
Funds for Debt Service	181	181	181	181	181	181	181	181	181	181
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	181	181	181	181	181	181	181	181	181	181
Interest	(126)	(120)	(113)	(106)	(97)	(88)	(78)	(66)	(54)	(40)
Principal	(55)	(62)	(68)	(76)	(84)	(93)	(104)	(115)	(128)	(142)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)										
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	11.03	11.03	11.03	11.03	11.03	11.03	11.03	11.03	11.03	11.03
(Capital Component)	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79	5.79
(Energy Component)	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32
(Nonfuel Component)	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
(Capital Component)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
(Energy Component)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
(Nonfuel Component)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-6a

Steamtown District Heating and Cooling Project

INPUT DATA FOR ECONOMIC ANALYSIS

Preliminary

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers

COST BASIS YEAR — All Costs Presented in this Table are 1990 dollars

	Project Parameters	Phase 1 1990	Phase 2 1991	Phase 3 1992	Phase 4 1993
ANNUAL QUANTITIES (Totaled)					
Heating Sales (mmbtu)		10064	10064	13991	21012
Cooling Sales (tonhr)		106200	106200	219000	339000
Steam for Heating (mlbs)		10064	10064	13991	21012
Steam for Cooling (mlbs)		1806	1806	3725	5766
Elec for Heating (mwhr)		7714	7714	21447	44362
Elec for Cooling (mwhr)		4888	4888	20159	42977
Labor Force (men)		0	0	0	0
CAPITAL COST (by phase)					
Plant ($1000)		265	0	150	215
Piping ($1000)		242	0	425	116
Contingency ($1000)		51	0	58	33
Total ($1000)		558	0	633	364
FINANCING					
Interest Rate (%)	11%				
Term (Yrs)	20				
Percent Financed	100%				
UNIT ENERGY COSTS					
Ave Electric Cost ($/kwhr)		0.085	0.085	0.085	0.085
Steam Cost ($/mlb)	5.00				
Heating Price ($/mmbtu)	NA				
Cooling Price ($/tonhr)	NA				
OTHER ANNUAL EXPENSES					
Average Labor ($/manyr)		$0	$0	$0	$0
Administration ($/yr)		$0	$0	$0	$0
Maintenance (% of investment)	2%				
Taxes/Insurance (% of invest)	0%				
Chiller Lease ($/yr)		$0	$0	$0	$0
MISCELLANEOUS					
Escalation	5%				

Table 4-6b

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	106200	106200	219000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	1806	1806	3725	5766	5766	5766	5766	5766	5766	5766
Elec for Heating (mwhr)	7714	7714	21447	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	89848	89848	195359	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.25	5.51	5.79	6.08	6.38	6.70	7.04	7.39	7.76
Ave Electric ($/kwhr)	0.085	0.089	0.094	0.098	0.103	0.108	0.114	0.120	0.126	0.132
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	558	0	698	421	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	106	109	189	270	277	284	291	298	306	314
Cooling Sales	34	34	93	133	136	140	143	147	151	155
E. EXPENSES ($1000)										
Steam	50	53	77	122	128	134	141	148	155	163
Electric	8	9	20	35	37	39	41	43	45	47
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	11	12	26	36	38	40	42	44	46	48
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	70	73	124	193	203	213	223	234	246	259
F. DEBT SERVICE ($1000)										
Principal	9	10	22	31	34	38	42	46	51	57
Interest	61	60	136	180	177	173	169	164	159	154
Total Debt Service	70	70	158	211	211	211	211	211	211	211
Funds for Debt Service	70	70	158	211	211	211	211	211	211	211
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	70	70	158	211	211	211	211	211	211	211
Interest	(61)	(60)	(136)	(180)	(177)	(173)	(169)	(164)	(159)	(154)
Principal	(9)	(10)	(22)	(31)	(34)	(38)	(42)	(46)	(51)	(57)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)	NA									
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	10.56	10.82	13.48	12.87	13.17	13.50	13.84	14.19	14.57	14.96
(Capital Component)	5.29	5.29	7.55	6.72	6.72	6.72	6.72	6.72	6.72	6.72
(Energy Component)	4.43	4.65	4.67	5.00	5.25	5.52	5.79	6.08	6.39	6.70
(Nonfuel Component)	0.84	0.88	1.26	1.15	1.21	1.27	1.33	1.40	1.47	1.54
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.32	0.32	0.42	0.39	0.40	0.41	0.42	0.43	0.44	0.46
(Capital Component)	0.16	0.16	0.24	0.21	0.21	0.21	0.21	0.21	0.21	0.21
(Energy Component)	0.13	0.14	0.15	0.15	0.16	0.17	0.18	0.19	0.19	0.20
(Nonfuel Component)	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-6b

