ENERGY CONSERVATION

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COO-4979-1(Vol.2)

DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES THROUGH POWER-PLANT RETROFIT AND DISTRIBUTION NETWORK

Final Report, Volume 2. Tasks 1–3

By
James R. Watt
George A. Sommerfield

August 1979

Work Performed Under Contract No. EM-78-C-02-4979

Toledo Edison Company
Toledo, Ohio

MASTER

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

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DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES THROUGH POWER PLANT RETROFIT AND DISTRIBUTION NETWORK

Task 1
Demonstration Team

James R. Watt
George Sommerfield

Toledo Edison Company
Toledo, Ohio

October 1978
Revised August 1979

Prepared for
THE U.S. DEPARTMENT OF ENERGY
UNDER CONTRACT No. EM-78-C-02-4979

3.1 TASK 1 - DEMONSTRATION TEAM

ABSTRACT

3.1.1 Task Deliverables

A detailed list of each member organization of the Demonstration Team, their staff members, qualifications, and experience.

3.1.1 List Demonstration Team Members

Toledo Edison Company (the Company) is the project manager for the Demonstration Team. As such, the Company organized a Demonstration Team representing the technical competence and community involvement required to conclude a successful Demonstration Project.

Members of the Demonstration Team and their basic areas of responsibilities are as follows:

Toledo Edison Company - Project Manager
Battelle Columbus Laboratories - Marketing, Institutional and Economic Issues
Stone & Webster Engineering Corp. - Cogeneration Retrofit and Distribution Network
Ohio Department of Energy - Review and Advise
Public Utilities Commission of Ohio - Review and Advise
Toledo Metropolitan Area Council of Governments - Review and Advise

Specific persons and their qualifications are documented in the body of the Task 1 report.

3.1.2 Task Deliverables

List all issues affecting the work program, the individuals that will deal with each issue, their organizational affiliation, and their background that qualifies them to deal with the issues assigned.

3.1.2 Work Program

The following pages indicate the organization of work, personnel responsibility, allocation of time and resources by task, and the summary work plan. The reader is invited to read the text of 3.1.2 in the report for further details.

3.1.3 Task Deliverables

List parties of interest, process developed to involve each, role each will play, extent of commitment of each party, and documentation of their commitment.

3.1.3 Parties of Interest

Parties of interest have been divided into two broad categories, local and state. The identification of these parties and the process for involvement in the project will be done at a local level by the Toledo Metropolitan Area Council of Governments (TMACOG), and on a state level by the Ohio Department of Energy (ODOE).

TMACOG was a successful proposer to RFP-78-4299. The project develops a Comprehensive Community Energy Management Plan (CCEMP). An integral part of that project is to identify new sources of energy and involve local parties of interest. To that end, TMACOG organized an Energy Guidance Group, made up of a cross section of interested citizens in the area. The Energy Guidance Group has extended the use of their monthly meetings as a forum for Toledo Edison to apprise interested parties on the progress of the Phase 1 effort.

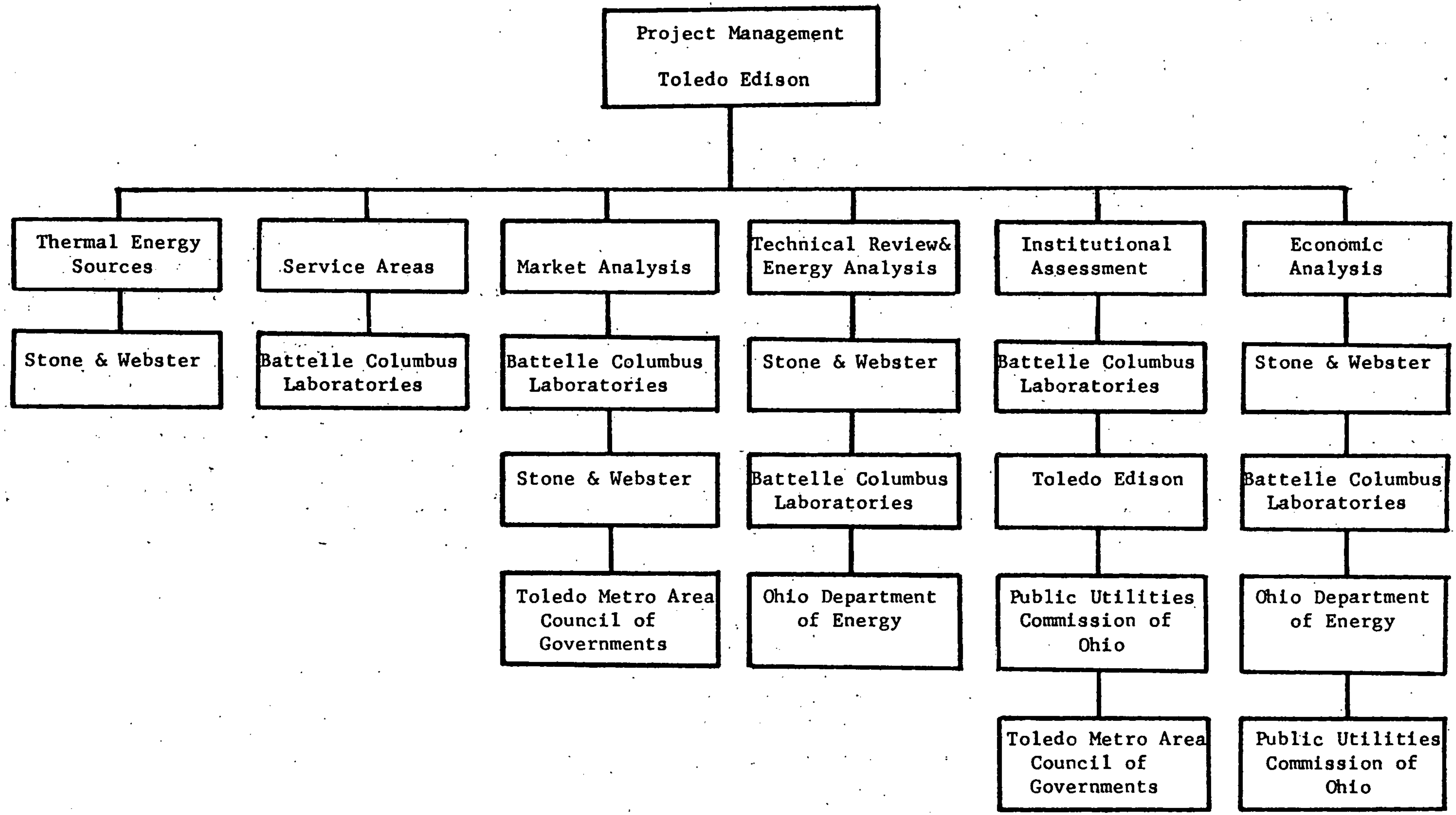
At the state level, ODOE formed a nine-member committee consisting of representatives of other key state organizations. These organizations are listed below.

Ohio Department of Energy
Department of Natural Resources
Department of Agriculture
Environmental Protection Agency
Department of Transportation
Department of Commerce
Department of Economic and Community Development
Ohio Board of Regents
Ohio Agricultural Research & Development Center

TC 1A/44-46

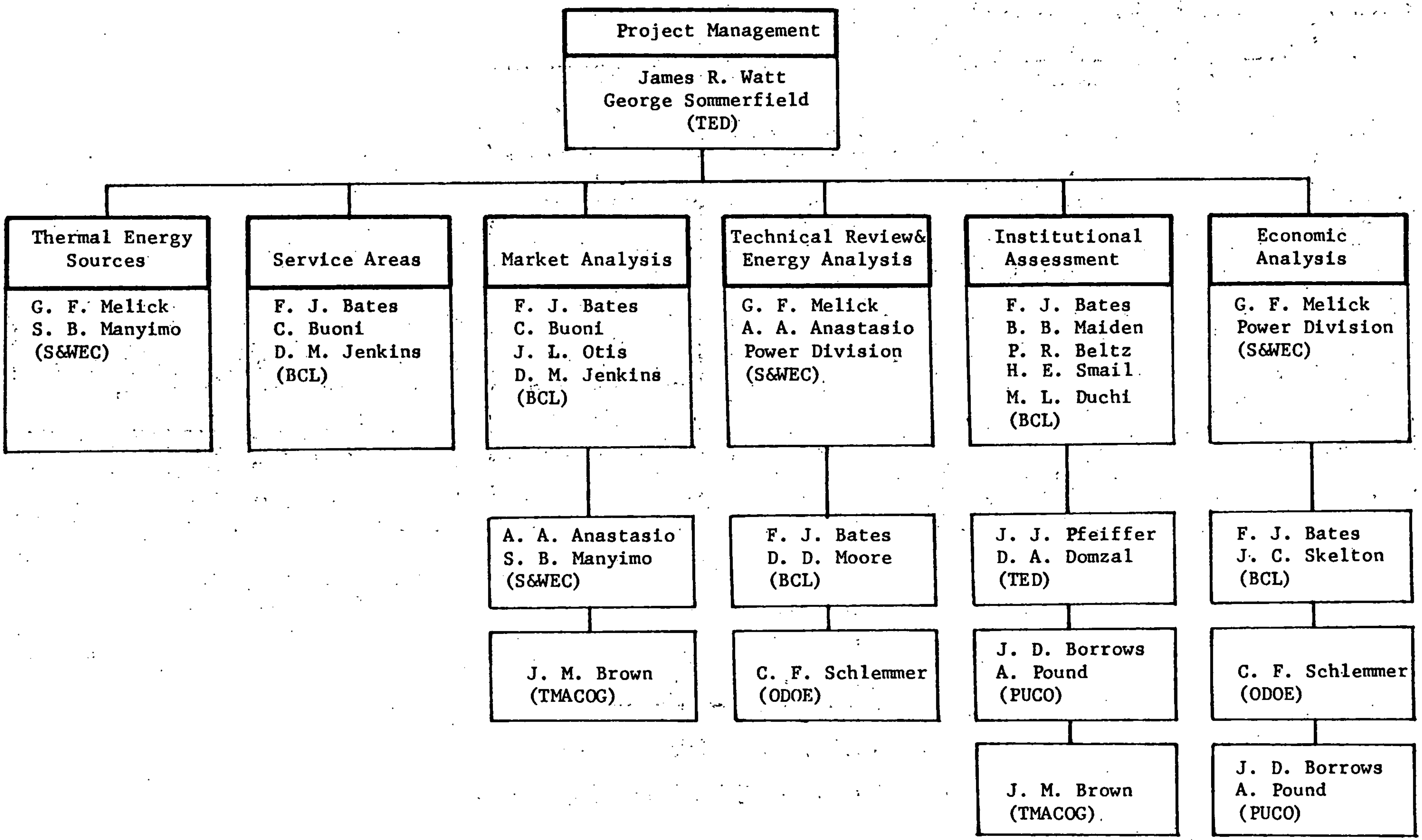
PHASE 1 DISTRICT HEATING & COOLING PROJECT

DEMONSTRATION TEAM ORGANIZATION CHART



PHASE 1 DISTRICT HEATING & COOLING PROJECT

DEMONSTRATION TEAM PERSONNEL RESPONSIBILITY



Toledo Edison Company

PHASE 1 DISTRICT HEATING AND COOLING PROJECT

Allocation of Time and Resources

TASK NO.	DESCRIPTION	TOLEDO EDISON		STONE & WEBSTER		BATTELLE COLUMBUS		SCHEDULE DATE	
		MH	COST	MH	COST	MH	COST	START	STOP
Task 1	Demo. Team Work Management Plan	400	$ 8,000	56	$ 1,816	20	$ 1,100	9/1	12/18
1.1	Organize Team	100	2,000	56	1,816	20	1,100	9/1	9/15
1.2	Identify Issues, Assign Duties	100	2,000	--		--		9/1	9/15
1.3	Involve Parties of Interest	50	1,000	--		--		9/1	10/12
1.4	Propose Subsequent Team	50	1,000	--		--		9/1	5/18
	Task Report	100	2,000	--		--		9/11	12/18
Task 2	Identify Source & Service Area	107	2,140	306	9,926	152	4,210	9/1	1/24
2.1	Identify Plants	20	400	306	9,926	--		9/1	11/14
2.2	Identify Service Area	20	400	--		52	1,320	9/1	1/5
2.3	Survey Building Types	35	700	--		100	2,890	9/1	1/5
	Task Report	32	640	--		--		10/19	1/24
Task 3	Energy Market Analysis	173	3,460	195	6,325	944	42,670	9/1	2/28
3.1	Evaluate Market & Assess	30	600	48	1,557	208	7,690	9/1	1/26
3.2	Establish Supply Conditions	30	600	48	1,557	200	7,690	9/1	1/5
3.3	Evaluate Fuel Switching	24	480	59	1,914	252	12,960	1/5	2/28
3.4	Identify Generic Nature of Market	16	320	40	1,297	284	14,330	1/5	2/28
	Task Report	73	1,460	--		--		2/21	3/15
Task 4	Technical Review	107	2,140	1470	47,682	220	14,202	10/9	3/23
4.1	Assess Retrofit Schemes	--		200	6,487	--		10/9	3/23
4.2	Assess Alternatives	--		200	6,487	--		10/9	3/23
4.3	Assess Modes of Operation	--		200	6,487	--		11/20	3/23
4.4	Evaluate Effects on Plant Oper.	15	300	200	6,487	--		11/20	3/23
4.5	Determine Effects on Capacity	15	300	200	6,487	60	3,301	11/20	3/23
4.6	Develop Distribution Schemes	--		200	6,487	--		11/3	3/23
4.7	Evaluate Heat Storage	--		70	2,273	--		12/4	3/23
4.8	Assess Scarce Fuel Savings	--		200	6,487	160	10,901	12/4	3/30
	Task Report	77	1,540	--		--		1/12	4/30
Task 5	Institutional Assessment	300	9,000	--		1244	57,507	9/12	3/12
5.1	Effects of Regulation	--		--		204	9,953	9/25	2/19
5.2	Utility Arrangements	100	2,000	--		292	14,387	9/25	2/28
5.3	Easements, Franchises	40	2,800	--		--		10/9	1/31
5.4	State and Local Taxes	--		--		184	8,303	9/25	2/28
5.5	Mandate to Serve	10	700	--		--		10/9	1/31
5.6	Environmental Regulations	--		--		220	10,372	9/25	2/28
5.7	Siting and Zoning Laws	--		--		256	10,432	9/25	2/28
5.8	Review Corporate Charter	10	700	--		--		10/9	1/31
5.9	Develop Schedule of Approvals	40	800	--		88	4,060	2/21	2/28
	Task Report	100	2,000	--		--		3/9	4/2
Task 6	Preliminary Economic Analysis	95	1,900	575	18,651	396	14,163	12/1	4/10
6.1	Economic Sensitivity Display	10	200	300	9,731	76	2,446	1/12	4/10
6.2	Assess Impacts	10	200	275	8,920	68	2,338	1/12	4/10
6.3	Estimate Revenue	--		--		120	4,649	12/1	4/10
6.4	Assess Impact of Project	10	200	--		132	4,730	12/1	4/10
	Task Report	65	1,300	--		--		2/14	5/4
Task 7	Proposal for Further Work	132	2,640	180	5,840	100	5,390	2/5	5/18
7.1	Reevaluate Demonstration Team	20	400	--		32	1,760	2/5	5/18
7.2	Proposal for Further Work	112	2,240	180	5,840	68	3,630	2/5	5/18
Task 8	Letters of Coop., Commitment	40	800	--		--		12/19	5/18
8.1	Obtain Letters of Commitment	20	400	--		--		2/19	2/2
	a. Major End-Users								
	b. Local Government Involved								
8.2	Obtain Letters of Commitment	20	400	--		--		2/19	5/11
	a. Members of Demo. Team								
	b. Utilities Affected								
Task 9	Detailed Work Management Plan	120	2,400	200	6,487	292	15,758	5/7	5/18
9.1	Provide Work Management Plan	50	1,000	200	6,487	292	15,758	5/7	5/18
	a. Individual Work Packages								
	b. PERT Charts, etc.								
	c. Milestone Chart								
	d. Cost Breakdown								
9.2	Provide Organizational Plan	50	1,000	--		--		5/7	5/18
	a. Organizational Chart								
	b. Responsible Individuals								
	c. Manpower and Resources								
	d. Qual. & Level of Effort								
	Task Report	20	400	--		--		5/7	5/18
Final Report		80	1,520	100	3,244			5/7	5/18
Total Phase 1 Effort		1554	$34,000	3082	$99,971	3368	$155,000		

PHASE 1 DISTRICT HEATING & COOLING PROJECT

Summary Work Plan

Task Description	September	October	November	December	January	February	March	April	May	June	July
TASK 1 Organize Demonstration Team	▬▬	▬▬						▬▬	▬▬		
TASK 2 Identify Thermal Energy Sources and Service Areas	▬▬	▬▬	▬▬	▬▬	▬▬						
TASK 3 Energy Market Analysis	▬▬	▬▬	▬▬	▬▬	▬▬	▬▬	▬▬				
TASK 4 Technical Assessment and Review		▬▬	▬▬	▬▬	▬▬	▬▬	▬▬	▬▬			
TASK 5 Institutional Assessment	▬▬	▬▬	▬▬	▬▬	▬▬	▬▬	▬▬	▬▬			
TASK 6 Preliminary Economic Analysis				▬▬	▬▬	▬▬	▬▬	▬▬	▬▬		
TASK 7 Proposal for Further Work						▬▬	▬▬	▬▬	▬▬		
TASK 8 Letters of Cooperation and Commitment				▬▬	▬▬	▬▬	▬▬	▬▬	▬▬		
TASK 9 Detailed Work Management Plan									▬▬		
Detailed Work Management Plan	26	5		18							
Oral Presentation										X	
Team Meetings		19		5	26	21		20	18		
Monthly Reports	25	25	25	25	25	25	25	25	25		
Task Reports		(1)			(2)		(3)	(5)	(4) (6) (7)		
Final Report									31		

April 18, 1979

Numbers indicate date submitted except for Task Reports.
Task Report submittals are identified by Task Number.

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3.1 Task 1 - Demonstration Team

Toledo Edison Company (the Company) is the project manager for the Demonstration Program. As such, the Company has organized a Demonstration Team representing the technical competence and the community involvement required to build the broad base of support that will be necessary to conclude a successful Demonstration Program. The Company is confident that the Demonstration Team has the inherent expertise to evaluate the technical, legal, economic, and marketing issues related to the utilization of by-product heat from power generation to supply district heating and cooling services. Members of the team are as follows:

Toledo Edison Company
Battelle Columbus Laboratories
Stone & Webster Engineering Corporation
Ohio Department of Energy
Public Utilities Commission of Ohio
Toledo Metropolitan Area Council of Governments

The Demonstration Team includes members possessing outstanding technical and institutional backgrounds. Battelle Columbus Laboratories will address the institutional, economic, and marketing issues. Stone & Webster Engineering Corporation will identify and evaluate the thermal supply schemes. Each of these firms has demonstrated considerable expertise in their respective areas.

The Ohio Department of Energy, the Public Utilities Commission of Ohio, and the Toledo Metropolitan Area Council of Governments will advise the Demonstration Team in the critical areas of institutional coordination and public commitment. The Ohio Department of Energy will provide a means to obtain resources available from the State and its agencies to assist the Demonstration Team. As the results of the Demonstration

Program develop, there is an expressed interest from the Ohio Department of Energy that it may want to commit both time and money to Phases 2 and 3. The Public Utilities Commission of Ohio and the Toledo Metropolitan Area Council of Governments have pledged to assist the principal investigators as the Demonstration Program moves from the conceptual stage to the detailed feasibility stage. The Demonstration Team Organization is pictured on the next page.

3.1.1 Members of the Demonstration Team

3.1.1A Toledo Edison Company

Toledo Edison Company serves an area of 2500 square miles in Northwestern Ohio with electric energy. The number of retail customers has increased to over 257,000 in all customer classes. Nearly 7.5 billion kilowatt hours resulted in 1977 revenue of nearly $277 million. Approximately 46% of this energy is used in the industrial sector. Because of the strong base of industrial loads the annual load factor in 1977 was 66%. Summer peak loads are still experienced although the recent dependence on electric heating in all sectors of our customer mix may change that fact. The 1978 summer peak was 1423 MW.

Over the last 75 years the prime activity of the Toledo Edison Company has been the electric power business. However, in two communities Toledo Edison Company distributes natural gas, which results in less than $3 million in annual revenue. In addition, for the past 50 years, the sale of district heating steam has provided a source of thermal energy to the central business district in Toledo. Approximately $2.3 million in revenue resulted from this district heating operation in 1977.