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	339000	339000	339000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	5766	5766	5766	5766	5766	5766	5766	5766	5766	5766
Elec for Heating (mwhr)	44362	44362	44362	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	314177	314177	314177	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	8.14	8.55	8.98	9.43	9.90	10.39	10.91	11.46	12.03	12.63
Ave Electric ($/kwhr)	0.138	0.145	0.153	0.160	0.168	0.177	0.186	0.195	0.205	0.215
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	0	0	0	0	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	323	332	342	352	362	373	385	397	410	423
Cooling Sales	159	164	168	173	178	184	190	196	202	208
E. EXPENSES ($1000)										
Steam	171	180	189	198	208	218	229	241	253	265
Electric	50	52	55	57	60	63	67	70	73	77
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	51	53	56	59	62	65	68	71	75	79
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	271	285	299	314	330	346	364	382	401	421
F. DEBT SERVICE ($1000)										
Principal	63	70	78	87	96	107	118	132	146	162
Interest	147	140	133	124	114	104	92	79	65	49
Total Debt Service	211	211	211	211	211	211	211	211	211	211
Funds for Debt Service	211	211	211	211	211	211	211	211	211	211
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	211	211	211	211	211	211	211	211	211	211
Interest	(147)	(140)	(133)	(124)	(114)	(104)	(92)	(79)	(65)	(49)
Principal	(63)	(70)	(78)	(87)	(96)	(107)	(118)	(132)	(146)	(162)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)										
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	15.37	15.80	16.26	16.74	17.24	17.76	18.31	18.89	19.50	20.14
(Capital Component)	6.72	6.72	6.72	6.72	6.72	6.72	6.72	6.72	6.72	6.72
(Energy Component)	7.04	7.39	7.76	8.15	8.56	8.98	9.43	9.91	10.40	10.92
(Nonfuel Component)	1.62	1.70	1.78	1.87	1.96	2.06	2.16	2.27	2.39	2.51
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.47	0.48	0.50	0.51	0.53	0.54	0.56	0.58	0.60	0.61
(Capital Component)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
(Energy Component)	0.21	0.23	0.24	0.25	0.26	0.27	0.29	0.30	0.32	0.33
(Nonfuel Component)	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-6c

Steamtown District Heating and Cooling Project

INPUT DATA FOR ECONOMIC ANALYSIS

Preliminary

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers

COST BASIS YEAR — All Costs Presented in this Table are 1990 dollars

	Project Parameters	Phase 1 1990	Phase 2 1991	Phase 3 1992	Phase 4 1993
ANNUAL QUANTITIES (Totaled)					
Heating Sales (mmbtu)		10064	10064	13991	21012
Cooling Sales (tonhr)		106200	106200	219000	339000
Steam for Heating (mlbs)		10064	10064	13991	21012
Steam for Cooling (mlbs)		1806	1806	3725	5766
Elec for Heating (mwhr)		7714	7714	21447	44362
Elec for Cooling (mwhr)		4888	4888	20159	42977
Labor Force (men)		0	0	0	0
CAPITAL COST (by phase)					
Plant ($1000)		265	0	150	215
Piping ($1000)		242	0	425	116
Contingency ($1000)		51	0	58	33
Total ($1000)		558	0	633	364
FINANCING					
Interest Rate (%)	11%				
Term (Yrs)	20				
Percent Financed	100%				
UNIT ENERGY COSTS					
Ave Electric Cost ($/kwhr)		0.085	0.085	0.085	0.085
Steam Cost ($/mlb)	5.00				
Heating Price ($/mmbtu)	NA				
Cooling Price ($/tonhr)	NA				
OTHER ANNUAL EXPENSES					
Average Labor ($/manyr)		$0	$0	$0	$0
Administration ($/yr)		$0	$0	$0	$0
Maintenance (% of investment)	2%				
Taxes/Insurance (% of invest)	0%				
Chiller Lease ($/yr)		$0	$0	$0	$0
MISCELLANEOUS					
Escalation	0%				

Table 4-6d

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	106200	106200	219000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	1806	1806	3725	5766	5766	5766	5766	5766	5766	5766
Elec for Heating (mwhr)	7714	7714	21447	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	89848	89848	195359	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ave Electric ($/kwhr)	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	558	0	633	364	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	106	106	175	242	242	242	242	242	242	242
Cooling Sales	34	34	86	119	119	119	119	119	119	119
E. EXPENSES ($1000)										
Steam	50	50	70	105	105	105	105	105	105	105
Electric	8	8	18	30	30	30	30	30	30	30
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	11	11	24	31	31	31	31	31	31	31
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	70	70	112	167	167	167	167	167	167	167
F. DEBT SERVICE ($1000)										
Principal	9	10	21	28	32	35	39	43	48	53
Interest	61	60	129	167	164	160	156	152	147	142
Total Debt Service	70	70	150	195	195	195	195	195	195	195
Funds for Debt Service	70	70	150	195	195	195	195	195	195	195
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	70	70	150	195	195	195	195	195	195	195
Interest	(61)	(60)	(129)	(167)	(164)	(160)	(156)	(152)	(147)	(142)
Principal	(9)	(10)	(21)	(28)	(32)	(35)	(39)	(43)	(48)	(53)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)	NA									
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	10.56	10.56	12.54	11.54	11.54	11.54	11.54	11.54	11.54	11.54
(Capital Component)	5.29	5.29	7.16	6.23	6.23	6.23	6.23	6.23	6.23	6.23
(Energy Component)	4.43	4.43	4.23	4.32	4.32	4.32	4.32	4.32	4.32	4.32
(Nonfuel Component)	0.84	0.84	1.14	0.99	0.99	0.99	0.99	0.99	0.99	0.99
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.32	0.32	0.39	0.35	0.35	0.35	0.35	0.35	0.35	0.35
(Capital Component)	0.16	0.16	0.23	0.19	0.19	0.19	0.19	0.19	0.19	0.19
(Energy Component)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
(Nonfuel Component)	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-6d

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers

Purpose: Determine Breakeven Unit Energy Cost

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	339000	339000	339000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	5766	5766	5766	5766	5766	5766	5766	5766	5766	5766
Elec for Heating (mwhr)	44362	44362	44362	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	314177	314177	314177	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ave Electric ($/kwhr)	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	0	0	0	0	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	242	242	242	242	242	242	242	242	242	242
Cooling Sales	119	119	119	119	119	119	119	119	119	119
E. EXPENSES ($1000)										
Steam	105	105	105	105	105	105	105	105	105	105
Electric	30	30	30	30	30	30	30	30	30	30
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	31	31	31	31	31	31	31	31	31	31
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	167	167	167	167	167	167	167	167	167	167
F. DEBT SERVICE ($1000)										
Principal	59	66	73	81	90	100	111	123	136	151
Interest	136	130	122	114	105	96	85	72	59	44
Total Debt Service	195	195	195	195	195	195	195	195	195	195
Funds for Debt Service	195	195	195	195	195	195	195	195	195	195
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	195	195	195	195	195	195	195	195	195	195
Interest	(136)	(130)	(122)	(114)	(105)	(96)	(85)	(72)	(59)	(44)
Principal	(59)	(66)	(73)	(81)	(90)	(100)	(111)	(123)	(136)	(151)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)										
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	11.54	11.54	11.54	11.54	11.54	11.54	11.54	11.54	11.54	11.54
(Capital Component)	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23
(Energy Component)	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32	4.32
(Nonfuel Component)	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
(Capital Component)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
(Energy Component)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
(Nonfuel Component)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-7a

Steamtown District Heating and Cooling Project

INPUT DATA FOR ECONOMIC ANALYSIS

Preliminary

Option 3: District Energy from the Gas House
with Hot Water Convertors, Electric Chillers & Ice Storage

COST BASIS YEAR — All Costs Presented in this Table are 1990 dollars

	Project Parameters	Phase 1 1991	Phase 2 1991	Phase 3 1992	Phase 4 1993
ANNUAL QUANTITIES (Totaled)					
Heating Sales (mmbtu)		10064	10064	13991	21012
Cooling Sales (tonhr)		106200	106200	219000	339000
Steam for Heating (mlbs)		10064	10064	13991	21012
Steam for Cooling (mlbs)		0	0	0	0
Elec for Heating (mwhr)		7714	7714	21447	44362
Elec for Cooling (mwhr)		89848	89848	195359	314177
Labor Force (men)		0	0	0	0
CAPITAL COST (by phase)					
Plant ($1000)		315	0	225	170
Piping ($1000)		242	0	425	116
Contingency ($1000)		56	0	65	29
Total ($1000)		613	0	715	315
FINANCING					
Interest Rate (%)	11%				
Term (Yrs)	20				
Percent Financed	100%				
UNIT ENERGY COSTS					
Ave Electric Cost ($/kwhr)		0.085	0.068	0.069	0.070
Steam Cost ($/mlb)	5.00				
Heating Price ($/mmbtu)	NA				
Cooling Price ($/tonhr)	NA				
OTHER ANNUAL EXPENSES					
Average Labor ($/manyr)		$0	$0	$0	$0
Administration ($/yr)		$0	$0	$0	$0
Maintenance (% of investment)	2%				
Taxes/Insurance (% of invest)	0%				
Chiller Lease ($/yr)		$0	$0	$0	$0
MISCELLANEOUS					
Escalation	5%				

Table 4-7b

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 3: District Energy from the Gas House
with Hot Water Convertors, Electric Chillers & Ice Storage

Purpose: Determine Breakeven Unit Energy Cost

Year	1991	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	106200	106200	219000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	7714	7714	21447	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	89848	89848	195359	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.25	5.25	5.51	5.79	6.08	6.38	6.70	7.04	7.39	7.76
Ave Electric ($/kwhr)	0.089	0.072	0.077	0.082	0.086	0.090	0.094	0.099	0.104	0.109
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	644	0	788	365	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	118	117	203	278	285	291	298	306	313	321
Cooling Sales	37	37	100	137	140	143	147	151	154	158
E. EXPENSES ($1000)										
Steam	53	53	77	122	128	134	141	148	155	163
Electric	9	7	17	29	31	32	34	36	37	39
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	13	14	30	39	41	43	45	47	49	52
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	74	73	124	190	199	209	220	230	242	254
F. DEBT SERVICE ($1000)										
Principal	10	11	25	33	37	41	45	50	56	62
Interest	71	70	155	193	189	185	180	175	170	164
Total Debt Service	81	81	180	226	226	226	226	226	226	226
Funds for Debt Service	81	81	180	226	226	226	226	226	226	226
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	81	81	180	226	226	226	226	226	226	226
Interest	(71)	(70)	(155)	(193)	(189)	(185)	(180)	(175)	(170)	(164)
Principal	(10)	(11)	(25)	(33)	(37)	(41)	(45)	(50)	(56)	(62)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)	NA									
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	11.72	11.64	14.53	13.24	13.54	13.86	14.19	14.54	14.91	15.30
(Capital Component)	6.10	6.10	8.61	7.19	7.19	7.19	7.19	7.19	7.19	7.19
(Energy Component)	4.65	4.52	4.49	4.81	5.05	5.30	5.57	5.85	6.14	6.45
(Nonfuel Component)	0.97	1.02	1.43	1.24	1.30	1.36	1.43	1.50	1.58	1.66
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.35	0.35	0.46	0.40	0.41	0.42	0.43	0.44	0.46	0.47
(Capital Component)	0.18	0.18	0.27	0.22	0.22	0.22	0.22	0.22	0.22	0.22
(Energy Component)	0.14	0.14	0.14	0.15	0.15	0.16	0.17	0.18	0.19	0.20
(Nonfuel Component)	0.03	0.03	0.05	0.04	0.04	0.04	0.04	0.05	0.05	0.05
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-7b