DEMONSTRATION TEAM ORGANIZATION

TOLEDO EDSION COMPANY

CORPORATE DEVELOPMENT MISSION
JAMES R. WATT, R&D DIRECTOR, PROJECT MANAGER
GEORGE A. SOMMERFIELD, ASSISTANT PROJECT MANAGER

STONE & WEBSTER ENGINEERING CORP.

ANDREW A. ANASTASIO, STUDY MANAGER
GEORGE F. MELICK, JR.,CONSULTANT

BATTELLE COLUMBUS LABORATORIES

F. JERE BATES, STUDY MANAGER
DAVID D. MOORE, CONSULTANT

PUBLIC UTILITIES COMMISSION OF OHIO

JOHN D. BORROWS, DIRECTOR
DEPARTMENT OF UTILITIES

OHIO DEPARTMENT OF ENERGY

CHRIS F. SCHLEMMER,
ENERGY ANALYST

TOLEDO METROPOLITAN AREA COUNCIL OF GOVERNMENTS

CALVIN M. LAKIN,
EXECUTIVE DIRECTOR

JUNE M. BROWN,
ASSOCIATE DIRECTOR,
ENVIRONMENTAL AFFAIRS

The experience and expertise of Toledo Edison Company as an electric utility operating large power plants and distributing energy in its service area is an important asset to this project. The ability to forecast system loads, develop expansion plans, complete complex construction programs on a timely basis, and market the services provided are all activities within the corporate experience.

The Corporate Development Mission includes the planning and research functions of Toledo Edison Company. The specific experience of the Research and Development Division is relevant to the subject proposal and will be utilized. Load surveys, load management studies, and the development of complex computer models for evaluating changing load patterns have been primary outputs of this group. Two studies supported by the Federal Energy Administration are noted below:

Development of an Industrial Load Simulation Model

In a typical Ohio utility system, industrial load is the largest, most concentrated component of the total electric consumption. The overall impact of altering the use patterns of major industrial customers must be evaluated prior to implementing incentives to encourage customers to shift their loads. A computer model was developed by Toledo Edison in cooperation with the Public Utilities Commission of Ohio and the Federal Energy Administration to simulate changes in industrial use patterns and to determine the economic impact of those changes in serving the aggregate system load.

Demonstration of an Economical Energy Storage System

This study demonstrated a heat storage system to supply supplemental heat, as required, by a heat pump during system peak load hours. Electrohydronic storage systems were installed on three residential heat pumps. Energy consumption of these custom designed systems were compared to three heat pump installations with supplemental resistance heating elements. Toledo Edison Company completed this project under a cooperative agreement with the Public Utilities Commission of Ohio and the Federal Energy Administration.

Toledo Edison Company is the project manager of the Demonstration Program. In this rôle they will direct and coordinate the activities of the Demonstration Team. The leadership exercised by Toledo Edison Company through its Corporate Development Staff will result in the timely completion of this study including the reports and other deliverables requested by the Department of Energy.

The personal resumes of the key personnel are provided in the following pages.

JAMES R. WATT PROJECT MANAGER

EDUCATION

Toledo University - B.S. Electrical Engineering, Cum Laude, 1956.

LICENSES AND REGISTRATIONS

Professional Engineer - Ohio

PROFESSIONAL AFFILIATIONS

Eta Kappa Nu - Electrical Engineering Honor Society - Member
Tau Beta Pi - Engineering Honor Society - Member
American Society of Heating, Refrigeration, & Air Conditioning Engineers - Member

PUBLICATIONS

"Heat Reclaim, Variable Volume Air Serve New Office", Heating Piping and Air Conditioning, April, 1972.

EXPERIENCE SUMMARY

Mr. Watt is presently Director of Research and Development Division at Toledo Edison and has directed and participated in a number of studies of alternate energy sources. Included are two studies on alternatives for the downtown Toledo heating system and one cogeneration study. Mr. Watt was primarily responsible for the direction of these efforts in addition to determining heat balances and optimization of thermal cycles.

Mr. Watt is also responsible for customer load surveys utilizing magnetic tape recording meters. Load management by various schemes such as radio and ripple control are also his responsibility. His department recently completed two stages of a cooperative agreement with the Public Utilities Commission of Ohio and the Federal Energy Administration entitled, "An Industrial Load Simulation Model" and "Demonstration of an Economic Energy Storage System".

As Manager of Technical and Support Services prior to his present assignment, Mr. Watt provided technical assistance to the Customer Services Section. He served as the special consultant to the Toledo school system on heating and energy conservation during the construction of nine new schools. He was the Company's liaison with the designers of the mechanical system of the 17-story Edison Plaza. He served on the University of Toledo advisory board for curriculum at the two-year community college. He has many years of experience in all aspects of space conditioning. His prior work experience in the pneumatic temperature control industry and the additional marketing experience as Power Engineer at Toledo Edison round out a sound background in the energy field.

RECENT EXPERIENCE RECORD

Toledo Edison Company - Toledo, Ohio

1976 to date	Appointed Director of Research & Development Division Duties included are administration of all the Company's Research & Development efforts and direction and participation in special projects such as solar assisted hot water installations, the Toledo Edison-FEA-PUCO Cooperative Agreement, cogeneration studies, and other studies of alternative energy systems. Load Management and Load Survey Section are a part of Research & Development Division.
1966 to 1976	Appointed Manager of Technical and Support Services (Prior to 1976, known as Technical Services) Responsibilities included lending technical assistance to Marketing group; maintaining liaison between Company,

architectural and engineering firms, and public authorities such as the University of Toledo. Conceived and implemented load survey metering, translation and associated computer programs.

1962 to 1966 Appointed to Senior Power Engineer

Joined Toledo Edison on 1972 as Power Engineer and appointed to Senior Power Engineer soon after. Duties included advisory capacity on utility matters to industrial customers.

JOHNSON SERVICE COMPANY - MILWAUKEE, WISCONSIN

1960 to 1962 Sales Engineer, Louisville Office

Bid, designed, supervised installation of pneumatic control systems on industrial processes, commercial space conditioning equipment and systems.

1956 to 1959 Sales Engineer, Akron Office

Bid, designed, supervised installation of pneumatic control systems on industrial processes, commercial space conditioning equipment and systems.

GENERAL ELECTRIC COMPANY - ERIE, PENNSYLVANIA

1959 to 1960 Design Engineer, Variable Speed Drives

Designed and tested rotary and static AC to DC conversion and associated controls for metal working industry Designed wire drawing drive for final professional engineer's requirement.

GEORGE A. SOMMERFIELD | ASSISTANT PROJECT MANAGER

EDUCATION

University of Toledo - M.S. in Industrial Engineering - 1974
University of Toledo - B.S. in Electrical Engineering - 1969

HONORS

Tau Beta Pi - Engineering Honorary Society - Member
Eta Kappa Nu - Electrical Engineering Honorary Society - Member

REGISTRATIONS

Engineer-in-Training - Ohio

PROFESSIONAL AFFILIATIONS

Institute of Electrical and Electronic Engineers - Member
Power Engineering Society - Toledo Chapter Chairman
National Management Association - Member

PUBLICATIONS

"Forecasting Load Growth", Transmission and Distribution, October, 1974.

EXPERIENCE SUMMARY

George Sommerfield joined Toledo Edison Company in January, 1970, as an Assistant Engineer in Distribution Engineering. He progressed to the positions of Senior Assistant Engineer in July of 1972 and Associate Engineer in March of 1975. George was responsible for planning the expansion of the distribution system and preparing the appropriate construction budget items. In October, 1975, he was promoted to the position of Research and Development Engineer and subsequently to his present position of Research Projects Manager. His present duties include organizing Toledo Edison Company's Research & Development program, maintaining liaison with research projects sponsored by the Electric Power Research Institute, and managing in-house research programs.

Other Toledo Edison Company Support

Various engineers and technical people from the utility's staff will be utilized from time to time to review the alternative thermal energy system concepts. Plant operating personnel will have an input to the technical and economic assessment of the various proposed engineering alternatives. Similarly, marketing services personnel will aid the marketing and economic consultant in conducting analyses of the present and future market for a thermal energy system in each service area being considered. Distribution Engineering personnel will review the impact of thermal energy systems on the electrical distribution expansion plans for these proposed service areas.

3.1.1B Battelle Columbus Laboratories

Battelle Columbus Laboratories is one of two principal subcontractors selected by Toledo Edison Company for the Demonstration Team. Their activities will primarily involve the marketing and institutional assessments required in the Phase 1. Their role is especially significant in Phase 1 and they intend to continue to support Toledo Edison Company through Phases 2 and 3 as the detailed analysis continues to determine the best candidate demonstration system configuration. They will report to Toledo Edison and will exchange information with the engineering consultant, Stone & Webster in developing the detailed reports for each task.

Battelle's expertise will be utilized to identify and define the market potential district heating and cooling systems within candidate service areas. They will evaluate the impact of alternative energy supply schemes on the future consumption of electrical energy and scarce fossil fuels. Institutional arrangements, taxes, environmental regulations, revenue forecasts, and economic analyses are other responsibilities of Battelle. After the preliminary evaluation is completed, Battelle will assist in the formulation of the detailed proposal required to continue the Demonstration Program.

Battelle Columbus Laboratories is the original research center of Battelle Memorial Institute, a nonprofit, public-purpose organization which performs research under contract for both government and industry. The Columbus staff totals about 2,600, of whom about half hold academic degrees and about one-quarter hold advanced degrees. The research staff includes scientists, engineers, and economists representing practically every technical discipline. They average about 13 years of research experience per person.

Battelle Columbus has a technical organization which does not confine a research program within a single group or department. Any person on the staff can work on any research program that requires his specific expertise. The flexibility is of particular importance to this Demonstration Program because the problems are broad and often complex and they fall in many technical areas. Thus, a multidisciplinary approach helps in problem solving. Whatever the nature of the research problem, Battelle's technical breadth makes it practical to assemble the required research team.

Toledo Edison Company believes that Battelle has the relevant experience and expertise to accomplish the marketing, institutional, and economic assessments required. Two projects particularly relevant to the Demonstration Program are summarized as follows:

Markets for Waste to Energy Systems - Industrial Sponsors

In 1973, Battelle researchers conducted a comprehensive market survey for an industrial sponsor on the diverse markets for municipal "waste to energy" systems. As with any developing technology, no single system dominates the market and a stated objective of this program was to closely evaluate each competing system. Many interviews were conducted with decision makers from cities across the nation to learn their reactions and/or biases to the competing systems. Based on this market research coupled with detailed technical economic evaluations of the major systems, Battelle was able to recommend the specific strategies needed to enter this new business.

An Analysis of Waste to Energy District Heating & Cooling Systems - Industrial Sponsor

This study identified and evaluated relevant factors (institutional, social, economic, environmental, and technical) needed to aid the sponsor in formulating a business strategy to capitalize upon developments in the municipal waste-to-energy-systems market. Special emphasis was placed on factors directly associated with District Heating and Cooling Systems.

Telephone conversations were held with one to four people in each of the 153 largest cities with populations exceeding 100,000. This was supplemented by trips to thirty (30) cities throughout the U.S.

In depth, one-to-two-hour interviews were held with two to four people in each city.

Sixteen (16) Favorable Supply Aspects of Waste to Energy Systems and eleven (11) Favorable Demand Aspects of District Steam and Chilled Water Systems were identified and analyzed. As a result, a "General" Organization Strategy and twelve (12) "Local" Organization Considerations and Tactics were suggested as company marketing initiatives.

Resumes for key personnel of Battelle Columbus Laboratories follow.

F. JERE BATES

STUDY MANAGER

EDUCATION

Franklin and Marshall College - B.A. in Economics, 1965
Lehigh University - M.S. in Economics, 1972

PROFESSIONAL AFFILIATIONS

National Association of Business Economists
Omicron Delta Epsilon - Honor Society
Beta Gamma Sigma - Honor Society

EXPERIENCE SUMMARY

At Battelle, Mr. Bates has been engaged in projects which include electric utility load forecasting, regional energy studies, and energy marketing analysis. His economic analysis and accounting background enable him to bring specific expertise to these studies.

Mr. Bates has worked in both the industrial and utility sectors of the business community. His experience with an electric utility includes expansion planning and electric demand and energy forecasting. His responsibilities of Supervisor of Load Analysis included forecasting of kilowatthour sales, customers, and revenues by rate class and forecasting of peak loads.

In conjunction with the above duties, Mr. Bates represented his company on a planning committee of an integrated power pool. During this period he chaired the committee which conducted several regional research studies to identify the weather component which contributes to the peak electric demand.

RECENT EXPERIENCE RECORD

Battelle Columbus Laboratories - Columbus, Ohio

1977 to date — Utility Economist, Economics and Management Systems.

Mr. Bates is engaged in electric utility and other energy fields research. Examples of his experience are:

Electric Utility Load Forecasting. Mr. Bates is engaged in the development of forecasting methods and forecasts of electricity loads. The Battelle model, SHAPES - Systems for Hourly and Annual Peak and Energy Simulation, incorporates and endogenous regional economic/demographic sector and explicitly treats over 40 electric end-use categories of electric consumption including a projection of daily load curves by month, day of the week, and weather conditions.

Regional Energy Studies. The development of alternative regional long-range energy consumption patterns is currently being directed by Mr. Bates. The consumption patterns and forecasts are being developed by energy type within all consuming sectors.

Market Potential Analyses. Mr. Bates is a major participant in the preparation of economic comparisons of alternative energy sources. He has developed energy source selection criteria that impact on energy station design and market potential.

General Public Utilities Service Corporation - Reading, Pennsylvania

1971 to 1977	Planning and Economics Division	
		Wide-ranging experience including short and long-term analysis of fuel availability and price, analysis of fixed charges, and economic evaluation of alternative capital investment proposals. Direction of load forecasting and analysis as Supervisor - Load Analysis. GPU representative on, and served as chairman of, the Load Analysis Subcommittee of the PJM Interconnection (electric power pool).

Metropolitan Edison Company - Reading, Pennsylvania

1969 to 1971	Assistant to the Director of Pensions	
		All aspects of pensions activities were undertaken as well as other personnel-related activities.
1967 to 1969	Internal Auditor	
		Responsibility of conducting audits in all phases of electric utility operations.

DAVID D. MOORE — CONSULTANT

EDUCATION

Missouri School of Miners
University of Missouri - B.S. in Chemical Engineering
University of California - The Executive Program

LICENSES AND REGISTRATIONS

Professional Engineer - Ohio

PROFESSIONAL AFFILIATIONS

American Petroleum Institute
American Chemical Society
National Association of Business Economists

SELECTED PUBLICATIONS

"Support Systems for Northern Communities", Fourth National Northern Development Conference - Edmonton, Alberta - November, 1967.

Coauthor with Nelson, H. W., "Outlook for Fuels as Sources of Energy", Sixth Pitt Conference on Business Prospects - Pittsburgh, Pennsylvania - 1959.

EXPERIENCE SUMMARY

Mr. Moore is presently Research Leader, Energy and Environmental Systems Analysis, primarily responsible for providing technical leadership in energy economics and systems analysis. Since returning to active research in 1971 he has conducted a wide variety of studies for both the Federal Government and private industry involving energy economics, long-range cost and availability of various forms of energy, supply-demand relationships, environmental implication involved in the recovery and utilization of various types of energy, alternative energy systems, electric power reliability, and energy transportation costs.

He is presently engaged in the management of a study of alternative energy systems to improve conservation and reduce requirements of oil and gas at selected military installations. Other recent studies in which he was a participant include: "Alternative Fuels and Power Supplies for a Major Industrial Complex", "Reliability of Electric for Selected Utility Systems, 1977-1986", "Federal Incentives Used to Stimulate Energy Production", and "Development of an Economics Model for Oil Shale and Synthetic Fuels".

As manager of the Economics and Information Research Department he was responsible for the development and execution of a wide range of research activities in socioeconomics, technical economics and information analysis. Prior to that time he spent several years in energy economics, energy systems research, and in petroleum refining operations.

Mr. Moore is a member of the Newcomers Society and is listed in American Men of Science, Who's Who in Commerce and Industry, and Who's Who in the Midwest.

RECENT EXPERIENCE RECORD

Battelle Columbus Laboratories - Columbus, Ohio

1975 to date	Research Leader, Energy and Environmental Systems Analysis Duties are to provide technical leadership in Energy Systems Analysis involving energy-environmental/economic trade-offs, energy availability and costs and synthetic fuels technical/economic analysis.

1974 to 1975 Manager, Energy Systems and Economics Research Section

This was a one-year appointment to organize a new section and develop plans for growth in research activities in Energy Systems Analysis.

1971 to 1974 Senior Research, Technical & Business Planning Research Dept.

This assignment involved developing and executing research assignments in business planning and technical economic research primarily in the field of energy for government agencies and industrial firms.

1970 to 1971 Assistant Director, Battelle Columbus Laboratories

Responsibilities included various planning activities for the Battelle Columbus Laboratories and overall Management of Communications and Public Relations.

1957 to 1970 Manager, Economics and Information Research Department

Responsibilities included overall management of research activities in Socioeconomics, Technical Economics, and Information Research. Member of General Management Committee.

1953 to 1957 Chief, Technical Economics Division

Responsibilities involved management and direction of research in technical economics and business planning.

1950 to 1953 Assistant Chief, Technical Economics Division

Responsible for technical economic research, energy economics and in process and related industries.

OTHER BATTELLE COLUMBUS LABORATORIES SUPPORT

The following are brief biographical sketches of Battelle's Subtask Leaders:

CORINNE M. BUONI (Analyst - Energy and Environmental Systems Assessment Section). M.S., Natural Resource Allocation and Management, The Ohio State University.

Ms. Buoni recently joined Battelle as an energy analyst. She was previously the Chief of Energy Conservation Program Development with the Ohio Department of Energy. In this capacity she was responsible for the development and implementation of the State Energy Conservation Plan, the development of energy conservation guidelines for state government agencies, the preparation of environmental impact statements, and the development of an approach for assuring adoption of an energy conservation building code for the state.

BENJAMIN G. MAIDEN (Principal Researcher - Community, Regional, and Environmental Planning Section). M.S., Water Resource Development, The Ohio State University; PhD, Resource Analysis, the Ohio State University (In Process).

Mr. Maiden has focused his efforts on programs dealing with energy/environmental policy analysis and implementation program development. He has had a leadership role on programs dealing with policy analysis relative to water resource management, land use planning, solid waste/resource recovery planning, and energy development. Many of these programs involved the formulation of policy options and implementation alternatives to deal with emergent energy and environmental problems. For example, he was involved with an analysis of the impact of the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500 (including consequent EPA regulations) on existing institutions in the Great Lakes Region. This study included preparing recommendations concerning alternative implementation strategies to handle the problems that were identified. In another recent study, Mr. Maiden looked at institutional barriers to the development of solar energy for industrial use. This study analyzed incentives and disincentives that are currently being employed by the Federal government, and suggested new approaches to foster solar energy development in industry.

JOHN C. SKELTON (Systems Analyst - Economics, Planning and Policy Analysis Section). MBA, Managerial Economics and Financial Analysis, Cornell University; M. Engr., Operations Research/Industrial Engineering, Cornell University.

Mr. Skelton is primarily interested in applying quantitative and economic analysis to problems found in business. Most recently he developed a computerized financial model analyzing potential private sector energy conservation investments with respect to alternative fuel price, stock market price, and product demand scenarios. Other projects include the economic feasibility of fusion technology for industrial process heat, applications of psychometrics to consumer marketing, and development of corporate models integrating on a cost basis all components of the manufacturing function.

3.1.1C Stone & Webster Engineering Corporation

Stone & Webster is the other principal subcontractor selected by Toledo Edison to perform specific tasks required in this Demonstration Program. Their role will be primarily involved with engineering aspects of the program. Stone & Webster has the experience and expertise to handle this project throughout all the phases. They will report to Toledo Edison Company and exchange information with Battelle Columbus Laboratories, the other principal subcontractor, in completing each task.

Stone & Webster will identify the plants which have potential for cogeneration, evaluate end user problems, determine distribution system alternatives, and conduct an overall technical review and assessment. Additionally, they will conduct the economic analysis of the installation and operation of all necessary subsystems. The engineering analysis required in the initial phase will be preliminary and conceptual in scope. As the Demonstration Program moves to subsequent phases, the engineering effort will become more detailed and specific to the plants and the service areas identified.

Stone & Webster Engineering Corporation has been organized to supply engineering services since 1889. To date it has been associated with the installation of over 77 million kW of hydro, nuclear, and fossil-fired electric generating facilities. It has also designed and/or constructed over 11,000 miles of transmission lines and associated substations.

The main office for Stone & Webster Engineering Corporation is located in Boston, Massachusetts. Operations centers are located in New York, New York; Denver, Colorado; and Cherry Hill, New Jersey. The Cherry Hill Operations Center, which will support this Demonstration Study, is a full service engineering corporation employing about 1200 people. Of these, about 450 are engineers and 400 are designers. Current projects at this office include three nuclear plants, a coal-fired plant, and numerous special services in support of operating fossil-fired plants and cogeneration facilities.

Stone & Webster has extensive experience and expertise in cogeneration and energy distribution projects. Two projects especially relevant to the Demonstration Program are summarized as follows:

Cogeneration Feasibility Study - Department of Energy

Stone & Webster is currently performing an extensive cogeneration feasibility study utilizing several alternative steam sources. The study is funded by the Department of Energy through Union Carbide, Nuclear Division, at the Oak Ridge National Laboratory. The study considers sites in Orange, Texas; Geismar, Louisiana; Lake Charles, Louisiana; and North Baton Rouge, Louisiana. The study includes conceptual layouts, cost estimates, and technical evaluations of each alternative.

Coal Fired Cogeneration Study - Industrial

Stone & Webster is currently performing a study of replacing the gas and oil fired steam capacity of Monochem, Inc., Borden Chemical, and Uniroyal Chemicals at Geismar, Louisiana, with a central coal fired generation plant. The new facility will produce about 1,500,000 lb/hr of process steam at various pressures and generate about 71 MW net of electricity for plant use. The study scope includes conceptual design, capital and operating cost estimates, and a determination of the availability and price of coal.

Personnel having background and experience relevant to particular project areas will be drawn upon from within the Cherry Hill Operations Center organization as their expertise is required. Resumes of key personnel follow.

ANDREW A. ANASTASIO STUDY MANAGER

EDUCATION

Brooklyn Polytechnic Institute - Graduate courses in Mechanical Engineering, 15 credits
Pratt Institute - B.S. in Mechanical Engineering

Training

U.S. Navy - Supervisor Development Institute Course, Basics of Instruction

LICENSES AND REGISTRATIONS

Professional Engineer - New Jersey

EXPERIENCE SUMMARY

Mr. Anastasio joined Stone & Webster in April 1978 as a Project Engineer in the Power Division. He has had 16 years of experience on various fossil and industrial projects as a Mechanical Engineer. His most recent experience was with Paul L. Geiringer and Associates. He was a Project Manager/Engineer involved in the direction and coordination of engineering activities including design, specifications, bid analysis, costing, and scheduling. He was also totally responsible for the liaison and coordination with the client's engineering and operating staffs. These projects included coal, oil, and gas fired units.

RECENT EXPERIENCE RECORD

Stone & Webster Engineering Corporation - Cherry Hill, New Jersey

1978 to date — Appointed Project Engineer for Lignite Reference Fossil Power Plant.

Mr. Anastasio is directing the overall project effort to develop site plans and general arrangement drawings for a 700-800 MW lignite coal fired power plant.

Paul L. Geiringer and Associates - Marlton, New Jersey

1973 to 1978	During this period in his work career, Mr. Anastasio was intimately involved in the design of a coal fired boiler plant for Kraft, Inc., a total energy plant for Harvard Medical School, and many other sizeable projects associated with district heating and cooling systems and electric power generation. Most appropriate for this project is his experience in the design and replacement of the entire hot water district heating system for McGuire Air Force Base and the enlarging of the central heating and cooling distribution system to serve the new educational complex at the Marine Base, Quantico, Virginia.

Davy Powergas - Lakeland, Florida - Paul L. Geiringer and Assoc.

1957 to 1973	Mr. Anastasio was responsible for the design, equipment purchase and cost control of various fossil fueled electric generating plants. Also pertinent to this project is his experience with boiler replacement at Sunmount State School, the expansion of boiler plants and district heating and cooling system for Rutgers University, the design of a central heating and cooling plant and distribution system for at C.W. Post College and the design of a total energy plant for Sears Roebuck and Company Merchandise Center.

GEORGE F. MELICK CONSULTANT

EDUCATION

New York University - M.A. Degree, Historical and Philosophic Foundations of Education
Columbia University - Master of Engineering, Design Project: Steam Condenser Design
Stevens Institute of Technology - M.S. in Mechanical Engineering with Heat Power Option
Princeton University - B.S.E. in Mechanical Engineering

LICENSES AND REGISTRATIONS

Professional Engineer - New Jersey

PROFESSIONAL AFFILIATIONS

American Society of Mechanical Engineers - Member
American Society of Engineering Education - Member
National Society of Professional Engineers - Member
Sigma IX, Pi Tau Sigma, Tau Beta Pi - Member
New Jersey Society of Professional Engineers - Member

SELECTED PUBLICATIONS

"An Assessment of Energy Storage Systems Suitable for Use by Electric Utilities", EPRI EM-264 Project 225 ERDA E(11-1)-2501 Final Report July 1976 (contributed to section on Thermal Energy Storage).

EXPERIENCE SUMMARY

Mr. Melick is a studies specialist and consultant in the Power Division with 31 years of experience in Mechanical Engineering. While employed at Stone & Webster, he has directed and participated in three studies involving energy utilization, conservation, and cogeneration.

In both cogeneration studies Mr. Melick was responsible for development of the thermal cycles, preparation of heat balances, optimization of equipment and piping, and providing assistance to cost estimates.

Before these assignments, Mr. Melick was Study Manager for a study that evaluated various methods of waste heat utilization for generation of electricity at a western phosphorus producing plant.

Prior to joining Stone & Webster Engineering Corporation, Mr. Melick was an engineering educator for 21 years at Rutgers University, Columbia University, and Stevens Institute of Technology. He taught the undergraduate and graduate levels, and directed sponsored research in the application of operations research techniques to the design of steam power plants. At Rutgers, he served as Assistant Dean, Associate Dean, and Acting Dean of the College of Engineering.

RECENT EXPERIENCE RECORD

Stone & Webster Engineering Corporation - Cherry Hill, New Jersey

1977 to date — Appointed Consultant in the Power Division.

Cogeneration Feasibility Study - Department of Energy

Refer to Corporate Experience for details.

Mr. Melick is responsible for the heat balances, thermal cycle, and optimazation of equipment and piping.

Cogeneration Study - Industrial

Refer to Corporate Experience for details.

His responsibilities on this study are similar to those described for the Department of Energy study.

Rutgers University - New Brunswick, New Jersey

1961 to 1977

Mr. Melick taught various courses in mechanical engineering and was responsible for coordinating undergraduate educational programs of the college. He was involved in program development during a period of rapidly increasing enrollment as the college grew from 1,000 students to over 1,500 ~~in~~ the years from 1975 to 1977. In 1976, Mr. Melick was appointed Acting Dean, College of Engineering and was responsible for managing the efforts of 86 faculty members organized in six departments plus the Bureau of Engineering Research.

Public Service Electric and Gas Company - Newark, New Jersey

1966 to 1975

Here he performed engineering and economic studies of nuclear fossil fired, and combined cycle power systems. (Employed full time during the summers of 1966, 1967, and 1969-1975, and part-time during the school years from 1969 to 1975.)

3.1.1D <u>Advisory Members of the Demonstration Team</u>

In addition to the two subcontractors, Toledo Edison Company has three advisory members of the Demonstration Team which represent the state and regional interests in energy alternatives. These include the Ohio Department of Energy, the Public Utilities Commission of Ohio, and the Toledo Metropolitan Area Council of Governments. Each will be a member of the Demonstration Team. At each of the review meetings with the subcontractors the advisory members will input objectives of state and local government and help interpret results to date on the tasks. In the following summaries, the overall roles and involvement of the advisory members are outlined.

<u>Ohio Department of Energy</u>

The Ohio Department of Energy is the department of state government responsible for coordinating and developing the energy resources for Ohio and implementing federal objectives at the state level. The Forecasting and Planning Department is responsible for matching future capacity additions with the projected energy requirements. Conservation, resource development, and fuel substitution will be necessary to lessen the current dependence on scarce gas and oil. The state's forecasting division considers both the short term and long term energy needs and the relationship between energy and other segments of Ohio's economy. The contribution of this department could be significant in achieving the ultimate goals of the Demonstration Program.

The Ohio Department of Energy will integrate this Demonstration Program into the energy alternatives which are being considered for continued development and believed necessary to meet the future energy requirements in Ohio. The use of by-product heat from electric power plants to provide thermal source energy offers the potential to combine the benefits of conservation, substitution of plentiful fuels for imported oil, and cogeneration in a way which may yield significant benefits. If the results reported after successive phases of the Demonstration Program are positive, the Ohio Department of Energy plans involvement in overcoming any and all institutional barriers to the successful commercialization of this project. Interest exists in the potential extension of the technology to other areas of the state.

The role of the state energy agency increases as the phases proceed. During the initial phase, their input will be mainly advisory. However, once the preliminary assessment indicates technological and economic viability, their contributions will be specifically defined. The possibility exists that the Ohio Department of Energy will then contribute to Phases 2 and 3 by committing both time and money to the project.

Public Utilities Commission of Ohio

The Public Utilities Commission of Ohio is composed of three commissioners appointed by the Governor. Duties of the Commission include regulation of all public services such as transportation and energy supply. The Department of Public Utilities provides staff reports to the Commission dealing with requests for increased tariffs, abandonment of service, and other matters. The Department of Public Utilities will represent the Public Utilities Commission of Ohio on the Demonstration Team.

The role of the Public Utilities Commission on the Demonstration Team will be to review the task reports and integrate the results into the regulatory process. The Public Utilities Commission and its staff will also be involved in reviewing rates for thermal energy systems, developing alternative rate formulations and determining if existing regulatory precedent acts as a real impediment to developing viable thermal energy systems. The problems of allocating costs, financing construction, and assessing benefits associated with cogeneration must also be resolved with the assistance of this regulatory agency. The Public Utilities Commission and its staff will be involved in the initial three phases and again in Phase 7 when a system is in operation.

Toledo Metropolitan Area Council of Governments

The Toledo Metropolitan Area Council of Governments (TMACOG) presently is an association of 57 units of local government representing the five-county Ohio State Planning Region 4B and the County of Monroe in southeast Michigan. An Executive Committee of 29 members meets monthly. An Executive Director and Associate Director of Environmental Affairs are complemented by a staff of planners and administrators in the field of land use, public safety, social science, and energy.

The role of TMACOG will be to represent the interest of local governments, industry, social, and economic organizations on the Demonstration Team. Approaches to energy substitution and district heating systems must allow for interaction between the utility, the subcontractors, government, and the community. The involvement of TMACOG secures the coordination and commitment of these groups by involving them in the planning process throughout the phases of the Demonstration Program.

3.1.2 Work Program

Toledo Edison Company is the Prime Contractor for the Demonstration Study. Mr. James R. Watt, Director of Research and Development, of Toledo Edison will act as the Project Manager. He will be the single individual responsible to the Department of Energy and to Toledo Edison management for the progress of this study. He will be assisted by Mr. George A. Sommerfield, Research Projects Manager, who will act as Assistant Project Manager. These men will be responsible to coordinate the overall project through task and subtask assignments among the members of the Demonstration Team.

Battelle Columbus Laboratories will study candidate service areas, analyze the market for thermal energy sources within those areas, and determine precisely how the institutional arrangements will affect the development of thermal energy systems. Mr. F. Jere Bates, Utility Economist, will act as Study Manager and will be responsible for the tasks assigned to Battelle. He will be assisted by Mr. David D. Moore, Consultant.

Stone & Webster Engineering Corporation will perform the technical review and assessment studies. Mr. Andrew A. Anastasio, Study Manager, will be responsible for the tasks assigned to Stone & Webster and will report to Mr. Watt of Toledo Edison Company. Mr. Anastasio will be assisted by Mr. George F. Melick, Consultant, who will provide support and special analyses.

Three members of the Demonstration Team have roles which are primarily advisory and/or review. They are the Ohio Department of Energy, the Public Utilities Commission of Ohio, and the Toledo Metropolitan Area Council of Governments. Mr. Christian F. Schlemmer, Energy Specialist, will represent the Ohio Department of Energy. His responsibility will be to advise the team concerning energy plans for Ohio. Mr. John D. Borrows, Director, Department of Utilities will represent the Public Utilities Commission of Ohio. He will advise the team as to the regulations which may be necessary for the new thermal energy system. Finally, Mr. Calvin M. Lakin, Executive Director, and Ms. June M. Brown, Project Director - Energy, will represent the Toledo Metropolitan Area Council of Governments. They will reflect the attitudes of local government and will provide a forum for local community involvement in the use of thermal energy.

The participation of these advisory members is expected to increase as the Demonstration Program advances to successive phases. In Phase 1, any initiative required to obtain information from these supporting members will be assumed by Toledo Edison or its subcontractors. In a review capacity, these members may request that outputs be modified or may contribute in any way they feel necessary to promote the success of the Demonstration Project.

The Phase 1 District Heating and Cooling Program Allocation of Time and Resources is shown on Page 36. It assigns manpower and dollars to all issues affecting the work program. Page 37 is the Demonstration Team Organization Chart which shows the organizations that are responsible for each major effort. The Demonstration Team Personnel Responsibility on page 38 indicates who will perform the work in the various efforts. Backgrounds of key personnel can be found in 3.1.1.

In addition, the Summary Work Plan is shown on page 39. Pages 36 through 39 are part of the Detailed Work Management Plan as submitted under 4.1.1.

Toledo Edison Company

PHASE 1 DISTRICT HEATING AND COOLING PROJECT

Allocation of Time and Resources

TASK NO.	DESCRIPTION	TOLEDO EDISON MH	TOLEDO EDISON COST	STONE & WEBSTER MH	STONE & WEBSTER COST	BATTELLE COLUMBUS MH	BATTELLE COLUMBUS COST	SCHEDULE DATE START	SCHEDULE DATE STOP
Task 1	Demo. Team Work Management Plan	400	$ 8,000	56	$ 1,816	20	$ 1,100	9/1	12/18
1.1	Organize Team	100	2,000	56	1,816	20	1,100	9/1	9/15
1.2	Identify Issues, Assign Duties	100	2,000	--		--		9/1	9/15
1.3	Involve Parties of Interest	50	1,000	--		--		9/1	10/12
1.4	Propose Subsequent Team	50	1,000	--		--		9/1	5/18
	Task Report	100	2,000	--		--		9/11	12/18
Task 2	Identify Source & Service Area	107	2,140	306	9,926	152	4,210	9/1	1/24
2.1	Identify Plants	20	400	306	9,926	--		9/1	11/14
2.2	Identify Service Area	20	400	--		52	1,320	9/1	1/5
2.3	Survey Building Types	35	700	--		100	2,890	9/1	1/5
	Task Report	32	640	--		--		10/19	1/24
Task 3	Energy Market Analysis	173	3,460	195	6,325	944	42,670	9/1	2/28
3.1	Evaluate Market & Assess	30	600	48	1,557	208	7,690	9/1	1/26
3.2	Establish Supply Conditions	30	600	48	1,557	200	7,690	9/1	1/5
3.3	Evaluate Fuel Switching	24	480	59	1,914	252	12,960	1/5	2/28
3.4	Identify Generic Nature of Market	16	320	40	1,297	284	14,330	1/5	2/28
	Task Report	73	1,460	--		--		2/21	3/15
Task 4	Technical Review	107	2,140	1470	47,682	220	14,202	10/9	3/23
4.1	Assess Retrofit Schemes	--		200	6,487	--		10/9	3/23
4.2	Assess Alternatives	--		200	6,487	--		10/9	3/23
4.3	Assess Modes of Operation	--		200	6,487	--		11/20	3/23
4.4	Evaluate Effects on Plant Oper.	15	300	200	6,487	--		11/20	3/23
4.5	Determine Effects on Capacity	15	300	200	6,487	60	3,301	11/20	3/23
4.6	Develop Distribution Schemes	--		200	6,487	--		11/3	3/23
4.7	Evaluate Heat Storage	--		70	2,273	--		12/4	3/23
4.8	Assess Scarce Fuel Savings	--		200	6,487	160	10,901	12/4	3/30
	Task Report	77	1,540	--		--		1/12	4/30
Task 5	Institutional Assessment	300	9,000	--		1244	57,507	9/12	3/12
5.1	Effects of Regulation	--		--		204	9,953	9/25	2/19
5.2	Utility Arrangements	100	2,000	--		292	14,387	9/25	2/28
5.3	Easements, Franchises	40	2,800	--		--		10/9	1/31
5.4	State and Local Taxes	--		--		184	8,303	9/25	2/28
5.5	Mandate to Serve	10	700	--		--		10/9	1/31
5.6	Environmental Regulations	--		--		220	10,372	9/25	2/28
5.7	Siting and Zoning Laws	--		--		256	10,432	9/25	2/28
5.8	Review Corporate Charter	10	700	--		--		10/9	1/31
5.9	Develop Schedule of Approvals	40	800	--		88	4,060	2/21	2/28
	Task Report	100	2,000	--		--		3/9	4/2
Task 6	Preliminary Economic Analysis	95	1,900	575	18,651	396	14,163	12/1	4/10
6.1	Economic Sensitivity Display	10	200	300	9,731	76	2,446	1/12	4/10
6.2	Assess Impacts	10	200	275	8,920	68	2,338	1/12	4/10
6.3	Estimate Revenue	--		--		120	4,649	12/1	4/10
6.4	Assess Impact of Project	10	200	--		132	4,730	12/1	4/10
	Task Report	65	1,300	--		--		2/14	5/4
Task 7	Proposal for Further Work	132	2,640	180	5,840	100	5,390	2/5	5/18
7.1	Reevaluate Demonstration Team	20	400	--		32	1,760	2/5	5/18
7.2	Proposal for Further Work	112	2,240	180	5,840	68	3,630	2/5	5/18
Task 8	Letters of Coop., Commitment	40	800	--		--		12/19	5/18
8.1	Obtain Letters of Commitment a. Major End-Users b. Local Government Involved	20	400	--		--		2/19	2/2
8.2	Obtain Letters of Commitment. a. Members of Demo. Team b. Utilities Affected	20	400	--		--		2/19	5/11
Task 9	Detailed Work Management Plan	120	2,400	200	6,487	292	15,758	5/7	5/18
9.1	Provide Work Management Plan a. Individual Work Packages b. PERT Charts, etc. c. Milestone Chart d. Cost Breakdown	50	1,000	200	6,487	292	15,758	5/7	5/18
9.2	Provide Organizational Plan a. Organizational Chart b. Responsible Individuals c. Manpower and Resources d. Qual. & Level of Effort	50	1,000	--		--		5/7	5/18
	Task Report	20	400	--		--		5/7	5/18
Final Report		80	1,520	100	3,244			5/7	5/18
Total Phase 1 Effort		1554	$34,000	3082	$99,971	3368	$155,000		

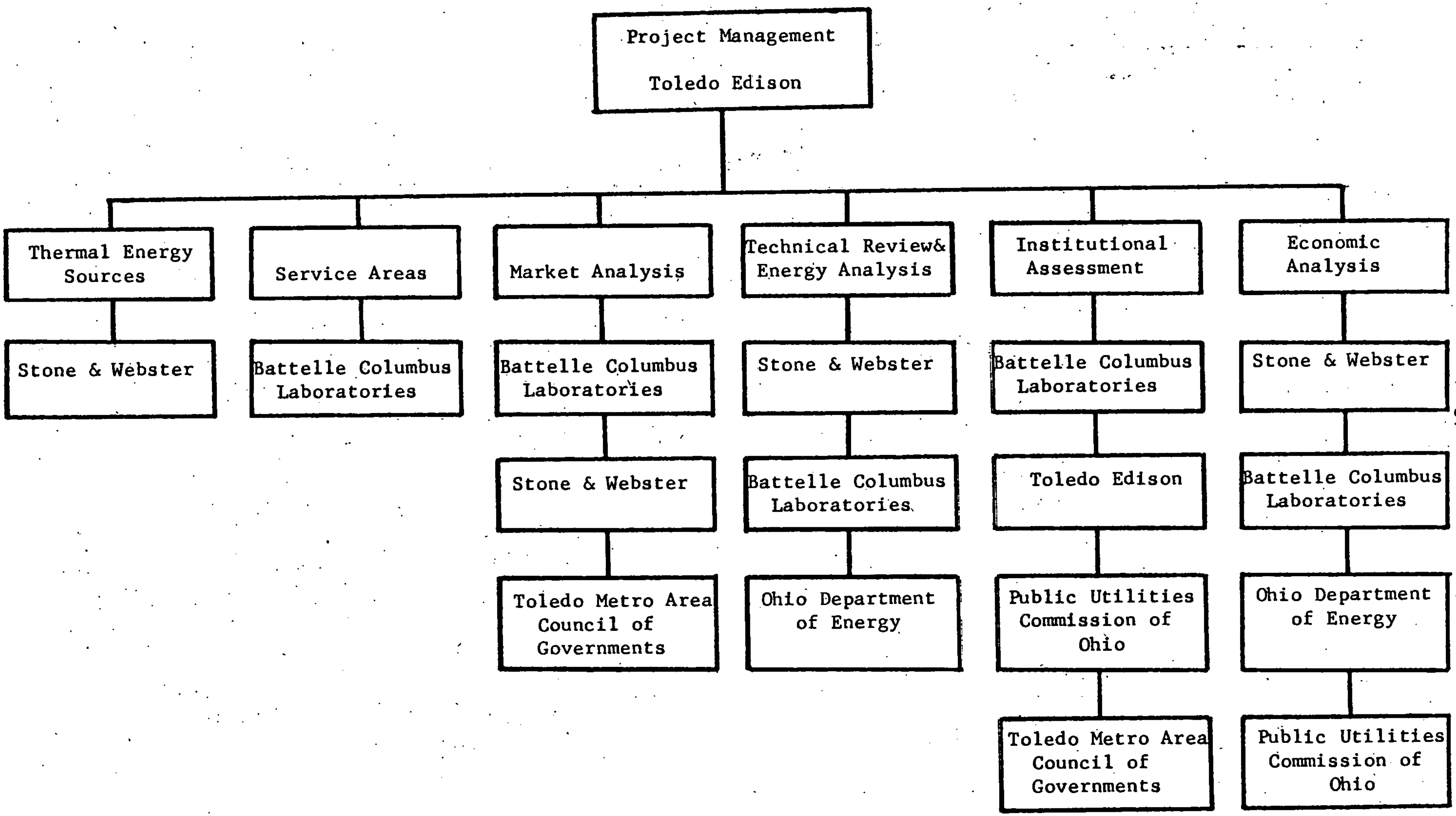
PHASE 1 DISTRICT HEATING AND COOLING PROJECT