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 3: District Energy from the Gas House
with Hot Water Convertors, Electric Chillers & Ice Storage

Purpose: Determine Breakeven Unit Energy Cost

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	339000	339000	339000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	44362	44362	44362	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	314177	314177	314177	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	8.14	8.55	8.98	9.43	9.90	10.39	10.91	11.46	12.03	12.63
Ave Electric ($/kwhr)	0.115	0.121	0.127	0.133	0.140	0.147	0.154	0.162	0.170	0.178
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	0	0	0	0	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	330	339	348	358	368	379	391	403	415	428
Cooling Sales	162	167	172	176	181	187	192	198	205	211
E. EXPENSES ($1000)										
Steam	171	180	189	198	208	218	229	241	253	265
Electric	41	43	45	48	50	53	55	58	61	64
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	55	57	60	63	66	70	73	77	81	85
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	267	280	294	309	324	341	358	375	394	414
F. DEBT SERVICE ($1000)										
Principal	69	76	84	94	104	116	128	142	158	175
Interest	157	150	141	132	122	110	97	83	68	50
Total Debt Service	226	226	226	226	226	226	226	226	226	226
Funds for Debt Service	226	226	226	226	226	226	226	226	226	226
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	226	226	226	226	226	226	226	226	226	226
Interest	(157)	(150)	(141)	(132)	(122)	(110)	(97)	(83)	(68)	(50)
Principal	(69)	(76)	(84)	(94)	(104)	(116)	(128)	(142)	(158)	(175)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)										
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	15.70	16.13	16.57	17.04	17.54	18.05	18.60	19.17	19.76	20.39
(Capital Component)	7.19	7.19	7.19	7.19	7.19	7.19	7.19	7.19	7.19	7.19
(Energy Component)	6.77	7.11	7.46	7.84	8.23	8.64	9.07	9.53	10.00	10.50
(Nonfuel Component)	1.74	1.83	1.92	2.01	2.11	2.22	2.33	2.45	2.57	2.70
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.48	0.49	0.51	0.52	0.54	0.55	0.57	0.59	0.60	0.62
(Capital Component)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
(Energy Component)	0.21	0.22	0.23	0.24	0.25	0.26	0.28	0.29	0.31	0.32
(Nonfuel Component)	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-7c

Steamtown District Heating and Cooling Project

INPUT DATA FOR ECONOMIC ANALYSIS

Preliminary

****

Option 3: District Energy from the Gas House
with Hot Water Convertors, Electric Chillers & Ice Storage

****

COST BASIS YEAR — All Costs Presented in this Table are 1990 dollars

	Project Parameters	Phase 1 1991	Phase 2 1991	Phase 3 1992	Phase 4 1993
ANNUAL QUANTITIES (Totaled)					
Heating Sales (mmbtu)		10064	10064	13991	21012
Cooling Sales (tonhr)		106200	106200	219000	339000
Steam for Heating (mlbs)		10064	10064	13991	21012
Steam for Cooling (mlbs)		0	0	0	0
Elec for Heating (mwhr)		7714	7714	21447	44362
Elec for Cooling (mwhr)		89848	89848	195359	314177
Labor Force (men)		0	0	0	0
CAPITAL COST (by phase)					
Plant ($1000)		315	0	225	170
Piping ($1000)		242	0	425	116
Contingency ($1000)		56	0	65	29
Total ($1000)		613	0	715	315
FINANCING					
Interest Rate (%)	11%				
Term (Yrs)	20				
Percent Financed	100%				
UNIT ENERGY COSTS					
Ave Electric Cost ($/kwhr)		0.085	0.068	0.069	0.070
Steam Cost ($/mlb)	5.00				
Heating Price ($/mmbtu)	NA				
Cooling Price ($/tonhr)	NA				
OTHER ANNUAL EXPENSES					
Average Labor ($/manyr)		$0	$0	$0	$0
Administration ($/yr)		$0	$0	$0	$0
Maintenance (% of investment)	2%				
Taxes/Insurance (% of invest)	0%				
Chiller Lease ($/yr)		$0	$0	$0	$0
MISCELLANEOUS					
Escalation	0%				

Table 4-7d

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 3: District Energy from the Gas House
with Hot Water Convertors, Electric Chillers & Ice Storage