Allocation of Time and Resources

October 5, 1978
April 18, 1979

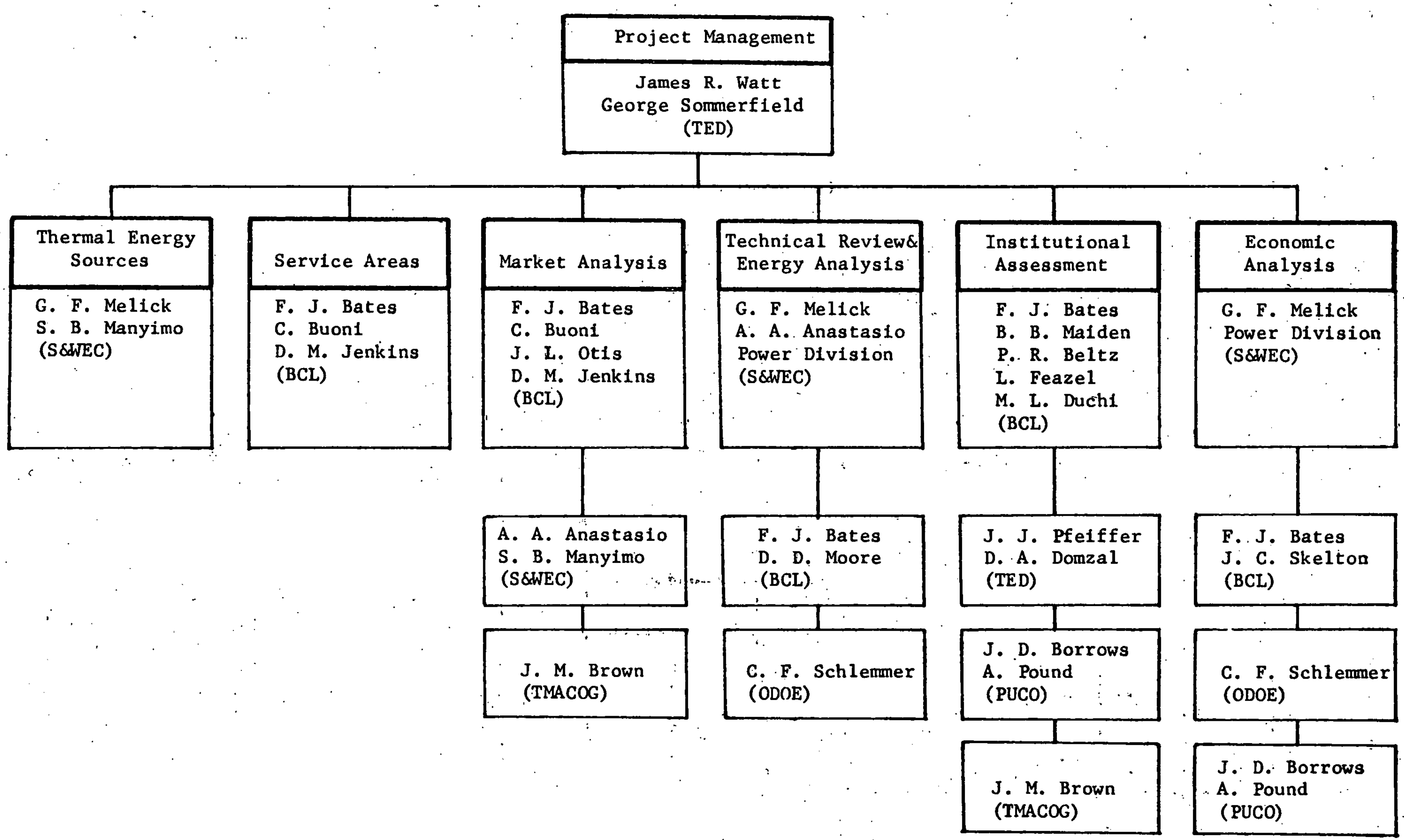
PHASE 1 DISTRICT HEATING & COOLING PROJECT

DEMONSTRATION TEAM ORGANIZATION CHART



PHASE 1 DISTRICT HEATING & COOLING PROJECT

DEMONSTRATION TEAM PERSONNEL RESPONSIBILITY



PHASE 1 DISTRICT HEATING & COOLING PROJECT

Summary Work Plan

Task Description	September	October	November	December	January	February	March	April	May	June	July
TASK 1 Organize Demonstration Team	━━━	━━━						━━━	━━━		
TASK 2 Identify Thermal Energy Sources and Service Areas	━━━	━━━	━━━	━━━	━━━						
TASK 3 Energy Market Analysis	━━━	━━━	━━━	━━━	━━━	━━━	━━━				
TASK 4 Technical Assessment and Review		━━━	━━━	━━━	━━━	━━━	━━━	━━━			
TASK 5 Institutional Assessment	━━━	━━━	━━━	━━━	━━━	━━━	━━━	━━━			
TASK 6 Preliminary Economic Analysis				━━━	━━━	━━━	━━━	━━━	━━━		
TASK 7 Proposal for Further Work						━━━	━━━	━━━	━━━		
TASK 8 Letters of Cooperation and Commitment				━━━	━━━	━━━	━━━	━━━	━━━		
TASK 9 Detailed Work Management Plan									━━━		
Detailed Work Management Plan	26	5		18							
Oral Presentation										X	
Team Meetings		19		5	26	21		20	18		
Monthly Reports	25	25	25	25	25	25	25	25	25		
Task Reports		(1)			(2)		(3)	(5)	(4) (6) (7)		
Final Report									31		

Numbers indicate date submitted except for Task Reports.
Task Report submittals are identified by Task Number.

April 18, 1979

3.1.3 Parties of Interest

Introduction

Parties of interest have been divided into two broad categories, local and state. The identification of these parties and the process for involving them in the project will be done on a local level through the Toledo Metropolitan Area Council of Governments (TMACOG), and at the state level through the Ohio Department of Energy.

The use of TMACOG as a means to involve parties of interest is unique, since TMACOG is embarking on a Demonstration Project that interfaces with the District Heating and Cooling Demonstration Project.

On June 12, 1978, the Toledo Metropolitan Area Council of Governments responded to RFP 78-4299 which requested proposals to design a Demonstration Program to develop a Comprehensive Community Energy Management Plan (CCEMP). TMACOG has been selected by the Department of Energy and has negotiated a contract for the Demonstration Program. One of the necessary tasks in the successful development of a CCEMP is the identification and involvement of local parties of interest.

As a means to involve parties of interest and to effectively perform management, coordinative and administration tasks in the CCEMP, TMACOG has established an Energy Guidance Group. Cited below are some specific responsibilities taken from the proposal.

> "EGG will meet monthly at minimum with all scheduled meetings open to the public."

"EGG will conduct working sessions for local government and the public with each completed phase of the work schedule to assure final commitment to the plan and ICES process."

EGG will "Identify supplemental energy systems or options natural to the study area which incude recovery of waste heat from all varieties of thermal processes (including district heating and co-generation)."

3.1.3A Process to Involve Local Parties of Interest

The primary vehicle to involve local parties of interest to fulfill this portion of the District Heating & Cooling project will be the Energy Guidance Group of TMACOG. Their responsibilities include identification of district heating and cogeneration processes. Monthly meeting and work sessions with local governments, all open to the public, assure a means to involve these vitally interested parties in our Demonstration Program.

TMACOG has approved our request to address EGG at their monthly meetings to report our progress and to solicit advice and concerns of its members. This procedure has been chosen because some goals of TMACOG in their Demonstration Project closely parallel our goals in the District Heating and Cooling Demonstration Program. By utilizing the established Energy Guidance Group to involve parties of interest in the District Heating and Cooling Demonstration Program, duplication of efforts, redundancy and confusion will be eliminated.

A list of the members of EGG and the role each will play is included. A letter documenting commitment to our Demonstration Project is found on page 43. It should be noted that Mr. Michael D. Reed of Toledo Edison Company is a member of EGG. Mr. Reed reports directly to Mr. Watt, District Heating and Cooling Project Manager. In his role on EGG, Mr. Reed will provide customer class consumption electrical use patterns that are available and will advise the group on other matters related to electrical energy.

3.1.3B <u>Process to Involve Parties of Interest at the State Level</u>
Mr. Christian F. Schlemmer, Energy Analyst, Ohio Department of Energy, and a member of the Demonstration Team has formed a committee at the state level.

The Ohio Department of Energy has been actively working on conserving scarce fossil fuels by utilizing waste heat such as the Portsmouth Uranium enrichment facility. The responsibility of conserving scarce fuels and the experience of Mr. Schlemmer and others in the Ohio Department of Energy, make them a valuable and logical member of the Demonstration Team to involve interested parties at the state level.

The Committee consists primarily of representatives from other key state organizations. These representatives possess the ability to identify and assess institutional barriers that must be overcome to successfully conclude the program.

The Committee members, their organizational affiliation and their roles are listed on the following page. A letter of commitment is found on page 46.

TOLEDO METROPOLITAN AREA COUNCIL OF GOVERNMENTS
420 Madison Ave. / Suite 725
Toledo, Ohio 43604

October 6, 1978

Mr. James R. Watt
Project Manager
District Heating & Cooling Project
Toledo Edison Company
Toledo, Ohio 43652

SUBJECT: District Heating & Cooling Systems for Communities Through Power Plant Retrofit and Distribution Network

Dear Mr. Watt:

The Toledo Metropolitan Area Council of Governments is the Project Manager of a Demonstration Project to develop a Comprehensive Community Energy Management Plan. The project design includes the establishment of an Energy Guidance Group to direct the management, technical and coordinative tasks.

As Chairman of the Energy Guidance Group, I am pleased to inform you that the membership welcomes the opportunity to apprise the progress of your Phase I effort. We extend the use of the EGG monthly meetings as a forum to this end.

The EGG membership is aware of the Toledo Edison Company role as contractor in the above titled project funded by the Department of Energy. We are charged with the responsibility to evaluate supplemental energy sources and are, therefore, an interested party to your program.

We recognize that obstacles of an institutional and social nature could significantly impact the success of your project. To the extent that analytical work, policy development and social interaction is needed, we would be willing to contribute information and advice within the scope of our activities which are complementary to your project.

Sincerely,

Francis E. Szollosi

Francis E. Szollosi, Chairman
Energy Guidance Group

mt

Enclosure: Membership Roster

cc: EGG membership

ENERGY GUIDANCE GROUP (EGG)

Members, Roles

EGG Members	Role in Project
1. Francis E. Szollosi Chairman Lucas County Commission	Spokesman for EGG, chairing all working sessions of CCEMP and EGG monthly sessions, and reporting monthly all EGG actions to TMACOG Executive Committee. Also reports progress to Lucas County elected and appointed bodies.
2. M. Fil Line, Jr. Community Relations Mgr. Columbia Gas of Ohio, Inc.	Energy advisor on natural gas supplies and costs relating to projected demands.
3. James A. Palmer Energy Information Committee Chairman Toledo Area Chamber of Commerce (Bus. Affiliation: Libbey-Owens-Ford Co.)	Liaison with business community and advisor relating to industrial demand needs.
4. Ray Kest Toledo City Councilman	Advise and review. Liaison with Toledo city departments and elected officials.
5. Edward C. Smith Assistant City Manager City of Toledo	Advise and review. Direct involvement of manager's office which is pivotal to city departments.
6. Zere C. Smith Sandusky County Commissioner	Advise and review. Reports progress to Sandusky County elected and appointed officials.
7. John Ault Wood County Commissioner	Advise and review. Reports progress to Wood County elected and appointed officials.
8. E. W. Hoermann, District Manager Ohio Edison Company	Advise and review. Report progress to Ottawa County elected and appointed officials and advises on electrical system methodologies.
9. Charles Stark, Architect Richards, Bauer & Moorhead	Advise and review. Construction techniques feasible for structural changes for existing and new construction.

10.	Tom Ryan Deputy Director of Conservation Ohio Department of Energy	Liaison to Ohio's Energy Conservation Planning. Reports progress directly to Robert Ryan, Director, Ohio Department of Energy.
11.	Michael D. Reed Load Survey Supervisor Toledo Edison Company	Advisor on electrical forecasts, data source, and costs relating to projected demands.
12.	Dr. Ivan Kurtz Assistant to the President Owens Technical College.	Advise and review. Liaison to educational institutions.
13.	Wayne Zachrich Building Industry Assn. of Northwest Ohio	Advise and review. Liaison to home builders and remodelers.
14.	Dr. Carmen Calabrese Manager of Industry Marketing Midland-Ross Technical Center	Advise and review. Liaison to supplemental energy systems.
15.	United Auto Workers	Advise and review. Liaison to labor organizations and their energy conservation and solar projects.
16.	Mike Ferner Ohioans for Utility Reform	Advise and review. Liaison to advocacy groups for rate structure reforms, solar and energy conservation projects.
17.	Mary Mancini League of Women Voters	Advise and review. Liaison to public educational awareness groups relating to energy conservation and decentralization of traditional energy sources.
18.	James Carl Director of Facility Engineering Teledyne CAE	Advise and review. Liaison to supplemental energy systems.

James A. Rhodes
GOVERNOR

OHIO DEPARTMENT OF ENERGY
30 East Broad Street 34th Floor
Columbus, Ohio 43215
(614) 466-6797

Robert S. Ryan
DIRECTOR

October 12, 1978

Mr. James R. Watt
Toledo Edison Company
Edison Plaza
300 Madison Avenue
Toledo, Ohio 43652

Dear Jim:

The Ohio Department of Energy looks forward to the District Heating and Cooling project now commencing.

As we discussed, we have asked members from various state departments and agencies to participate in advising and assisting you on state matters. A list of the pertinent groups and a representative of each is enclosed. Mr. Robert Masoner will assist as State Co-Chairman.

Thank you for your efforts on behalf of furthering the state's energy resources.

Sincerely,

Chris Schlemmer

Chris Schlemmer
Chairman of State Committee

CFS/kls
Enclosure
cc: R. S. Ryan, ODOE
R. C. Masoner, ODOE

STATE OF OHIO COORDINATING COMMITTEE

Organizations, Participants

	Organization	Participant
1.	Robert S. Ryan, Director Ohio Department of Energy 34th Floor, State Office Tower 30 East Broad Street Columbus, Ohio 43215	Mr. C. F. Schlemmer, Jr. Mr. Robert Masoner
2.	Mr. Robert W. Teater, Director Department of Natural Resources Fountain Sqaure Columbus, Ohio 43224	
3.	Mr. John M. Stackhouse, Director Department of Agriculture 65 South Front Street, Room 713 Columbus, Ohio 43215	Mr. Al Baxter
4.	Mr. Ned E. Williams, Director Environmental Protection Agency 361 East Broad Street Columbus, Ohio 43215	
5.	Mr. David L. Weir, Director Ohio Department of Transportation 25 South Front Street Columbus, Ohio 43215	Mr. Wayne Kauble
6.	Mr. J. Gordon Peltier, Director Department of Commerce 180 East Broad Street Columbus, Ohio 43215	Mr. Dusty Roads
7.	Mr. James A. Duerk, Director Department of Economic and Community Development 25th Floor, State Office Tower 30 East Broad Street Columbus, Ohio 43215	Mr. Jerry Hamill
8.	Dr. James A. Norton, Chancellor Ohio Board of Regents 36th Floor, State Office Tower 30 East Broad Street Columbus, Ohio 43615	Mr. Larry O'Brien
9.	Dr. Richard Davis, Assistant Director Ohio Agriculture Research and Development Center Wooster, Ohio 44691	Dr. Richard Davis

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DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES THROUGH POWER PLANT RETROFIT AND DISTRIBUTION NETWORK

Task 2

Identify Thermal Energy Source(s) and Potential Service Area(s)

James R. Watt
George A. Sommerfield

Toledo Edison Company
Toledo, Ohio

December, 1978
Revised August 1979

Prepared for:
The U. S. Department of Energy
Under Contract No. EM-78-C-02-4979

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3.2 TASK 2 - IDENTIFY THERMAL ENERGY SOURCE(S) AND POTENTIAL SERVICE AREA(S)

ABSTRACT

3.2.1 Task Deliverables

Give a complete technical description of the candidate plant(s), its thermodynamic cycle, role in load dispatch, ownership and location.

3.2.1 Identify Candidate Power Plants

Stone & Webster Engineering Corporation is a member of the Demonstration Team employed as a subcontractor by Toledo Edison Company to identify thermal energy sources.

Accordingly, Stone & Webster personnel have investigated each of Toledo Edison's generating stations and have described the candidate plants, the existing equipment, the thermodynamic cycle, the plant fuel utilization and the station's role in load dispatch.

Toledo Edison's (TED) three steam power plants (Acme, Bay Shore, and Davis-Besse Stations) are potential candidates for retrofit to provide thermal energy to downtown Toledo and the surrounding communities.

Presently all three stations generate electricity. Technically, any or all of these stations could be modified to provide thermal energy for district heating and cooling. Each station is described briefly below.

Acme Station is primarily a coal fired intermediate electrical generating plant located approximately one mile from Water Street Station. Water Street Station is an oil fired boiler plant that serves the present Toledo Edison downtown thermal energy network. Gross output of Acme Station is rated at 315 MW.

Bay Shore Station is a coal fired power generating station on the Maumee River located approximately six miles northeast of downtown Toledo. The station became operational in 1955. In 1977, Bay Shore Station generated 54.4 percent of the total generation and interconnections owned by TED. Gross output is rated at 636 MW. With the operation of Davis-Besse Nuclear Station, the load factor of 80% may decrease somewhat.

Davis-Besse Nuclear Power Station is located at Locust Point Beach in Ottawa County. The station is approximately 25 miles east of downtown Toledo and is owned by TED and Cleveland Electric Illuminating Company. The station became operational on November 21, 1977, generating at 25 percent capacity. By January 23, 1978, it was generating at 75 percent capacity. Of the total power generated by the station in 1977, TED's share was approximately 50 percent. TED is responsible for the plant's operation. Gross output is rated at 905 MW. It is, of course, characterized as a base load plant.

3.2.2 Task Deliverables

List the potential service areas and supply location by political jurisdiction and proximity to the candidate plant(s). Include map(s) of areas showing location of plant(s), location of service areas, major land-use areas, and any other information necessary to characterize the potential service area and the community in which it is located.

3.2.2 Identify Service Areas and Energy Use

Battelle Columbus Laboratories (BCL) is the member of the Demonstration Team employed as a subcontractor by Toledo Edison to evaluate potential service areas for a district heating distribution network. Battelle's complete report regarding Task 3.2.2 is attached. A summary of the results of their work follows.

BCL determined the energy densities for the three counties in the immediate area of the candidate power plants: Davis-Besse Nuclear Power Station, Bay Shore Station and Acme Station. As shown in Figure 1, the area under consideration includes the counties of Lucas, Wood, and Ottawa. The aggregate energy use within the counties and the energy density for the planning districts indicate that only Lucas County contains potential service areas.

Based on energy density parameters developed in Sweden to determine expansion planning strategies for district heating systems, thirteen (13) favorable planning districts within Lucas County were selected for detailed study. The downtown Toledo area, a portion of Planning District No. 1, was the only area identified as "very favorable" in accordance with the Swedish parameters.

Since the planning districts are large (500-26,000 acres), the detailed evaluation necessary to select service areas must be done at the subdistrict (10-1,000 acres) level. A number of subdistricts adjacent to the downtown area were analyzed to determine if district heating could be a competitive energy source. As part of this effort, preliminary estimates of the delivered cost of thermal energy were made. The price of natural gas was escalated based on the best information available as the baseline cost of energy in future years.

In addition to the fuel cost, the delivered cost of district heating energy depends largely on the fixed charges for the retrofit required at power plant and the fixed charges for the distribution network. Forty-one (41) different combinations of power plants, steam systems, high temperature water systems and service areas within subplanning districts were considered. The costs developed are preliminary estimates used to compare the alternatives and are refined to the point where they can be compared directly with competitive energy sources.

Results indicate that retrofit schemes at Acme Station are more favorable than those considered at Bay Shore Station. The cost penalty against Bay Shore because of the distance from the high energy density service areas is significant. Davis-Besse is so remote from high density service areas that the cost of transmission facilities between the plant and candidate service areas results in a prohibitive cost of delivered district heating energy. A moderately priced retrofit at Acme Station does result in a favorable delivered cost of district heating energy when compared to the cost of natural gas in the 1985-1990 time period.

Because an existing steam distribution system is a part of this study, the question of converting this system to a modern hot water system was addressed. Replacement cost is too high for the resulting system to be competitive. However, several combination systems which provide steam to the existing steam service area and high temperature water to new service areas were determined to have merit.

Use of thermal energy for cooling does not appear to be justified either as a potential end use or as part of a chilled water system. The market survey will be used to estimate the cooling requirements so the potential for the cooling energy market can be documented.

Conclusion

The downtown Toledo steam distribution system can be the starting point for developing a new district heating system to serve an expanding market. A combination system supplying both steam and high temperature water could be competitive with the future price of natural gas. This would permit the expansion of the system into areas directly adjacent to the existing system and perhaps into planning subdistricts with significant thermal loads that would permit further expansion.

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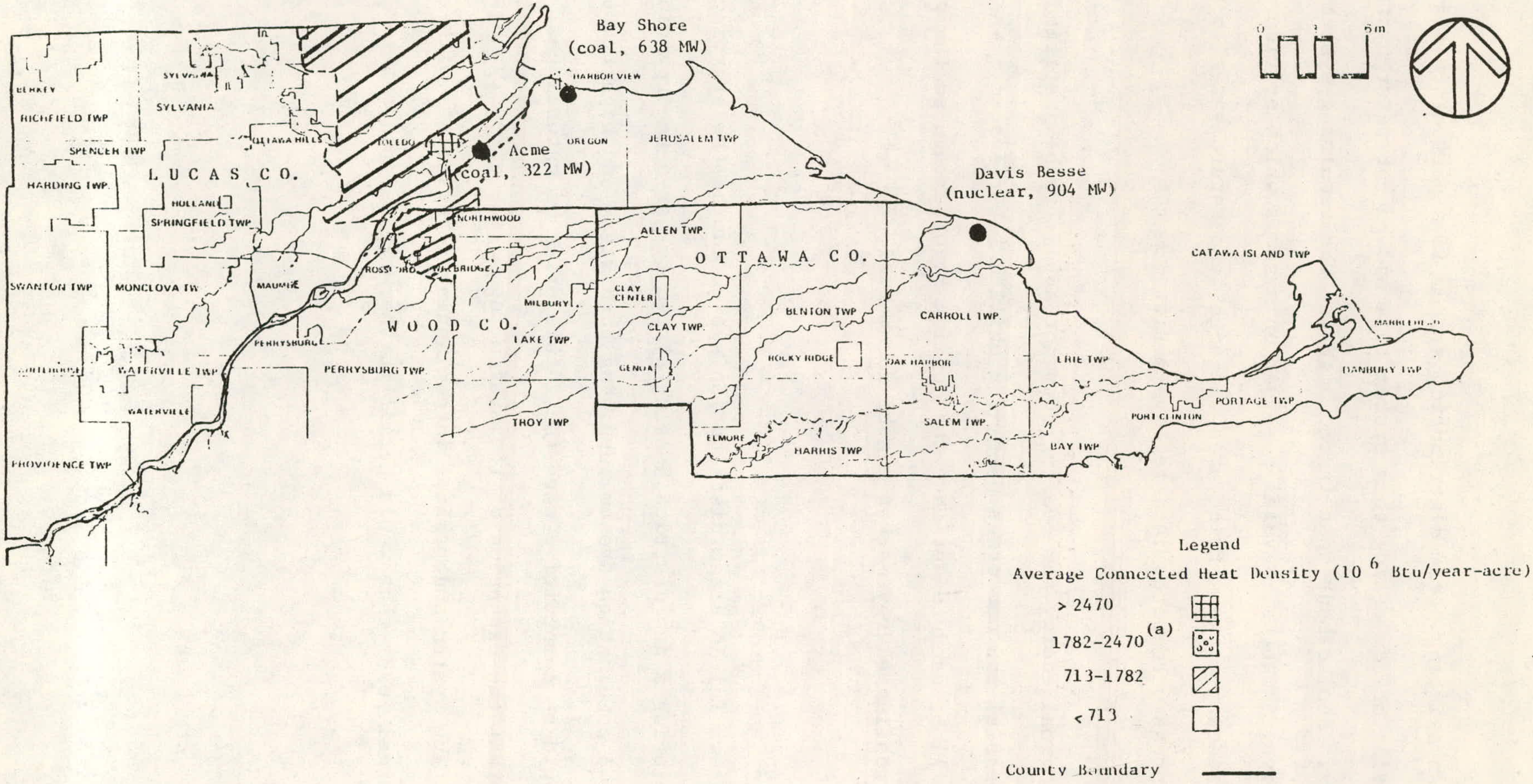

FIGURE 1. AVERAGE HEAT DENSITIES AND LOCATION OF MAIN THERMAL POWER PLANTS IN STUDY AREA. (NORTHWESTERN OHIO)

(a) There were no districts demonstrating heat densities in this range.

PART I - CANDIDATE PLANTS FOR RETROFIT

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3.2.1 Give a Complete Technical Description of the Candidate Plant(s), Its Thermodynamic Cycle, Role in Economic Dispatch, Ownership and Location

INTRODUCTION

Candidate Plants for Retrofit

Toledo Edison's (TED) three steam power plants, Acme, Bay Shore, and Davis-Besse Stations, are potential candidates for retrofit to provide thermal energy to downtown Toledo and the surrounding communities.

Presently, the stations generate electric power only. With innovative backfitting, the station(s) would generate power and provide thermal energy for district heating and cooling. Descriptions of each station, its existing equipment, fuel source and consumption, and the station's role in load dispatch are presented, and the potential for retrofit at each station is discussed.

Acme Station

Acme Station is located along the Maumee River and is approximately one mile from downtown Toledo, Ohio. The station became operational in 1918 and several boilers and steam turbine units have been added since, while others have been retired. The station is basically coal-fired but there is some use of oil, natural gas, and coke oven gas.

Existing Equipment

Existing equipment at the station consists of four oil/gas fired boilers, six coal fired boilers, and six steam turbine generator units ranging in capacity from 7 MW to 108 MW. Table 1-1 summarizes the existing equipment in the station.

TABLE 1-1

EXISTING EQUIPMENT - ACME STATION

BOILERS

Boiler No.	Manufacturer	Year Installed	Capacity	Fuel
9 & 10 11 & 12	C.E. C.E.	1969 1969	160,0001b/hr each @ 250 psig, 600°F	oil/gas
13	B&W	1938	253,000 lb/hr @ 825 psig, 825°F	coal
14 & 15	B&W	1952	350,000 lb hr each @ 825 psig, 825°F	coal
16	B&W	1951	650,000 lb/hr @ 1500 psig, 1000°F	coal
91 & 92	B&W	1949	500,000 lb/hr 850 psig, 950°F	coal

TURBINE GENERATORS

Turbine Unit No.	Capacity	Throttle Conditions	Exhaust
1	25 MW	235 psig, 600°F	Condenser
2	80 MW	1450 psig, 1000°F	Condenser
4	45 MW	235 psig, 600°F	Condenser
5	664 MW	825 psig, 825°F	Condenser
6	114 MW	820 psig, 950°F	Condenser
Topper Unit	7 MW	825 psig, 825°F	235 psig header

The station has an overall steam capacity of 3,243,000 lb/hr. and a gross megawatt capacity of 315 MW with 5 to 6 percent of the power being used for auxiliary purposes. Turbine units 1 and 4 draw their throttle steam from a steam header into which the topper turbine exhausts.

Additional steam is supplied to the header by pressure-reducing turbine bypass arrangements. Also, when the oil fired boilers are operating, the steam generated is supplied to this header. Should additional steam at 235 psig be required, turbine Unit 5 can supply such steam at a load of 45 MW or above. This unit is to be upgraded through spindle replacement and its last two rows of blades will also be replaced.

Thermodynamic Cycle

As can be seen from Table 1-1, the coal fired boilers have throttle conditions much higher than the oil/gas fired units. Boiler Nos. 13, 14, and 15 generate steam at 825^{o}F, which drives turbine Unit 5 and the topper turbine. The topper turbine exhausts into the steam header. Boiler No. 16 generates steam for the No. 2 turbine and the other high pressure boilers (Nos. 91 and 92) generate steam for No. 6 turbine. Turbine Units 1, 2, 4, 5, and 6 exhaust into once-through condensers using water from the Maumee River. These units also have multiple extraction points to provide steam for feedwater heating and other auxiliary functions such as oil heating and steam pumps. Steam to the deaerators is at 1.5 psig. For the high pressure boilers, boiler feedwater temperatures are on the order of 400^{o}F after passing through the heaters.

Plant Fuel Utilization

Although the Acme Station is primarily coal fired, the station is required to burn coke oven gas in at least one boiler. The gas is a byproduct produced at a nearby coke plant.

In 1977, the station consumed 14.01 x 10^{12} BTU of fuel, of which 12.22 x 10^{12} BTU were from coal, 1.03 x 10^{12} BTU from coke gas, 1.44 x 10^{9} BTU were from natural gas, 12.74 x 10^{9} BTU from propane, and 744.68 x 10^{9} BTU from oil.

Of the 14.01 x 10^{12} BTU consumed, 87 percent of the total consumption was supplied by coal, with coke gas supplying about 7 percent. The station's fuel consumption was increased steadily since, 1975, largely because of its increased total generation each successive year. Overall station efficiency in 1977 was 25 percent and boiler efficiency averaged 77.8 percent. The station has onsite storage facilities for propane gas, No. 2 and No. 6 fuel oils, and coal.

Station Role in Load Dispatch

The annual station load factor of the Acme Station was 34.6 percent in 1976 and 46.2 percent in 1977. It may be characterized as an intermediate loaded electrical generating plant. Unit 2, the most efficient unit and the most likely candidate for retrofitting, had a load factor of 56.6 percent in 1976 and 66.1 percent in 1977. The station generated 957 x 10^{6} KWH (gross) in 1976, and 1,109 x 10^{6} KWH (gross) in 1977. These figures represented 11.23 and 12.61 percent of the total generation and interconnection for TED in the respective years.

Bay Shore Station

Bay Shore Station is a coal fired power generating station on the Maumee River located approximately six miles northeast of downtown Toledo. The station became operational in 1955. In 1977, Bay Shore Station generated 54.4 percent of the total generation and interconnection owned by TED.

Existing Equipment

The station has four coal fired steam generators with a combined steam capacity of 4,357,000 lb/hr. Boilers Nos. 1 and 2 are rated at 950,000 lb/hr. each, while Boiler No. 3 is rated at 952,000 lb/hr. and Boiler No. 4 is rated at 1,505,000 lb/hr.

Steam is generated at 2000 psig and 1050°F in Boiler Nos. 1 and 2, with a 1000°F reheat cycle in each unit. In Boiler Nos. 3 and 4, steam is generated at 2400 psig and 1050°F, with a 1000°F reheat cycle in each unit. Each boiler generates steam for a separate steam turbine generator. The four steam turbine generators range in size from 136 MWe to 220 MWe. Turbine Units 1, 2, and 3 are rated at 136, 138, and 142 MWe, respectively, with Unit 4 rated at 220 MWe.

Thermodynamic Cycle

The high pressure high temperature steam generated in each boiler drives a high pressure turbine unit. The intermediate pressure turbine unit is driven by the 1000°F steam from the reheater.

Exhaust from the intermediate pressure turbine drives the double flow low pressure turbine units. Both the high and intermediate turbine units have multiple extractions for feedwater heating. Additional extractions on the low pressure double flow turbine unit supply dearating steam and low pressure feedwater heaters. Exhaust from the low pressure turbine unit is condensed in a once-through water-cooled condenser and then pumped to the boiler through the feedwater heaters. The high pressure feedwater heaters boost the boiler feed temperature to about 500°F at full boiler capacity.

Besides the feedwater extractions, steam for auxiliary services is extracted from the cold reheat cycle and fed into a common header. The pressure of the steam in the header is kept at 235 psig.

Plant Fuel Utilization

Based on 1977 plant data, the total fuel consumption by the Bay Shore Station was 41.56×10^{12} BTU. During the preceeding year, the station consumed 42.1×10^{12} BTU. In either year, oil consumption by the station amounted to no more than .25 percent of the total fuel consumed. The rest of the fuel consumed was coal. Overall thermal efficiency of this plant averaged 36.47 percent in 1977.

Station Role in Load Dispatch

The Bay Shore station generated $4{,}731.55 \times 10^{6}$ KWH (gross) in 1977. This represents 54.4 percent of the total generation and interconnection of TED. In 1976 the station's gross power generation was $4{,}811.42 \times 10^{6}$ KWH. In each of the above years, the station had a load factor of about 80 percent. The units in this station have been on the line over 92 percent of the time from initial startup. The station load factor should decrease somewhat as Davis-Besse Nuclear Power Station assumes more base load.

<u>Davis-Besse Nuclear Power Station</u>

The Davis-Besse Nuclear Power Station is located at Locust Point Beach in Ottawa County. The station is approximately 25 miles east of downtown Toledo and is owned by TED and Cleveland Electric Illuminating Company. The station became operational on November 21, 1977, generating at 25 percent capacity. Of the total power generated by the station in 1977, TED's share was approximately 50 percent. TED is responsible for the plant's operation.

Existing Equipment

The station will consist of three 905 MWe units. Currently, only Unit 1 is operational with Units 2 and 3 scheduled for later dates. Steam is generated in a B&W nuclear steam supply system at 875 psig and $850^{o}F$. The plant has at present a steam capacity of 11×10^{6} lb/hr. This capacity will increase as Units 2 and 3 go into service.

Thermodynamic Cycle

The 875 psig and $580^{o}F$ throttle steam drives a double flow turbine with one extraction for feedwater heating. Steam for feedwater heating is taken from the exhaust, and the main flow goes to a moisture separating reheater. The low pressure turbines are driven by steam from the reheater at 188 psia. These turbines have four extractions for feedwater heating.

The low pressure turbines exhaust at 1.5" Hg into a condenser. The condensate enters the first stage heater at $112.4^{o}F$ and leaves the last stage heater at $455.7^{o}F$ at rated turbine flow. Although the plant has a steam capacity of 11×10^{6} lb/hr., it has not yet reached this capacity since it became operational in September, 1977.

Plant Fuel Utilization

Davis-Besse is a nuclear station. Its fuel utilization is measured in terms of average reactor core burn-up rate. The station, however, does use fuel oil for auxiliary purposes.

Since becoming operational, the station consumed 625,000 gallons of oil in 1977. In terms of total heat input into the station, the oil consumed represents about 1.8 percent. The overall plant efficiency in 1977 was 31.7 percent.

Station Role in Load Dispatch

When the Davis-Besse Station is in operation, it carries the base load for TED. Available statistics cover the startup period and are not representative of current operation. During the last four months of 1977 the load factor averaged 23 percent and the reactor availability factor averages 75 percent. The unit is now operational at full power.

PART II - SELECTION OF CANDIDATE SERVICE AREAS

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3.2.2 List the Potential Service Areas and Supply Location by Political Jurisdiction and Proximity to the Candidate Plant(s). Include Map(s) of Areas Showing Location of Plant(s), Location of Service Areas, Major Land-Use Areas, and Any Other Information Necessary to Characterize the Potential Service Area and the Community in Which It Is Located.

INTRODUCTION

This report presents and discusses the framework and supporting data for the selection of potential service areas for district heating and cooling in the surrounding Toledo area. In this regard, the objectives of this task are to:

- Develop and apply a methodology to identify and select potential service areas, and
- Characterize the potential service areas.

These results, in conjunction with the technical analyses of the candidate power plants, provide the basis for the planning and conduct of the energy market study.

The report is presented in three sections. The first section describes the location of the potential service areas relative to the candidate power plants, current energy sources and climate. In the second section, the methodology employed is outlined with clarification of major assumptions and criteria. The results in the final section are discussed and analyzed in terms of their implications for district heating and cooling schemes for the candidate power plants. Appendices outline methodologies and assumptions in more detail.

BACKGROUND

The study area encompasses Lucas and Ottawa counties as well as the northern portion of Wood County. The area extent totals 717 square miles with a population of 548,000 (1975). The city of Toledo is the most densely populated area, accounting for over 70 percent of the population and 13 percent of the land area. Growth projections over the next ten years indicate considerable variation both within and between counties. Annual growth trends over this time period for Lucas, Ottawa, and Wood (northern portion only) are 0.2, 1.6 and 2.8 percent, respectively.[1]

Natural gas, and to a lesser extent, petroleum, are the predominant energy sources for space and hot water heating. Natural gas accounts for 74 percent of the energy requirements for these end-uses. Industrial process steam production consumes large quantities of natural gas and petroleum. Fifty three percent and seven percent, respectively, of process steam requirements are met by these sources. This significant reliance on natural gas and oil enhances the attractiveness of substituting more abundant energy sources (coal) for scarce ones through district heating and cooling.

The following end-uses and their shares of the total energy consumption highlight the significant potential for district heating applications in the study area:

	Percent Share of Total
Space Heat and Hot Water	65
Process Steam	27
Air Conditioning	8
	100

The two existing predominantly coal-fired power stations in close proximity to the downtown Toledo area (one and six miles respectively) are Acme (322 MW) and Bay Shore (638 MW). The Davis Besse nuclear plant (904 MW) is approximately 25 miles from the downtown area. The power plants and their locations are indicated in Figure 1.

The climate in this region is primarily humid continental. Normal monthly temperatures range from 25°F in January to 72°F in July. The average temperature over the year is 49°F, with the record lowest temperature measured at -17°F and the record highest at 99°F. On the average, there are only fifteen days a year when the temperature reaches 90°F or higher, and only eight days when it drops to zero or lower. The normal number of heating degree days are 6,366. Cooling degree days average around 659.[2]

METHODOLOGY

The size of the study area dictated use of a sequentially phased approach to achieve task objectives and obtain the level of detail necessary for selecting potential service areas. This approach allowed the characterization and analysis of service areas appropriate to the phase of study. The three activities are outlined and discussed below.

The study area is subdivided into 45 planning districts ranging in size from 466 to 26,689 acres. In most instances, district borders are contiguous with political boundaries or major transportation corridors. Planning districts are further divided into subdistricts with size ranges of 13 to 953 acres in those cases indicating potential for district heating and cooling.

The following discussion focuses on these three activities. Overall methodology, assumptions and criteria are presented and discussed. The subsequent section presents and discusses the results of these subtasks.