Purpose: Determine Breakeven Unit Energy Cost

Year	1991	1991	1992	1993	1994	1995	1996	1997	1998	1999
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	106200	106200	219000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	10064	10064	13991	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	7714	7714	21447	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	89848	89848	195359	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ave Electric ($/kwhr)	0.085	0.068	0.069	0.070	0.070	0.070	0.070	0.070	0.070	0.070
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	613	0	715	315	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	112	111	186	248	248	248	248	248	248	248
Cooling Sales	35	35	92	122	122	122	122	122	122	122
E. EXPENSES ($1000)										
Steam	50	50	70	105	105	105	105	105	105	105
Electric	8	7	15	25	25	25	25	25	25	25
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	12	12	27	33	33	33	33	33	33	33
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	71	69	112	163	163	163	163	163	163	163
F. DEBT SERVICE ($1000)										
Principal	10	11	23	30	34	37	41	46	51	57
Interest	67	66	144	176	173	169	165	160	155	150
Total Debt Service	77	77	167	206	206	206	206	206	206	206
Funds for Debt Service	77	77	167	206	206	206	206	206	206	206
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	77	77	167	206	206	206	206	206	206	206
Interest	(67)	(66)	(144)	(176)	(173)	(169)	(165)	(160)	(155)	(150)
Principal	(10)	(11)	(23)	(30)	(34)	(37)	(41)	(46)	(51)	(57)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)	NA									
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	11.17	11.04	13.33	11.78	11.78	11.78	11.78	11.78	11.78	11.78
(Capital Component)	5.81	5.81	7.99	6.58	6.58	6.58	6.58	6.58	6.58	6.58
(Energy Component)	4.43	4.30	4.07	4.16	4.16	4.16	4.16	4.16	4.16	4.16
(Nonfuel Component)	0.93	0.93	1.27	1.05	1.05	1.05	1.05	1.05	1.05	1.05
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.33	0.33	0.42	0.36	0.36	0.36	0.36	0.36	0.36	0.36
(Capital Component)	0.17	0.17	0.25	0.20	0.20	0.20	0.20	0.20	0.20	0.20
(Energy Component)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
(Nonfuel Component)	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-7d

Steamtown District Heating and Cooling Project

ECONOMIC ANALYSIS FOR DISTRICT ENERGY SERVICE

Preliminary

Option 3: District Energy from the Gas House
with Hot Water Convertors, Electric Chillers & Ice Storage

Purpose: Determine Breakeven Unit Energy Cost

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
A. ANNUAL QUANTITIES										
Heating Sales (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Cooling Sales (tonhr)	339000	339000	339000	339000	339000	339000	339000	339000	339000	339000
Steam for Heating (mmbtu)	21012	21012	21012	21012	21012	21012	21012	21012	21012	21012
Steam for Cooling (mmbtu)	0	0	0	0	0	0	0	0	0	0
Elec for Heating (mwhr)	44362	44362	44362	44362	44362	44362	44362	44362	44362	44362
Elec for Cooling (mwhr)	314177	314177	314177	314177	314177	314177	314177	314177	314177	314177
Added Labor Force (men)	0	0	0	0	0	0	0	0	0	0
B. UNIT PRICES (Given)										
Unit Heating Price($/mmbtu)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Unit Cooling Price($/tonhr)	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H	Item H
Steam ($/mlbs)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Ave Electric ($/kwhr)	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
Average Labor ($/manyr)	0	0	0	0	0	0	0	0	0	0
C. INVESTMENTS ($1000)										
Plant and Piping	0	0	0	0	0	0	0	0	0	0
D. REVENUES ($1000)										
Heating Sales	248	248	248	248	248	248	248	248	248	248
Cooling Sales	122	122	122	122	122	122	122	122	122	122
E. EXPENSES ($1000)										
Steam	105	105	105	105	105	105	105	105	105	105
Electric	25	25	25	25	25	25	25	25	25	25
Labor	0	0	0	0	0	0	0	0	0	0
Maintenance	33	33	33	33	33	33	33	33	33	33
Administration	0	0	0	0	0	0	0	0	0	0
Chiller Lease	0	0	0	0	0	0	0	0	0	0
Property Tax/Insurance	0	0	0	0	0	0	0	0	0	0
Federal Tax(not considered)	0	0	0	0	0	0	0	0	0	0
Total Expenses	163	163	163	163	163	163	163	163	163	163
F. DEBT SERVICE ($1000)										
Principal	63	70	78	86	96	106	118	131	145	161
Interest	143	136	129	120	111	100	89	76	61	45
Total Debt Service	206	206	206	206	206	206	206	206	206	206
Funds for Debt Service	206	206	206	206	206	206	206	206	206	206
Coverage Ratio (funds/debt)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
G. PROFIT ($1000)										
Revenue Less Expenses	206	206	206	206	206	206	206	206	206	206
Interest	(143)	(136)	(129)	(120)	(111)	(100)	(89)	(76)	(61)	(45)
Principal	(63)	(70)	(78)	(86)	(96)	(106)	(118)	(131)	(145)	(161)
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
H. RESULTS										
Payback (yrs)										
Net Profit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
*Unit Heating Cost ($/mmbtu)	11.78	11.78	11.78	11.78	11.78	11.78	11.78	11.78	11.78	11.78
(Capital Component)	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58
(Energy Component)	4.16	4.16	4.16	4.16	4.16	4.16	4.16	4.16	4.16	4.16
(Nonfuel Component)	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Unit Cooling Cost ($/tonhr)	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
(Capital Component)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
(Energy Component)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
(Nonfuel Component)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
(Profit Component)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

components and determines the breakeven unit cost which matches the required revenue with the total costs. The three phases of implementation are assumed to occur over a period of four years beginning in 1990. Two cases are performed, one in which all costs are escalated to the year of operation at 5% and a second assuming 0% escalation.