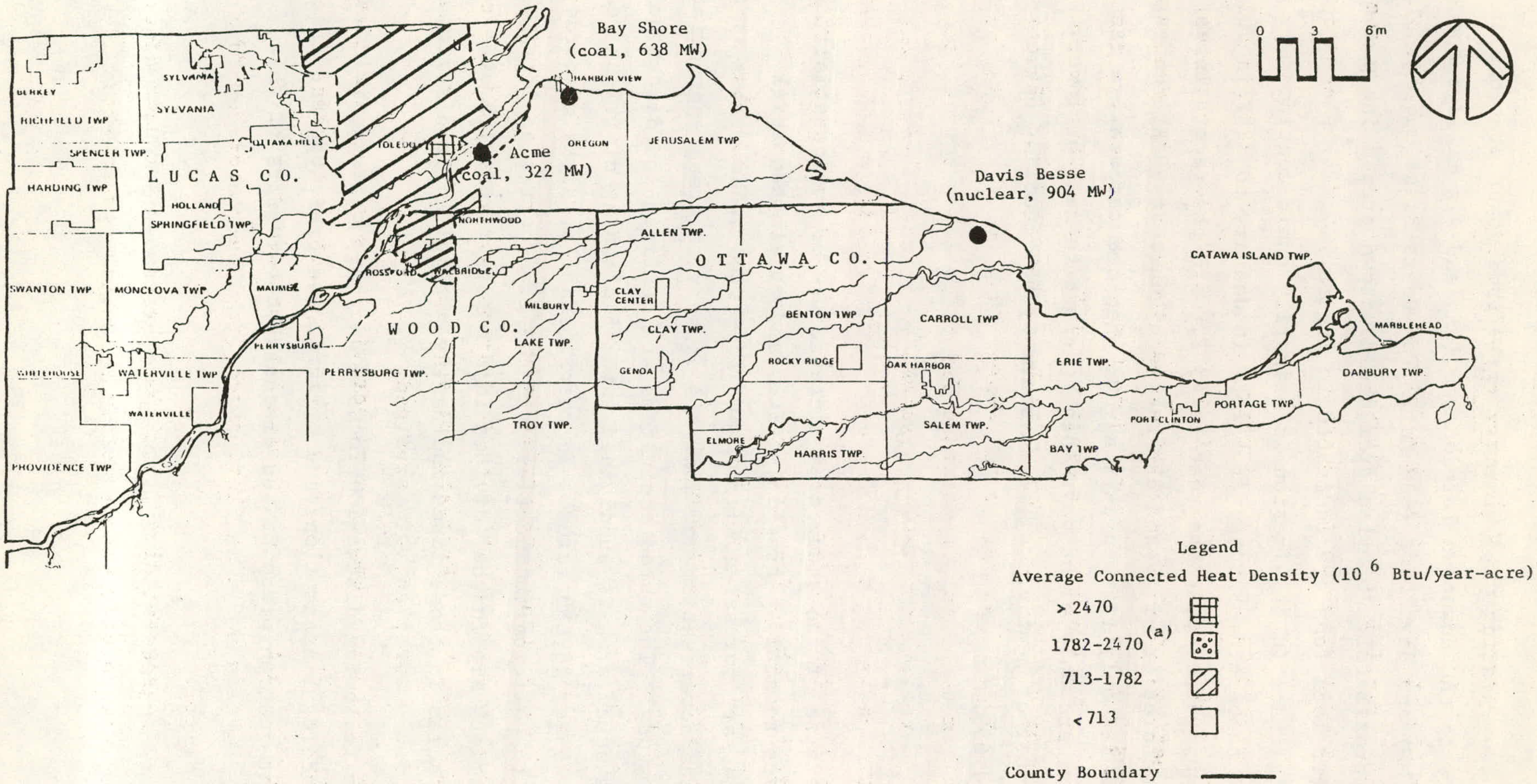

FIGURE 1. AVERAGE HEAT DENSITIES AND LOCATION OF MAIN THERMAL POWER PLANTS IN STUDY AREA. (NORTHWESTERN OHIO)

(a) There were no districts demonstrating heat densities in this range.

ACTIVITY 1: IDENTIFY SERVICE AREAS

The objective of Activity 1 has been to identify planning districts with potential for application of district heating and cooling. To achieve this goal required delineation of criteria and related data inputs.

The criterion utilized in this screening process was average energy density (million Btu/acre-year). This is defined for each planning district by end-use (heating, cooling, process steam) and sector (residential, commercial, and industrial). Energy densities in each planning district are compared to an average energy density standard to determine the relative attractiveness of district heating. The basis for retaining districts for further analysis is an aggregated energy density of heating, hot water and process steam end-uses greater than 713 million Btu's/acre-year. Swedish data on the relative attractiveness of district heating was utilized as the basis for this decision.[(3)] No comparable evaluation is undertaken for air conditioning since these energy densities are significantly lower than those for heating.

Each district is classified according to sector. Within each sector, end-uses are identified as follows:

- Heating
- Hot Water
- Cooling
- Process Steam (Industrial only).

The energy densities specified for each end-use are aggregated to achieve totals for each district. Estimates of areal extent (acres) and distance from a specified power plant are provided.

The methodology employed in Activity 1 is summarized below and displayed schematically in Figure 2. This approach is completed for each planning district in the three counties for the base year (1974):

- Identify building floor space (ft^2) by sector for each district
- Aggregate building floor space by sector for each district
- Estimate energy consumption by sector and end-use

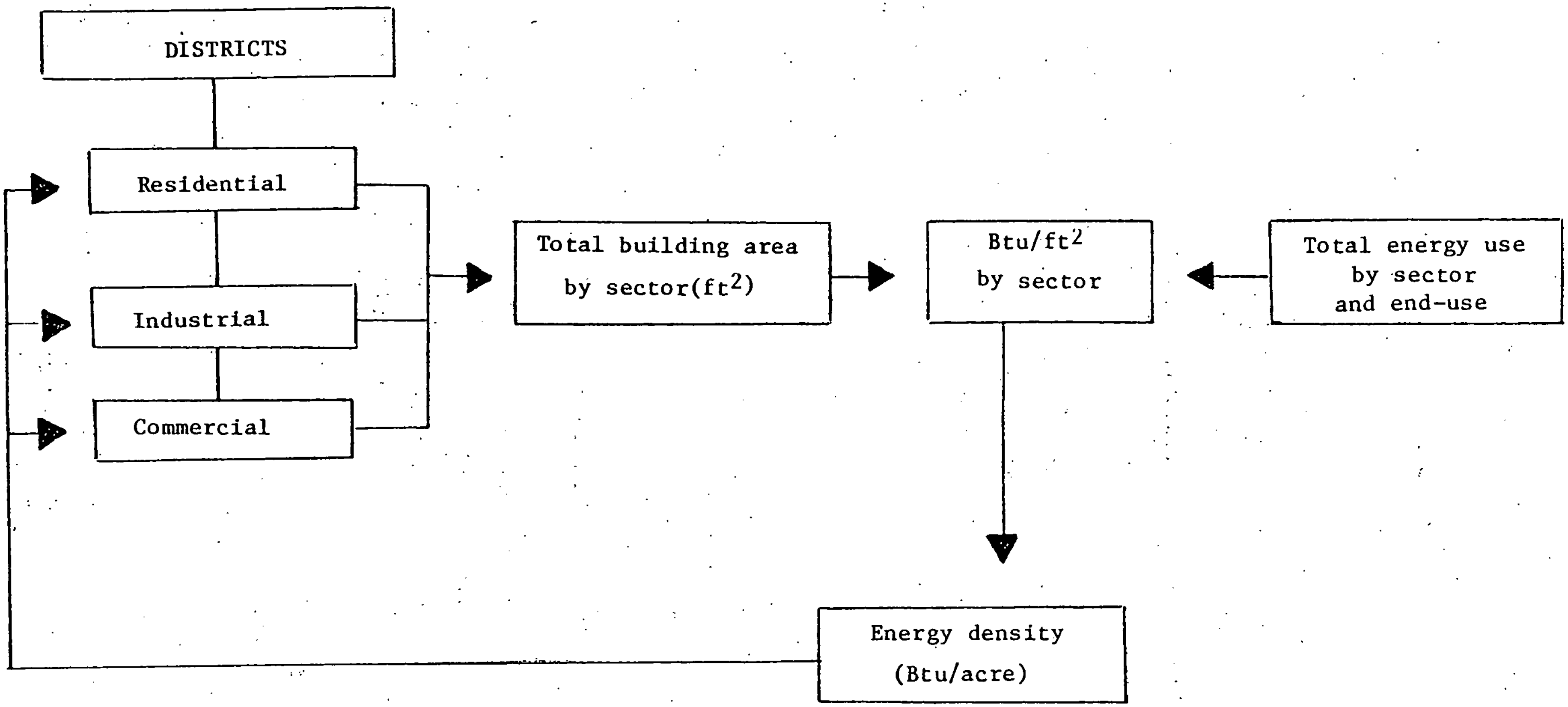

FIGURE 2. METHODOLOGY FOR ESTIMATING ENERGY DENSITY INDICATORS.

- Estimate building energy consumption (Btu/ft^2) by end-use and sector
- Estimate energy consumption densities (Btu/acre) of the district.

Building floor area for residential and commercial sectors was available by district from Toledo Metropolitan Area Council of Government's (TMACOG) 1974 Independent Variable Data Base.(4) Industrial data were obtained from the Ohio Industrial Directory. Industries and associated building areas were located in each district.

Energy consumption data were available at the county level from the Ohio Department of Energy for 1970. These figures were projected to the base year by applying annual growth rates for the State to the county. End-use consumption by sector was achieved by applying U.S. end-use patterns for 1968 to each county. Two major assumptions were made regarding end-use patterns for 1968 in each county. These were: (1) end-use patterns have not changed significantly since 1968, and (2) U.S. end-use patterns are applicable to Ohio counties.

Appendices A, B and C provide more detail on data sources and assumptions. Through this screening process, 31 districts were eliminated from further consideration in the next step of the analysis.

ACTIVITY 2: IDENTIFY ENERGY USE

In Activity 2, efforts were directed at obtaining estimates of annual and peak load requirements for each potential district heating system. These data were useful in identifying potential thermal loads at a candidate power plant and in estimating potential markets for district heating.

Energy density data are translated to annual requirements by sector and end-use for each district. Estimates of market penetration were made and then converted to peak capacity. It was assumed that peak capacity is reached at 5°F in a given year.

Data at the district level were not in the detail sufficient for analyzing potential distribution schemes, system type (hot water or steam), and related economic costs. These aspects are addressed in Activity 3.

ACTIVITY 3: SELECT SERVICE AREAS

This final effort required consideration of specific areas within districts in order to develop and compare energy densities, thermal loads and related cost data.

Subdistricts with significant energy densities and energy demand were identified for further study in this phase. Additional planning subdistricts surrounding these areas demonstrating intense concentration of building areas were included as possible areas for extending distribution lines. The residential sector was excluded from the preliminary analysis.

Energy densities were then obtained for heating by using an average of 165,000 Btu/ft^2-year. This estimate is corroborated by ASHRAE estimates of energy consumption in conventional office buildings.[5]

A number of options were then formulated for hot water and steam based on:

- Location of planning subdistrict relative to candidate power plants
- Assumed market penetration
- Annual and peak loads
- Load density
- Areal extent
- Building area.

Cost estimates were made encompassing the following elements:

- Power plant retrofit
- Operating and maintenance costs for each power plant retrofit
- Transmission costs
- Distribution costs
- Consumer retrofit costs
- Energy Losses.

Using these costs, estimates of the cost to deliver and use thermal energy in these subdistricts were made and compared with those for alternative energy sources. Current and future costs were considered. Subdistricts demonstrating potential on the basis of costs in the near to mid-term were then identified as areas appropriate for the energy market study(Task 3). Cooling options were examined from an energy efficiency perspective.

RESULTS

ACTIVITY 1: IDENTIFY SERVICE AREAS

Energy density indicators are provided in Table 1 for Lucas County and Tables B-1 and C-1 for Ottawa and Wood Counties. For each sector annual energy consumption per acre is indicated for various end-uses.

A review of the densities in the total columns indicate high densities for heating, hot water and process steam in several districts. The highest density is in District 1, the Toledo central business district. According to Swedish criteria specified in Table 2, this district is the most attractive. All districts having a total heating density for the above end-uses greater than 713 x 10^6 Btu/acre were retained for further study in order that all possibilities be examined. Districts 1-11, 15, 20, and 21 are the areas defined as meeting this criterion.

Heating densities for the study area are presented in Figure 1 and provide perspective on location of maximum densities with respect to the power plants. Downtown Toledo, the surrounding area to the west and a small portion to the south, are in relatively close proximity to the Bay Shore and Acme plants. These are the two plants included in the service area selection process.

TABLE 1. ENERGY DENSITY INDICATORS BY SECTOR (Lucas County)

Planning District	Areal Extent of Planning District (acres)	Linear Distance From Acme to District Center (miles)	ENERGY DENSITY INDICATORS (10^6 Btu/acre)										TOTALS		
			Commercial			Residential			Industrial		Cooling (a)				
			Heating	Hot Water	Cooling	Heating	Hot Water	Cooling	Heating	Process	Case 1	Case 2	Process	Heating and Hot Water	Cooling Case 1
1	849.7	1.31	2310.0	769.8	385.0	300.2	66.7	33.4	220.4	534.0	40.0	26.5	534	3667	458
2	1474.7	2.44	188.4	62.8	31.4	850.4	189.0	94.5	41.1	99.5	7.5	4.9	99	1332	133
3	1631.2	2.06	137.4	45.9	22.9	641.5	142.6	71.3	105.2	254.8	19.1	12.6	255	1073	113
4	2159.5	2.06	100.2	33.3	16.7	320.0	71.1	35.6	338.5	820.2	61.5	40.8	820	863	114
5-6	5916.6	0.75	75.0	25.0	12.5	283.8	63.1	31.5	99.6	241.4	18.1	12.0	241	546	62
7	5110.6	3.19	101.4	33.8	16.9	502.9	111.8	55.9	172.9	418.9	31.4	20.8	419	923	104
8	3391.6	4.50	99.0	32.9	16.5	327.2	72.7	36.3	488.8	1185.2	88.8	58.9	1185	1021	142
9	2013.6	4.31	118.2	39.5	19.7	558.2	124.0	62.0	54.1	131.0	9.8	6.5	131	894	91
10	2625.1	4.69	103.8	34.5	17.3	289.3	64.3	32.1	175.7	425.9	31.9	21.2	426	668	81
11	4030.6	3.94	23.4	7.7	3.9	18.5	4.1	2.0	384.2	941.3	70.6	46.8	941	438	76
12	2600.8	4.50	46.8	15.7	7.8	277.7	61.8	30.8	0	0	0	0	0	402	39
13	17194.7	4.50	9.0	2.9	1.5	38.7	8.6	4.3	12.2	29.5	2.2	1.4	29	71	8
16	5171.5	6.75	52.2	17.9	8.7	244.9	54.4	27.2	19.9	48.2	3.6	2.4	48	389	39
17	6946.3	8.81	69.6	23.2	11.6	95.9	21.3	10.6	12.6	30.5	2.3	1.5	30	223	24
18	10311.8	9.00	55.8	18.6	9.3	113.5	25.2	12.6	57.7	139.7	10.5	6.9	140	271	32
19	4096.3	6.94	199.2	80.0	33.2	186.4	41.4	20.7	16.6	40.2	3.0	2.0	40	524	57
20	1960.2	5.63	171.6	57.3	28.6	481.7	107.1	53.5	16.5	40.0	3.0	2.0	40	834	85
21	465.6	7.31	54.0	2.0	1.0	276.4	61.4	30.7	95.5	231.5	17.4	11.5	231	489	49
23	5720.5	9.75	46.8	15.6	7.8	102.8	22.8	11.4	0	0	0	0	0	188	19
24	8320.0	10.69	26.4	8.8	4.4	93.4	20.8	10.4	0	0	0	0	0	149	15
28	14248.8	9.56	2.4	0.8	0.4	5.3	1.2	0.6	0	0	0	0	0	10	1
34	1506.1	17.25	36.6	12.2	6.1	161.9	36.0	18.0	0	0	0	0	0	247	24
35	14733.9	13.50	1.2	0.4	0.2	9.6	2.1	1.1	0	0	0	0	0	13	1
36	16940.8	21.00	0.2	0.1	0.04	5.4	1.2	0.6	0	0	0	0	0	7	1
37	14384.8	18.75	2.0	0.6	0.3	8.5	1.9	0.9	0	0	0	0	0	13	1
38	22025.2	15.19	2.0	0.6	0.3	12.0	2.7	1.3	0.4	1.1	0.1	0.0	1.1	18	2
39	19221.2	16.13	0.6	0.2	0.1	4.1	0.9	0.5	2.8	6.8	6.8	0.3	6.8	9	1

(a) Industrial cooling demand was not available. This was estimated by assuming commercial space heating/cooling ratios of 5:1 are applicable to industry. This is Case 1. A more conservative estimate is Case 2, with a ratio of 10:1.

Source: Appendix A, Tables A-2 and A-3.

TABLE 2. ATTRACTIVENESS OF DISTRICT HEATING AS A FUNCTION OF DENSITY OF ENERGY USE[(a)]

Peak Density MM Btu/hr-acre	Average Corrected Load Density MM Btu's/yr-acre	Type of Land Use (Typical)	Attractiveness (Relative)
0.97	> 2470	Downtown, high-rise	Very favorable
0.70-0.97	1782 to 2470	Downtown, multi-story	Favorable
0.28-0.70	713 to 1780	City Core, Commercial or multi-family apartment	Possible
0.17-0.28	433 to 713	Residential, four two-family houses	Questionable
0.17	< 433	One family houses	Not possible

(a) This reference presented data in units of millions of Btu's per hour-acre/at peak load. This interpretation of the data was confirmed with Dr. Michael A. Karnitz of ORNL in a telephone conversation November 3, 1978.

Average load may be approximated by:

$$\frac{\text{MM Btu peak/hr-acre (24 hr/day) (6366 heating degree days/yr)}}{\text{(60 heating degree days/day at peak)}}$$

or

$$\frac{\text{2546.4 MM Btu/year average}}{\text{MM Btu/hr peak}}$$

Thus, the data in the reference were converted from MM Btu(hr-acre/peak) to MM Btu/yr-acre (average) by multiplying by 2546.4.

Source: Wahlman, Erik, "Energy Conservation Through District Heating- A Step by Step Approach," Districk Heating Workshop, October 1978, p.7.

ACTIVITY 2: IDENTIFY ENERGY USE

Annual energy consumption figures for the districts identified in Activity 1 were derived from Tables 1, and C-1 and are presented in Table 3. Shares of the potential market were estimated in order to determine total annual consumption for heating requirements. These results are displayed in Table 4.

In order to determine the required power plant capacity at peak load, it was necessary to convert the figures in Table 4, expressed as average million Btu/year, to million Btu/hour at peak. The results of this conversion and the associated assumptions are provided in Table 5. It is apparent that the hourly consumption at peak demand is considerably more than the current steam load (170 x 10^6 Btu/hr), even in District 1. Economic and technical factors considered in Activity 3 adjust the estimates accordingly.

ACTIVITY 3: SELECT SERVICE AREAS

Projected conventional energy costs (1978 dollars) are compared with the estimated cost of using thermal energy to provide a basis for selecting potential service areas for the energy market survey. The results of an energy analysis of various cooling options for an Acme retrofit scheme are also presented.

TABLE 3. 1974 ANNUAL ENERGY CONSUMPTION BY SECTOR AND END-USE (10^9 Btu).

Planning District	Commercial			Residential			Industrial				Totals		
	Heat	Hot Water	Cool	Heat	Hot Water	Cool	Heat	Process	Cool Case 1	Cool Case 2	Heat & Hot Water	Process	Cool[(a)]
1	1963	654	327	255	57	28	187	454	34	22	3116	454	337
2	278	93	46	1254	278	139	61	147	11	7	1964	147	196
3	224	75	37	1046	233	116	172	416	31	20	1750	416	184
4	216	72	36	691	153	77	731	1771	133	88	1863	1771	246
5-6	444	148	74	1679	373	186	589	1428	107	71	3233	1428	367
7	518	173	86	2570	571	286	884	2141	160	106	4716	2141	532
8	336	111	56	1110	246	123	1658	4020	301	200	3461	4020	480
9	238	79	40	1124	250	125	109	264	20	13	1800	264	185
10	272	90	45	759	169	84	461	1118	84	56	1751	1118	213
11	94	31	16	74	16	8	1549	3794	285	189	1764	3794	309
15	56	19	9	446	102	46	330	414	68	33	953	414	123
20	336	112	56	944	210	105	32	78	6	4	1634	78	167
21	251	9	5	1287	286	143	445	1078	81	53	2278	1078	229

(a) Case 1 included in total.

Source: Table 2.

TABLE 4. ANNUAL ENERGY CONSUMPTION AT ESTIMATED MARKET PENETRATIONS (10^6 Btu/Year)

Planning Districts	COMMERCIAL Heating and Hot Water 40%	INDUSTRIAL Heating 80%	INDUSTRIAL Process 20%	RESIDENTIAL Heating and Hot Water 1.0%	TOTAL Heating and Hot Water	TOTAL Process
1	1046800	149600	90800	3120	1199520	90800
2	148400	48800	29400	15320	212520	29400
3	119600	137600	83200	12790	269990	83200
4	115200	584800	354200	8440	708440	354200
5-6	236800	471200	285600	20520	728520	285600
7	276400	707200	428200	31410	1005010	428200
8	178800	1326400	804000	13560	1518760	804000
9	126800	87200	52800	13740	227740	52800
10	144800	368800	223600	9280	522880	223600
11	50000	1239200	758800	900	1290100	758800
15	30000	264000	828000	54800	348800	82800
20	179200	25600	15600	11540	216340	15600
21	104000	356800	215600	15730	476530	215600

Source: Table 3.

TABLE 5. REQUIRED CAPACITY AT ESTIMATED MARKET PENETRATION (10^6Btu/hr)[(a)]

Planning Districts	COMMERCIAL Heating and Hot Water	INDUSTRIAL Heating	INDUSTRIAL Process	RESIDENTIAL Heating and Hot Water	TOTALS Heating and Hot Water	TOTALS Process
1	411.392	58.793	15.164	1.226	471.411	15.164
2	58.321	19.178	4.910	6.021	83.520	4.910
3	47.002	54.077	13.894	5.026	106.105	13.894
4	45.274	229.826	59.154	3.317	278.417	59.154
5-6	93.062	185.182	47.695	8.064	286.308	47.695
7	108.62	277.930	71.509	12.344	398.894	71.509
8	70.268	521.270	134.268	5.329	596.867	134.268
9	49.832	34.270	8.818	5.400	89.502	8.818
10	56.906	144.938	37.341	3.647	205.491	37.341
11	19.650	487.006	126.720	0.354	507.010	126.720
15	1.790	103.752	13.828	21.536	137.078	13.828
20	70.426	10.060	2.605	4.535	85.021	2.605
21	40.872	140.222	36.005	6.182	182.276	36.005

(a) Space heating and hot water: Assumed 6366 heating degree days and 5°F at peak.
Process steam: Assumed an average between two possible operating situations with a coincident peak demand of 90%-4680 and 8000 operating hours per year.

Source: Table 4.

Projected Energy Prices

Current energy prices (1978 dollars) for the Toledo Metropolitan Area were projected through 1990 in constant 1978 dollars based on the application of annual growth rates in prices by energy source. The real growth rates are based on the Energy Information Administration's (USDOE)[6] medium demand and supply (oil and natural gas) case which assumes energy policies prior to the enactment of the 1978 National Gas Policy Act (NGPA). These projections are provided in Table 6 by energy source and sector in \$/MM Btu (where MM Btu = 10^6 Btu). It is assumed that the price of natural gas will not exceed the price of oil by more than ten percent.

The extensive reliance on natural gas in the Toledo area warranted more detailed consideration of natural gas prices for potential large users (commercial and industrial) of thermal energy from a district heating system. Low, medium and high cases for natural gas prices are utilized to account for the current uncertainty over price projections and are presented in Table 7 for the commercial and industrial sector. This range spans the estimates of various sources, including the AGA[(7)], which is one of the first studies to measure the economic impacts of the NGPA. Costs for natural gas in the time frame 1985-1990 are the basis of a comparison with thermal energy costs.

Costs of Delivering Thermal Energy

Planning subdistricts within districts identified in Activity 2 were identified for detailed consideration. Areal extent, building floor area and annual average thermal loads are provided in Table 8. Figures 3 and 4 indicate the location of these subdistricts. Parenthetically, it should be noted that subdistricts 1-21 are subdivided into an area encompassing the existing system (includes potential for new market) and one for extension of service beyond the existing service area. These

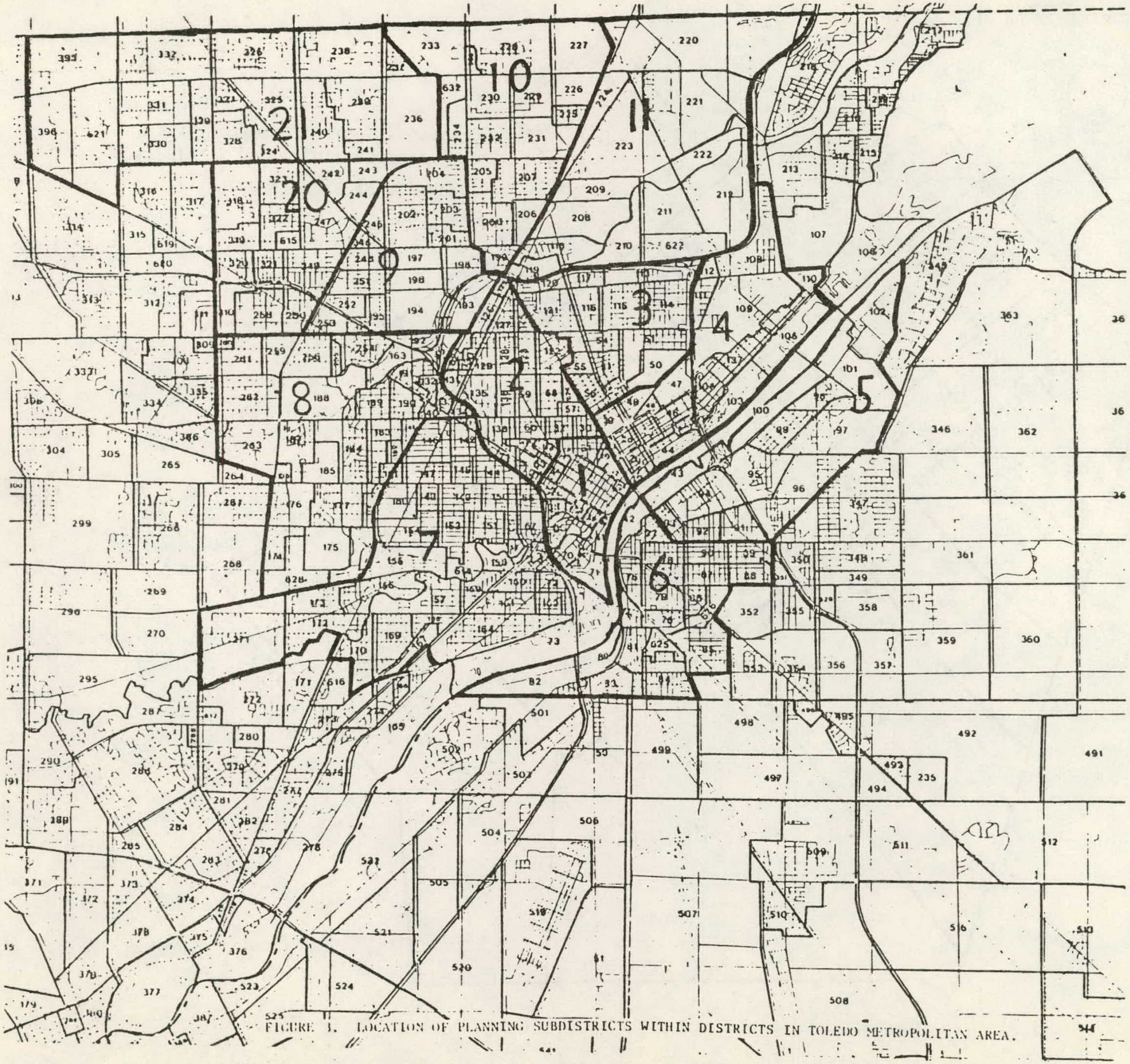

FIGURE 3. LOCATION OF PLANNING SUBDISTRICTS WITHIN DISTRICTS IN TOLEDO METROPOLITAN AREA.

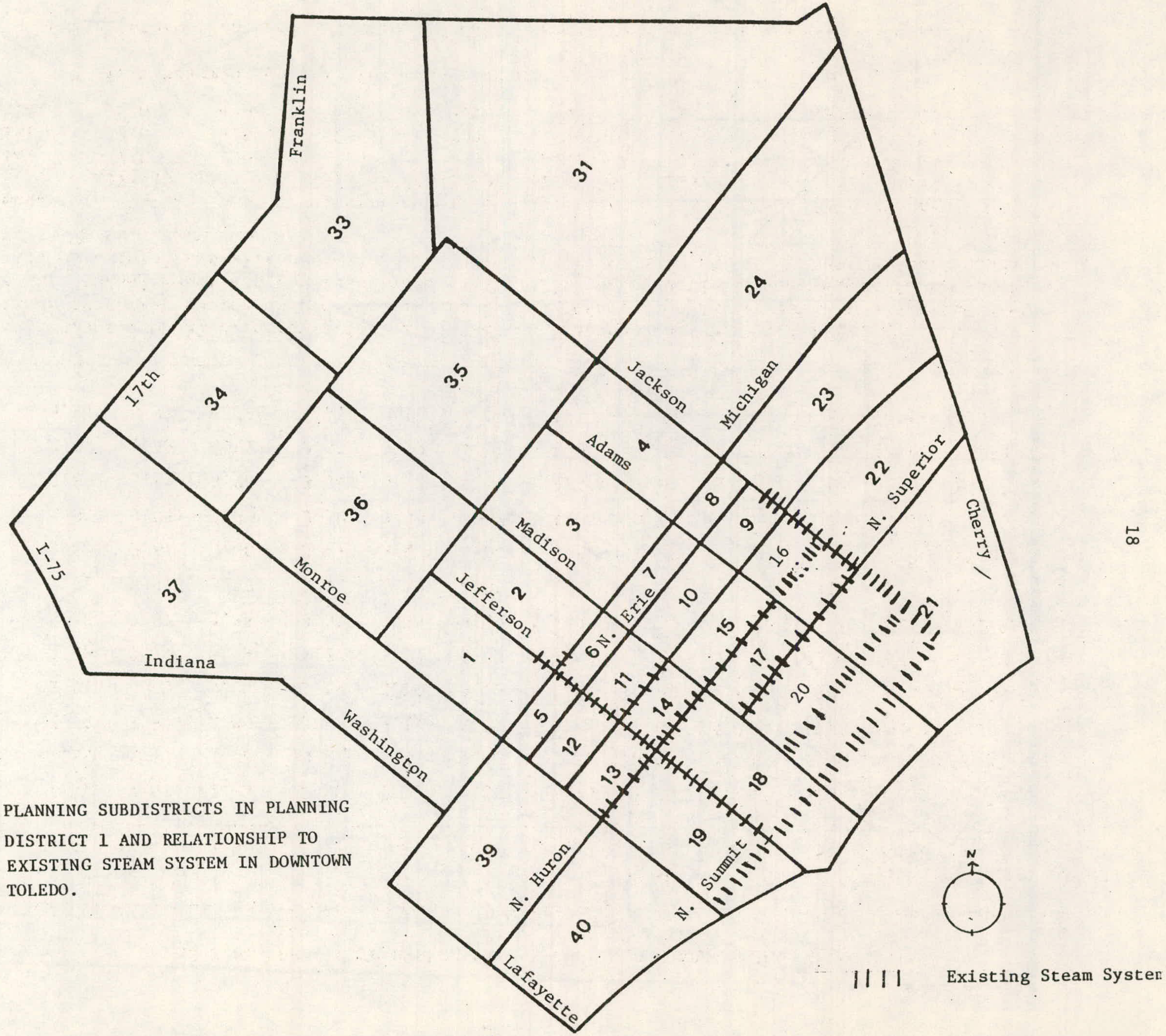

FIGURE 4. PLANNING SUBDISTRICTS IN PLANNING DISTRICT 1 AND RELATIONSHIP TO EXISTING STEAM SYSTEM IN DOWNTOWN TOLEDO.

TABLE 6. PROJECTED ENERGY PRICES FOR TOLEDO AREA (1978 $/MM Btu)(a)

	Natural Gas			Oil			Coal			Electricity		
Year	Ind.	Com.	Res.	Ind.	Com.	Res.	Ind.	Com.	Res.	Ind.	Com.	Res.
1979	2.41	2.47	2.63	2.96	2.96	3.56	3.23	3.23	4.28	9.09	14.80	14.74
1980	2.58	2.67	2.76	3.03	3.03	3.63	3.50	3.50	4,50	9.40	14.94	14.83
1981	2.76	2.83	2.89	3.11	3.11	3.70	3.69	3.69	4.74	9.72	15.09	14.91
1982	2.95	3.03	3.04	3.19	3.19	3.78	3.89	3.89	4.99	10.05	15.24	15.00
1983	3.16	3.24	3.19	3.27	3.27	3.85	4.09	4.09	5.26	10.39	15.40	15.09
1984	3.38	3.47	3.35	3.35	3.35	3.93	4.31	4.31	5.53	10.75	15.55	15.19
1985	3.62	3.71	3.52	3.43	3.43	4.01	4.54	4.54	5.83	11.11	15.71	15.28
1986	3.80	3.81	3.66	3.47	3.47	4.04	4.58	4.58	5.90	11.22	15.80	15.35
1987	3.85	3.85	3.80	3.50	3.50	4.08	4.62	4.62	5.97	11.33	15.90	15.43
1988	3.89	3.89	3.96	3.54	3.54	4.12	4.66	4.66	6.04	11.45	15.99	15.51
1989	3.92	3.92	4.12	3.57	3.57	4.16	4.70	4.70	6.11	11.56	16.09	15.58
1990	3.97	3.97	4.28	3.61	3.61	4.19	4.74	4.74	6.19	11.68	16.18	15.66

(a) Projections from 1978 energy prices are based on the application of annual growth rates in prices by energy source as provided in the Energy Information Administration's average case in the "Annual Report to Congress--Volume II"(1977). An additional assumption is that the price of natural gas will not exceed the price of oil by more than 10%. The annual growth rates (%) applied are as follows:

Sector	Natural Gas		Distillate Oil		Coal		Electricity	
	1975-85	1985-90	1975-85	1985-90	1975-85	1985-90	1975-85	1985-90
Industrial	7.0	5.0	2.5	1.0	5.3	0.9	3.4	1.[illegible]
Commercial	7.0	4.0	2.5	1.0	NA*	1.2	1.0	0.[illegible]
Residential	5.0	4.0	2.0	0.9	NA*	1.2	0.6	0.[illegible]

* 5.3% assumed to apply for these cases.

Source: Energy Information Administration, USDOE, "Annual Report to the Congress--Volum[illegible] II, 1977.

Current energy prices for the Toledo area were obtained through telephone commur ications with Columbia Gas (natural gas), Toledo Edison (electricity) and independent su[illegible]pliers (coal and fuel oil).

TABLE 7. PROJECTED NATURAL GAS COSTS ($/MM Btu)[a] FOR TOLEDO AREA IN 1978 DOLLARS FOR THREE DEMAND CASES: INDUSTRIAL AND COMMERCIAL SECTOR.

	INDUSTRIAL			COMMERCIAL		
Year	Low	Medium	High	Low	Medium	High
1979	3.09	3.21	3.31	3.17	3.29	3.35
1980	3.19	3.44	3.63	3.27	3.56	3.73
1981	3.28	3.68	3.97	3.36	3.77	4.09
1982	3.39	3.93	4.38	3.47	4.04	4.51
1983	3.48	4.21	4.83	3.57	4.32	4.84
1984	3.59	4.51	4.97	3.68	4.63	4.97
1985	3.69	4.83	5.11	3.79	4.95	5.11
1986	3.80	5.07	5.16	3.93	5.08	5.16
1987	3.85	5.13	5.21	4.09	5.13	5.21
1988	4.04	5.19	5.27	4.25	5.19	5.27
1989	4.16	5.23	5.31	4.43	5.23	5.31
1990	4.28	5.29	5.37	4.61	5.29	5.37

(a) Assumes 0.75 gas efficiency at end-use (Source: Science and Policy Program, University of Oklahoma, "Energy Alternatives--A Comparative Analysis", Prepared for Council on Environmental Quality etal, 1975).

Source: Energy Information Administration, USDOE, "Annual Report to the Congress--Volume II", 1977.

TABLE 8. ANNUAL AVERAGE LOADS FOR SUBDISTRICTS.

		COMMERCIAL[a]		INDUSTRIAL[b]		TOTAL LOADS(10^6Btu/yr)
Subdistrict(s)	Areal Extent (Acres)	10^3ft^2	Average Load 10^6Btu/yr	10^3ft^2	Average Load 10^6Btu/yr	Average
1-21(existing)	57	2543	428000	--	--	428000
1-21(extended)	63	436	72000	--	--	72000
24	26	29	--(c)	1200	158400	158400
29	77	109	--	400	52800	52800
34,36	57	559	36894	--	--	36894
34,37	141	1135	74910	--	--	74910
44	97	34	--	363	47916	47916
47	67	25	--	370	48840	48840
64	13	94	6204	--	--	6204
100	325	0	--	1488	196416	19646
193	188	0	--	5500	726000	726000
193,118,119	542	161	--	6805	898260	898260
193,118,119,206	634	162	--	8055	1063260	1063200
209,203	671	57	--	2523	333036	33036
183	126	62	--	2777	366564	366564
177,175,628,174	645	167	--	2967	391644	391644
263	253	16	--	2160	285120	285120
171,172	516	9	--	931	122892	122892
221,222	787	61	--	585	77220	77220
315	106	(1041)(d)	--	1041	137412	137412
291	231	(1582)(d)	--	1582	208824	208824
519	880	5000	--	(5000)(d)	--	--

(a) Assumes 40% market penetration.
(b) Assumes 80% market penetration.
(c) No estimates completed because density too low to consider a general distribution system or no building area for category in subdistrict
(d) Indicates original categorization of building area. Shifted because of building characteristics.

Source: Tables 1, A-2 and A-3.

data provided the basis for specifying possible district heating schemes for the downtown and outlying areas.

Relevant parameters (e.g. peak thermal load, distance from thermal energy source, areal extent) were defined for potential district heating schemes to permit development of associated capital and operating costs for various retrofit schemes. The data from which capital and operating costs were derived are provided in Appendix D.

The district heating schemes defined for steam and hot water systems and their associated costs are displayed in Tables 9, 10 and 11. An annualized capital charge rate of 10% in real terms (17%, nominal terms) was assumed for comparison with the real cost projections of natural gas. This charge rate was applied to both utility and private investments to facilitate computations. Peak hourly demand was translated to average annual demand assuming 6366 heating degree days per year and 60 heating degree days on the coldest day. (See Table 2 for definition of the equation utilized to approximate average load).

An important distinction between Table 9, and Tables 10 and 11, should be clarified at this point. This relates to the assumption of thermal demand on the district heating system, and consequently, the impact of these demands on total costs. Thermal demands in Table 9 represent low to moderate extensions of the existing steam system and are integrated with moderately-sized power plant thermal retrofit capacities. In Tables 10 and 11, however, thermal demands are substantially higher and approach the upper limit of power plant thermal retrofit capacities. Each case in these tables assumes the available thermal capacity is sold out. Actual thermal demands in the near-to mid-term would not reach these levels. As a consequence, the costs in these two tables underestimate the real cost where a given case does not reflect full utilization of the capacity available from the power plant retrofit.

TABLE 9. AVERAGE DISTRICT HEATING SYSTEM COSTS ($/10^6 BTU)* AS A FUNCTION OF THERMAL DEMAND ON THE DISTRICT HEATING SYSTEM FOR TWO POWER PLANT RETROFIT SCHEMES AT ACME (1978 DOLLARS)[a]

Case[b]	Subdistricts in Service Areas[c]	Energy Form Delivered[d]	Plant Retrofit Scheme [Energy Form Produced, Peak Capacity (10^6 Btu/hr)][e]	Power Plant Retrofit[f]		Fuel Cost[g]	Transmission Lines and Auxiliaries[h]			Distri-bution[i]	Trans./ Dist. O&M[j]	Genl. Adm.[k]	Subtotal (Pretax)[l]	Subtotal (w/Taxes)[m]	Subtotal (Accounts for Thermal losses)[n]	User Retrofit[o]	Total[p]
				Power Plant	Misc. O&M		Trunk	Main	Aux.								
1	Existing System	S	A_1a (S,195)	0.13	0.33	1.22	0.55	0	0	0	0.34	0.06	2.63	2.97	3.71	0	3.71
2	Existing System	S	A_3e_2 (S,288)	0.01	0.33	1.22	0.68	0	0	0	0.34	0.06	2.64	2.98	3.50	0	3.50
3	Case 2, plus connection of additional customers in existing system	S	A_3e_2 (S,288)	0.01	0.28	1.22	0.58	-	0	(0)	0.34	0.06	2.49	2.83	3.33	0-0.25	3.33-3.58
4	Case 3, plus extensions in 1 thru 21	S	A_3e_2 (S,288)	0.01	0.24	1.22	0.50	-	0	0.25	0.34	0.06	2.63	2.96	3.48	0-0.25	3.48-3.73

*For each case, the total cost in the last column represents the real cost of delivering and using thermal energy. Each case may therefore be examined independently to determine the impact of thermal demands on district heating system costs. The reader is cautioned not to interpret this data as the result of an economic analysis. Cost estimates were determined for the sole purpose of identifying and ultimately selecting potential service areas for conducting an energy market study. Reference to the text and footnotes is essential to understanding the basis of calculations and application of results.