SUMMARY OF RESULTS

An annual cost comparison of on-site plants determined in Section 3 versus district energy determined in Section 4 are presented in the following tables.

* * * *

Annual Cost Comparison of On-Site Plants versus District Energy

Table 4-8: Option 1
Table 4-9: Option 2
Table 4-10: Option 3

* * * *

The tables summate the loads, and the components of on-site heating and cooling cost (capital, fuel and O&M) for the Steamtown buildings identified as potential customers of a district energy system. A similar summation is conducted assuming the unit costs determined for district heating and cooling for each of the three options. Total cost savings are calculated in the tables and summarized below for each option:

Annual Cost Comparison Summary
On-Site Plants vs. District Energy

District Energy Option	Estimated Annual Cost Savings
1. Hot Water Convertors/ Electric Chillers	17.1%
2. Hot Water Convertors/ Absorption Chillers	13.7%
3. Hot Water Convertors/ Electric Chillers/ Ice Storage	11.7%

These results suggest that Option 1 which selects hot water convertors and hi-efficiency centrifugal chillers for the energy substation is most attractive.

ACTION PLAN

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 the complex of railroad age buildings being renovated as Steamtown.
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 Gas Works Building as well as the plant itself.
3. Attain customer commitment and contract to select a district energy alternative, revising analyses accordingly to justify this approach to his satisfaction.
4. Retain a general contractor to construct the system.

Table 4-8

Steamtown District Heating and Cooling Project

ANNUAL COST COMPARISON OF ON-SITE PLANTS VERSUS DISTRICT ENERGY

Option 1: District Energy from the Gas House
with Hot Water Convertors & Electric Chillers
After Phase 3

Preliminary

***** HEATING *****

Customer Name	Load (mmbtu)	Capital ($)	Fuel ($)	O&M ($)	Total ($)	District Heating Total ($)	District Heating Savings ($)
		[-- Components of On-Site Heating Cost --]				[District Heating]	
Locomotive Shop	4,590	$12,200	$34,200	$7,700	$54,100	$50,628	$3,472
Office/ Storage I	4,080	$10,800	$30,400	$6,700	$47,900	$45,002	$2,898
Main of Way Building	1,394	$3,700	$10,700	$1,300	$15,700	$15,376	$324
Roundhouse	3,587	$9,500	$26,800	$7,300	$43,600	$39,565	$4,035
Oil House	340	$900	$2,700	$1,700	$5,300	$3,750	$1,550
Office/ Storage II	2,040	$5,400	$15,500	$4,000	$24,900	$22,501	$2,399
Signal Tower	255	$700	$2,100	$1,700	$4,500	$2,813	$1,687
Station Gift Shop	408	$1,100	$3,200	$2,500	$6,800	$4,500	$2,300
Silk Mill	3,434	$9,100	$25,700	$5,900	$40,700	$37,877	$2,823
Garage	884	$2,300	$6,700	$3,400	$12,400	$9,751	$2,649
Total	21,012	$55,700	$158,000	$42,200	$255,900	$231,762	$24,138
Percent		21.8%	61.7%	16.5%	100.0%		9.4%

Assumptions:
District Heating Unit Cost: 11.03 $/mmbtu (no escalation)

***** COOLING *****

Customer Name	Load (tonhr)	Capital ($)	Fuel ($)	O&M ($)	Total ($)	District Cooling Total ($)	District Cooling Savings ($)
		[-- Components of On-Site Cooling Cost --]				[District Cooling]	
Locomotive Shop	0	$0	$0	$0	$0	$0	$0
Office/ Storage I	79,200	$19,900	$7,100	$10,100	$37,100	$26,928	$10,172
Main of Way Building	27,000	$6,800	$2,400	$2,000	$11,200	$9,180	$2,020
Roundhouse	105,000	$26,400	$9,500	$10,900	$46,800	$35,700	$11,100
Oil House	7,800	$2,000	$700	$2,600	$5,300	$2,652	$2,648
Office/ Storage II	39,000	$9,800	$3,500	$5,900	$19,200	$13,260	$5,940
Signal Tower	3,600	$900	$300	$2,600	$3,800	$1,224	$2,576
Station Gift Shop	10,200	$2,600	$900	$3,800	$7,300	$3,468	$3,832
Silk Mill	67,200	$16,900	$6,000	$8,900	$31,800	$22,848	$8,952
Garage	0	$0	$0	$0	$0	$0	$0
Total	339,000	$85,300	$30,400	$46,800	$162,500	$115,260	$47,240
Percent		52.5%	18.7%	28.8%	100.0%		29.1%

Assumptions:
District Cooling Unit Cost: 0.34 $/tonhr (no escalation)

		Capital ($)	Fuel ($)	O&M ($)	Total ($)	District Total ($)	Savings ($)
Total Heating and Cooling		$141,000	$188,400	$89,000	$418,400	$347,022	$71,378
Percent		33.7%	45.0%	21.3%	100.0%		17.1%

Table 4-9

Steamtown District Heating and Cooling Project

ANNUAL COST COMPARISON OF ON-SITE PLANTS VERSUS DISTRICT ENERGY

Option 2: District Energy from the Gas House
with Hot Water Convertors & Steam Absorption Chillers
After Phase 3

Preliminary

***** HEATING *****

Customer Name	Load (mmbtu)	Capital ($)	Fuel ($)	O&M ($)	Total ($)	District Heating Total ($)	District Heating Savings ($)
		[-- Components of On-Site Heating Cost --]				[District Heating]	
Locomotive Shop	4,590	$12,200	$34,200	$7,700	$54,100	$52,969	$1,131
Office/ Storage I	4,080	$10,800	$30,400	$6,700	$47,900	$47,083	$817
Main of Way Building	1,394	$3,700	$10,700	$1,300	$15,700	$16,087	($387)
Roundhouse	3,587	$9,500	$26,800	$7,300	$43,600	$41,394	$2,206
Oil House	340	$900	$2,700	$1,700	$5,300	$3,924	$1,376
Office/ Storage II	2,040	$5,400	$15,500	$4,000	$24,900	$23,542	$1,358
Signal Tower	255	$700	$2,100	$1,700	$4,500	$2,943	$1,557
Station Gift Shop	408	$1,100	$3,200	$2,500	$6,800	$4,708	$2,092
Silk Mill	3,434	$9,100	$25,700	$5,900	$40,700	$39,628	$1,072
Garage	884	$2,300	$6,700	$3,400	$12,400	$10,201	$2,199
Total	21,012	$55,700	$158,000	$42,200	$255,900	$242,478	$13,422
Percent		21.8%	61.7%	16.5%	100.0%		5.2%

Assumptions:
District Heating Unit Cost: 11.54 $/mmbtu (no escalation)

***** COOLING *****

Customer Name	Load (tonhr)	Capital ($)	Fuel ($)	O&M ($)	Total ($)	District Cooling Total ($)	District Cooling Savings ($)
		[-- Components of On-Site Cooling Cost --]				[District Cooling]	
Locomotive Shop	0	$0	$0	$0	$0	$0	$0
Office/ Storage I	79,200	$19,900	$7,100	$10,100	$37,100	$27,720	$9,380
Main of Way Building	27,000	$6,800	$2,400	$2,000	$11,200	$9,450	$1,750
Roundhouse	105,000	$26,400	$9,500	$10,900	$46,800	$36,750	$10,050
Oil House	7,800	$2,000	$700	$2,600	$5,300	$2,730	$2,570
Office/ Storage II	39,000	$9,800	$3,500	$5,900	$19,200	$13,650	$5,550
Signal Tower	3,600	$900	$300	$2,600	$3,800	$1,260	$2,540
Station Gift Shop	10,200	$2,600	$900	$3,800	$7,300	$3,570	$3,730
Silk Mill	67,200	$16,900	$6,000	$8,900	$31,800	$23,520	$8,280
Garage	0	$0	$0	$0	$0	$0	$0
Total	339,000	$85,300	$30,400	$46,800	$162,500	$118,650	$43,850
Percent		52.5%	18.7%	28.8%	100.0%		27.0%

Assumptions:
District Cooling Unit Cost: 0.35 $/tonhr (no escalation)

		Capital ($)	Fuel ($)	O&M ($)	Total ($)	District Total ($)	Savings ($)
Total Heating and Cooling		$141,000	$188,400	$89,000	$418,400	$361,128	$57,272
Percent		33.7%	45.0%	21.3%	100.0%		13.7%

Table 4-10

Steamtown District Heating and Cooling Project

ANNUAL COST COMPARISON OF ON-SITE PLANTS VERSUS DISTRICT ENERGY

Option 3: District Energy from the Gas House
with Hot Water Convertors, Electric Chillers & Ice Storage
After Phase 3

Preliminary

***** HEATING *****

Customer Name	Load (mmbtu)	[-- Components of On-Site Heating Cost --] Capital ($)	Fuel ($)	O&M ($)	Total ($)	[District Heating] Total ($)	Savings ($)
Locomotive Shop	4,590	$12,200	$34,200	$7,700	$54,100	$54,070	$30
Office/ Storage I	4,080	$10,800	$30,400	$6,700	$47,900	$48,062	($162)
Main of Way Building	1,394	$3,700	$10,700	$1,300	$15,700	$16,421	($721)
Roundhouse	3,587	$9,500	$26,800	$7,300	$43,600	$42,255	$1,345
Oil House	340	$900	$2,700	$1,700	$5,300	$4,005	$1,295
Office/ Storage II	2,040	$5,400	$15,500	$4,000	$24,900	$24,031	$869
Signal Tower	255	$700	$2,100	$1,700	$4,500	$3,004	$1,496
Station Gift Shop	408	$1,100	$3,200	$2,500	$6,800	$4,806	$1,994
Silk Mill	3,434	$9,100	$25,700	$5,900	$40,700	$40,453	$247
Garage	884	$2,300	$6,700	$3,400	$12,400	$10,414	$1,986
Total	21,012	$55,700	$158,000	$42,200	$255,900	$247,521	$8,379
Percent		21.8%	61.7%	16.5%	100.0%		3.3%

Assumptions:
District Heating Unit Cost: 11.78 $/mmbtu (no escalation)

***** COOLING *****

Customer Name	Load (tonhr)	[-- Components of On-Site Cooling Cost --] Capital ($)	Fuel ($)	O&M ($)	Total ($)	[District Cooling] Total ($)	Savings ($)
Locomotive Shop	0	$0	$0	$0	$0	$0	$0
Office/ Storage I	79,200	$19,900	$7,100	$10,100	$37,100	$28,512	$8,588
Main of Way Building	27,000	$6,800	$2,400	$2,000	$11,200	$9,720	$1,480
Roundhouse	105,000	$26,400	$9,500	$10,900	$46,800	$37,800	$9,000
Oil House	7,800	$2,000	$700	$2,600	$5,300	$2,808	$2,492
Office/ Storage II	39,000	$9,800	$3,500	$5,900	$19,200	$14,040	$5,160
Signal Tower	3,600	$900	$300	$2,600	$3,800	$1,296	$2,504
Station Gift Shop	10,200	$2,600	$900	$3,800	$7,300	$3,672	$3,628
Silk Mill	67,200	$16,900	$6,000	$8,900	$31,800	$24,192	$7,608
Garage	0	$0	$0	$0	$0	$0	$0
Total	339,000	$85,300	$30,400	$46,800	$162,500	$122,040	$40,460
Percent		52.5%	18.7%	28.8%	100.0%		24.9%

Assumptions:
District Cooling Unit Cost: 0.36 $/tonhr (no escalation)

Total Heating and Cooling		$141,000	$188,400	$89,000	$418,400	$369,561	$48,839
Percent		33.7%	45.0%	21.3%	100.0%		11.7%

APPENDIX A

District Cooling Technology Options

APPENDIX A

DISTRICT COOLING TECHNOLOGY OPTIONS

INTRODUCTION

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.

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:

- 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 distribution 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.

- 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.

- 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.

- 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.

APPENDIX B

Distribution System Materials

APPENDIX B

DISTRIBUTION SYSTEM MATERIALS

As part of the study, one task is to develop in conceptual form a layout of distribution piping to link the heating and cooling source and the heating and cooling loads, taking into account the following considerations: thermal load density, interference with underground utilities, type of customers to be served, type of piping design to be used, reliability of supply, supply medium and temperatures.

The system would be of a closed four-pipe design with separate supply and return pipes for heating and cooling water circulated by pumps at the energy plant.

The piping sizes are determined by the heating and cooling loads and the water temperature drop in the system. A large temperature difference between supply and return lines minimizes the flow rate of circulating water, the piping size and the pumping power. The piping system for the district heating system is designed for a peak supply temperature of 200 F and a return temperature of 140 F. The piping system for the central cooling system is designed for a supply temperature of 43 F and a return temperature 58 F.

The underground carbon steel piping for the heating system should be physically protected against outside water contact. Equally important, the pipe insulation must be protected from moisture penetration that would increase the thermal conductivity of the insulation. The insulation must also be protected against mechanical abuse, ultraviolet degradation, erosion and other environmental hazards. If polyurethane foam insulation is used it must be protected against mechanical damage from weathering, handling abuse, field bending, casing pressures, water pressure, saddle-bearing forces, ground movement and damage in storage. The most economic and reliable method for providing the piping system with protection against the above problems is to use a shop-fabricated conduit design with a polyethylene casing.

Polyurethane foam is preferred because of its low thermal conductivity which provides excellent efficiency for the conduit system. During manufacture of the conduit, the foam is poured between the carrier pipe and the casing in liquid form and expands to occupy the space between the carrier pipe and the casing. The foam bonds itself to the pipe and casing walls, providing a structurally stable insulation that will not shift, settle or shrink with time to create voids.

The prefabricated conduit is installed by butt-welding the carrier pipe sections together. A steel fitting coated with a thick layer of polyethylene is bolted around the joint. Polyurethane is then poured through holes in the fitting to insulate the joint.

The conduit is manufactured and shipped to the field in lengths of 40 to 80 feet. All fittings and valves are also preinsulated and shipped in the form of a finished conduit section.

To protect the system and facilitate service, a combined alarm and fault locator system is built into the conduit during manufacture. The alarm system consists of two wires molded into the foam insulation during manufacture of the conduit. As the conduit sections are installed, the wires are connected, forming a continuous circuit through the piping system. The copper wires are connected to alarm/control boxes at either central or remote locations. The wires carry a low voltage current. When moisture enters the piping system, it completes the circuit between the wires and triggers an alarm. The alarm system not only detects the leak, but, by measuring resistance, locates the leak.

One alternative for the cooling piping installation is the use of ductile iron piping. A sample specification which addresses the primary requirements of this system and its installation would include:

- Ductile iron pipe shall conform to ANSI/AWWA C151/A21.51
- A minimum thickness class of 51 shall be used
- Primary transmission header piping shall consist of a push-on joint and gasket except as noted
- A concrete thrust block shall be provided at all changes in direction. Mechanical restrained joints shall be used for fittings at such locations.
- Individual building distribution lines shall be fitted with flanged ends and terminate at the buildings inside the foundation wall.
- The pipe shall be laid on a sand bed (minimum of 4 inches) and backfilled with select material free from rocks and foreign material.

Of course employment of prefabricated piping systems, such as the ones described for the heating system, is also available for chilled water distribution.