FOOTNOTES TO TABLE 9

(a) Costs to deliver and use energy ($/MM Btu, where 10^6 = MM Btu) to sub-districts within and surrounding the existing steam system are provided for two power plant retrofit schemes designed to produce steam. For each case, the total cost in the last column represents the real cost of delivering and using thermal energy. Each case may therefore be examined independently to determine the impact of thermal demand on district heating costs.

In general, capital and operating costs of elements of the district heating system have been provided by Stone and Webster Engineering Corporation and presented in Appendix D. The formula utilized to translate capital investments to average costs per unit of energy was:

$$V = \frac{W \cdot X}{Y \cdot Z}$$

where V = average cost per unit energy ($/MM Btu)
W = capital cost ($)
X = annualized capital charge in real terms = 0.10
Y = peak hourly demand (MM Btu/hour)
Z = conversion factor to convert peak demand (MM Btu/hour) to average demand (MM Btu/year) = 2546 (See Table 2 for the derivation of this factor).

This formula was applied to capital investments associated with the district heating system, i.e., footnotes "f" (power plant only), "h", "i", and"o". The footnotes reference how operating costs were derived.

The reader is referred to the footnotes and text for an explanation of the methodology, assumptions and results.

(b) Cases are numbered consecutively and grouped according to power plant retrofit schemes. Each case represents selected subdistricts with a specified thermal load. Extension of service areas for increased thermal loads is achieved to determine the effects on total system costs for each power plant retrofit scheme.

(c) Location of subdistrict are specified in Figures 3 and 4.

(d) The energy form delivered is specified as S (steam).

FOOTNOTES TO TABLE 9 (continued)

(e) Power plant retrofit schemes are lettered and numbered for identification purposes. A description of the scheme, steam/hot water conditions, and capital costs are defined in Appendix D. Included in parentheses are the energy form produced and the peak capacity.

(f) Power plant costs represent the capital investment to retrofit the power plant for the retrofit scheme specified. Miscellaneous operating and maintenance costs (at the power plant) are 40 percent of the fuel costs at the Acme plant.

(g) The actual fuel cost for coal chargable to a thermal energy system in 1978 was estimated at $0.85 MM Btu. This cost was escalated to 1985 with a real annual growth rate of 5.3 percent (see Table 6) to reflect the cost at the time when the district heating system is estimated to be operational.

(h) Transmission lines have been termed "trunk lines" and "main" lines. The trunk line is the transmission line from Acme to the Water Street Station (existing oil-fired district heating plant) or the transmission line extending from Bayshore to Acme. Main lines extend from the Water Street Station to the subdistrict(s) served. Capital investments for these transmission lines include costs for pumping stations and steam pressure reduction valves. A dash (--) in the column entitled "Mains" indicates costs are included in the distribution network. Auxiliary costs represent costs for heat exchangers where there is conversion of steam to hot water for transmission to more distant subdistricts.

(i) Distribution costs are investments for lines extending from the main lines to subdistricts. In some cases (see Footnote "h") distribution and transmission line costs have been combined. Distribution costs to connect new customers adjacent to the existing system in Case 3 have not been determined and are assumed to be negligible in this analysis.

(j) Operating and maintenance costs for transmission and distribution lines are based on actual costs in 1976 for maintaining the existing steam system (Source: Toledo Edison). These costs were inflated to 1978 dollars and divided by the sales for that year to obtain an average cost of $0.34/MM Btu.

(k) General and administrative costs include two elements, customer accounting and an administrative cost of 1.29% on annualized capital costs (Source: Toledo Edison). Customer accounting costs, based on actual costs for 1976, were inflated to 1978 dollars and divided by annual sales to obtain a cost of $0.05/MM Btu. The administrative cost on capital investment averaged $0.01/MM Btu. The total cost for this category is therefore $0.06/MM Btu.

FOOTNOTES TO TABLE 9 (continued)

(l) The pretax subtotal is the sum of the entries in the row.

(m) A tax of $0.34/MM Btu is added to the pretax subtotal. This includes $0.24/MM Btu as a gross receipts tax (4 percent of an average steam cost (before taxes) of $6.07/MM Btu) and $0.10/MM Btu for personal property and other taxes (excluding federal income taxes). The personal property and other tax category costs are based on actual costs and sales in 1977. (Source: Toledo Edison).

(n) The subtotal (with taxes) is adjusted for thermal losses in transmission and distribution. These thermal losses are as follows:

Existing steam system	20%
New hot water system	10%
New steam system	10%
Existing steam plus new steam/hot water system	15%

(o) User retrofit costs are average costs to connect end-user systems to steam supplied by district heating. This range of estimates includes a cost of zero for an existing steam customer and $0.25/MM Btu for a customer with a peak demand of 1.6 MM Btu/hour. Refer to Table 10, footnote "o" for capital costs associated with this latter case.

(p) The total column represents the total cost to the user to convert from an existing energy source to steam from district heating.

TABLE 10. AVERAGE DISTRICT HEATING SYSTEM COSTS* ($/$10^6$ BTU) FOR VARIOUS POWER PLANT RETROFIT SCHEMES: INTEGRATED DISTRICT HEATING SYSTEM (1978 DOLLARS)[a]

Case[b]	Subdistricts in Service Areas[c]	Energy Form Delivered[d]	Plant Retrofit Scheme [Energy Form Produced, Peak Capacity (10^6 Btu/hr)][e]	Power Plant Retrofit[f]		Fuel Cost[g]	Transmission Lines and Auxiliaries[h]			Distri-bution[i]	Trans./Dist. O&M[j]	Genl. Adm.[k]	Subtotal (Pretax)[l]	Subtotal (w/Taxes)[m]	Subtotal (Accounts for Thermal losses)[n]	User Retrofit[o]	Total[p]
				Power Plant	Misc. O&M		Trunk	Main	Aux.								
5	Existing System	S	A_3b (S,527)	0.36	0.33	1.22	0.19	0	0	0	0.34	0.06	2.50	2.84	3.55	0	3.55
6	Case 5, plus extension in 1-21	S	A_3b (S,527)	0.36	0.33	1.22	0.19	-	0	0.25	0.34	0.06	2.75	3.09	3.63	0-0.25	3.63-3.88
7	Case 6, plus 34, 36	S	A_3b (S,527)	0.36	0.33	1.22	0.19	-	0	0.43	0.34	0.06	2.93	3.27	3.85	0-0.25	3.85-4.10
8	Case 7, plus 34 thru 37	S	A_3b (S,527)	0.36	0.33	1.22	0.19	-	0	0.70	0.34	0.06	3.20	3.54	4.16	0-0.25	4.16-4.55
9	Existing System	S/HW	A_3d_2 (S,476)	0.40	0.33	1.22	0.21	0	0	0	0.34	0.07	2.57	2.91	3.64	0	3.64
10	Case 9, plus extension in 1-21	S/HW	A_3d_2 (S,476)	0.40	0.33	1.22	0.21	-	0.07	0.24	0.34	0.07	2.88	3.22	3.79	0-0.25	3.79-4.04
11	Case 10, plus 34, 36	S/HW	A_3d_2 (S,476	0.40	0.33	1.22	0.21	-	0.07	0.61	0.34	0.07	3.25	3.59	4.22	0-1.25	4.22-4.47
12	Case 11, plus 34 thru 37	S/HW	A_3d_2 (S,476)	0.40	0.33	1.22	0.21	-	0.07	1.21	0.34	0.07	3.85	4.19	4.93	0-1.25	4.93-6.18
13	Existing System	HW	A_3d_1 (S,440)	0.43	0.33	1.22	0.23	-	0.07	2.74	0.34	0.06	5.42	5.76	6.40	1.31	7.71
14	Case 13, plus extension in 1-21	HW	A_3d_1 (S,440)	0.43	0.33	1.22	0.23	-	0.07	2.86	0.34	0.06	5.54	5.88	6.53	1.25-1.31	7.78-7.84
15	Case 14, plus 34, 36	HW	A_3d_1 (S,440)	0.43	0.33	1.22	0.23	-	0.07	3.07	0.34	0.06	5.75	6.09	6.77	1.25-1.31	8.02-8.08
16	Case 15, plus 34-37	HW	A_3d_1 (S,440)	0.43	0.33	1.22	0.23	-	0.07	3.40	0.34	0.06	6.08	6.42	7.13	1.25-1.31	8.38-8.44
17	Existing System	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	-	0	2.74	0.34	0.09	5.57	5.91	6.57	1.31	7.88
18	Case 17, plus extension in 1-21	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	-	0	2.86	0.34	0.09	5.69	6.03	6.70	1.25-1.31	7.95-8.01
19	Case 18, plus 34, 36	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	-	0	3.47	0.34	0.09	6.30	6.64	7.38	1.25-1.31	8.63-8.69
20	Case 19, plus 34 thru 37	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	-	0	3.40	0.34	0.09	6.23	6.57	7.30	1.25-1.31	8.55-8.61
21	Existing System	HW	B_1 (HW,400)	0.15	0.21	1.22	3.46	0	0	2.74	0.34	0.11	8.23	8.57	9.52	1.31	10.83
22	Case 21, plus 100	HW	B_1 (HW,400)	0.15	0.21	1.22	3.46	0	0	1.98	0.34	0.11	7.47	7.81	8.67	1.25-1.31	9.92-9.98
23	Case 22, plus extensions in 1-21 and 34-37	HW	B_1 (HW,400)	0.15	0.21	1.22	3.46	0	0	1.09	0.34	0.11	6.58	6.92	7.69	1.25-1.31	8.94-9.00

*For each case, the total cost in the last column does not represent the real cost of delivering and using thermal energy. The system capacity is applied to all cost components (except distribution) within each case for a particular retrofit scheme regardless of the thermal demand of the area(s) served on the basis that the capacity of the district heating system would be utilized once all service area demands were aggregated. This situation occurs in the last case for a specified plant retrofit scheme. Distribution costs, on the other hand, were calculated according to the additional demand served on the basis that capital costs would be allocatable only to the new area served.

The reader is cautioned not to interpret this data as the result of an economic analysis. Cost estimates were determined for the sole purpose of identifying and ultimately selecting potential service areas for conducting an energy market study. Reference to the text and footnotes is essential to understanding the basis of calculations and application of results.

FOOTNOTES TO TABLE 10

(a) Costs to deliver and use energy ($/MM Btu, where 10^6 Btu = MM Btu) to sub-districts within and surrounding the existing steam system are provided for five power plant retrofit schemes involving the Acme (Cases 5-20) and Bayshore (Cases 21-23) plants.

In general, capital and operating costs of elements of the district heating system have been provided by Stone and Webster Engineering Corporation and are presented in Appendix D. Refer to Table 9, footnote "a" for a definition of the formula used to translate capital investments to average costs per unit of energy. The reader is referred to the footnotes and text for an explanation of the methodology, assumptions, and results.

(b) See Table 9.

(c) See Table 9.

(d) The energy form delivered is specified as S (steam); HW (hot water); or S/HW (steam and hot water). For the combined S/HW district heating system, the energy form delivered to the incremental thermal load is underlined.

(e) See Table 9.

(f) Power plant costs represent the capital investment to retrofit the power plant for the retrofit scheme specified. Miscellaneous operating and maintenance costs (at the power plant) are 40 and 20 percent of fuel costs for Acme and Bayshore plants, respectively.

(g)-(j) See Table 9.

(k) General and administrative costs include two elements, customer accounting and an administrative cost of 1.2% on annualized capital costs (Source: Toledo Edison). Customer accounting costs, based on actual costs for 1976, were inflated to 1978 dollars and divided by annual sales to obtain a cost of $0.05/MM Btu. The administrative cost, based on total capital investments, ranged from $0.01/MM Btu to $0.06/MM Btu, depending on the power plant retrofit scheme under consideration.

(l)-(n) See Table 9.

FOOTNOTES TO TABLE 10 (continued)

(o) User retrofit costs are average costs to connect end-user systems to steam or hot water supplied by district heating. Four options have been specified:

Option	Peak Customer Demand (MM Btu/hr)	Capital Investment	$/MM Btu
•Conversion of existing steam customers to district hot water system	1.5	50,000	1.31
•Conversion of an existing hot water system supplied by boilers to district hot water system	1.5	10,000	0.26
•Conversion of energy from district hot water system to supply end-user system	1.6	51,000	1.25
•Conversion of energy from district steam system to supply end-user system.	1.6	10,000	0.25

(p) See Table 9.

TABLE 11. AVERAGE DISTRICT HEATING COSTS* ($/$10^6$ BTU) FOR ONE POWER PLANT RETROFIT SCHEME FROM ACME: INDEPENDENT EXTENSIONS OF DISTRICT HEATING SYSTEM (1978 DOLLARS)[a]

Basis/Case[b]	Subdistricts in Service Areas[c]	Energy Form Delivered[d]	Plant Retrofit Scheme (Energy Form Produced Peak Capacity (10^6 Btu/hr))[e]	Power Plant Retrofit[f]: Power Plant	Power Plant Retrofit[f]: Misc. O&M	Fuel Cost[g]	Transmission Lines and Auxiliaries[h]: Trunk	Transmission Lines and Auxiliaries[h]: Main	Transmission Lines and Auxiliaries[h]: Aux.	Distribution[i]	Trans./Dist. O&M[j]	Genl. Adm.[k]	Subtotal (Pretax)[l]	Subtotal (w/Taxes)[m]	Subtotal (Accounts for Thermal Losses)[n]	User Retrofit[o]	Total[p]
Acme: Individual and Combined Cases																	
24	24	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	0.79	0	0	0.34	0.09	3.62	3.96	4.40	0.26 - 1.25	4.66 - 5.65
25	24, 29	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	1.02	0	0	0.34	0.09	3.85	4.19	4.66	0.26 - 1.25	4.92 - 5.91
26	44	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	1.42	0	0	0.34	0.09	4.25	4.59	5.10	0.26 - 1.25	5.36 - 6.35
27	44, 47	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.05	0	0	0.34	0.09	4.88	5.22	5.80	0.26 - 1.25	6.06 - 7.05
28	100	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.10	0	0	0.34	0.09	4.93	5.27	5.86	0.26 - 1.25	6.12 - 7.11
29	193, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.10	0	0	0.34	0.09	4.93	5.27	5.86	0.26 - 1.25	6.12 - 7.11
30	193, 118, 119, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	1.91	0	0	0.34	0.09	4.74	5.08	5.64	0.26 - 1.25	5.90 - 6.89
31	193, 118, 119, 206, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	1.93	0	0	0.34	0.09	4.76	5.10	5.67	0.26 - 1.25	5.93 - 6.92
32	193, 118, 119, 206, 209, 223, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.00	0	0	0.34	0.09	4.83	5.17	5.74	0.26 - 1.25	6.00 - 6.99
33	183, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.41	0	0	0.34	0.09	5.24	5.58	6.20	0.26 - 1.25	6.46 - 7.45
34	183, 177, 175, 628, 174, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	3.21	0	0	0.34	0.09	6.04	6.38	7.09	0.26 - 1.25	7.35 - 8.34
35	183, 263, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.42	0	0	0.34	0.09	5.25	5.59	6.21	0.26 - 1.25	6.47 - 7.46
36	183, 263, 177, 175, 628, 174	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.28	0	0	0.34	0.09	5.11	5.45	6.05	0.26 - 1.25	6.31 - 7.30
Acme: Direct vs. Indirect Routes																	
37	Case 29 plus 33, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	1.65	0	0	0.34	0.09	4.48	4.82	5.35	0.26 - 1.25	5.61 - 6.60
38	183 plus 193, indirect (Monroe)	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.21	0	0	0.34	0.09	5.04	5.38	5.98	0.26 - 1.25	6.24 - 7.23
39	183, 193, 64, indirect (Monroe)	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.21	0	0.04	0.34	0.09	5.04	5.38	5.98	0.26 - 1.25	6.24 - 7.23
40	Case 32 plus 36, direct	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	1.98	0	0	0.34	0.09	4.81	5.15	5.72	0.26 - 1.25	5.98 - 6.97
41	193 series plus 183 series, indirect (Monroe)	HW	A_3a (HW,400)	0.36	0.33	1.22	0.49	2.14	0	0	0.34	0.09	4.97	5.31	5.90	0.26 - 1.25	6.16 - 7.15

*For each case, the total cost in the last column does not represent the real cost of delivering and using thermal energy. The system capacity is applied to all cost components (except transmission main lines) within each case for a particular retrofit scheme regardless of the thermal demand of the area(s) served on the basis that the capacity of the district heating system would be utilized once all service area demands were aggregated. Transmission main line costs, on the other hand, were calculated according to the additional demand served on the basis that capital costs would be allocatable only to the new area served.

The reader is cautioned not to interpret this data as the result of an economic analysis. Cost estimates were determined for the sole purpose of identifying and ultimately selecting potential service areas for conducting an energy market study. Reference to the text and footnotes is essential to understanding the basis of calculations and application of results.

FOOTNOTES TO TABLE 11

(a) Costs to deliver energy ($/MM Btu) to subdistricts beyond the existing steam system and its contiguous borders are provided for a single power plant retrofit scheme. The reader is referred to the footnotes and text for an explanation of the methodology assumptions and results. Unless otherwise indicated, capital and operating costs for elements of the district heating system have been provided by Stone and Webster Engineering Corporation.

(b) Cases are numbered consecutively and include two major categories. The first represents individual and combined cases. Combined cases are extensions of the service area beyond the previous case to include additional thermal loads. This aggregation process is completed to determine the effects on total system costs. Note that these costs may overestimate actual costs achieved through combination with cases in Table 9. The second major category is designed to determine the effects of direct, separate routes to each major subdistrict (subdistrict 183 or 193) versus an indirect route. The indirect route utilizes a common line travesting Monroe Street. At a certain point, separate lines are directed to the northeast, to serve subdistrict 193, and the southwest, to serve 183.

(c)-(p) See footnotes to Tables 9 and 10.

For the smaller central district shown in Table 9, costs to deliver and use thermal energy (steam) to subdistricts within and surrounding the existing steam system for two power plant retrofit schemes from Acme are fairly low. Total delivered energy costs range from \$3.33 to \$3.73 per million Btu. The first case involves a plant retrofit scheme capable of satisfying existing thermal demands. Cases 2-4 involve a plant retrofit scheme capable of serving additional thermal demands. Each case may be examined independently to determine the effects of thermal demand on district heating costs.

Total costs to deliver and use thermal energy to subdistricts within and surrounding the existing steam system for five power plant retrofit schemes involving Acme (Cases 5-20) and Bay Shore plants (Cases 21-23) range from \$3.63 to \$10.63 per million Btu (Table 10). Cases are numbered consecutively and grouped according to power plant retrofit schemes. In Table 10, as well as Table 11, it is assumed that the total thermal capacity of the power plant retrofit scheme is utilized by customers and is therefore applicable to all cost components (except distribution lines in Table 10 and main lines in Table 11) within each case regardless of the thermal demand of the area(s) served. The basis of this assumption is that the capacity of the system would be utilized once all service area demands were aggregated.

In Table 11, incremental costs to deliver and use energy to subdistricts beyond the existing steam system and its contiguous borders are provided for a single power plant retrofit scheme involving hot water. Many of these cases have lower delivered energy costs than the cases in Table 10. As in Table 10, cases are numbered consecutively and include two major categories. The first category (Cases 24-36) represents individual and combined cases. Note that if outlying subdistricts are served, average costs for all customers would be lower than those shown in Table 11 (costs to central customers would be increased if rolled-in pricing was used.) The second major category is designed to determine the effects of direct separate transmission lines to each major subdistrict (subdistricts 193 or 183) versus the indirect route. The indirect route utilizes a common transmission line traversing Monroe Street. At a certain point, separate lines are directed to the northeast, to serve subdistrict 193, and the southwest, to serve subdistrict 183.

Comparison of natural gas costs in the 1985-1990 time frame with the cost of delivery and using energy to the customer in Tables 9, 10 and 11 assumes the district heating system is operational by 1985. Several trends emerging are highlighted below:

- the cost of delivering steam to existing and new customers under a moderately sized plant retrofit scheme (Table 9) is very favorable with projected natural gas prices (Table 7) under all demand cases in the 1985-1990 time frame.
- the cost of delivering steam to existing customers even with extensions into subdistricts as steam or hot water is favorable with projected natural prices (Table 10).
- the cost of delivering hot water to the downtown and contiguous areas is more than that of steam and exceeds projected natural gas prices regardless of the demand case considered (Table 10).
- the cost of delivering hot water from Acme is cheaper than from Bay Shore (Table 10).
- the cost of delivering hot water to outlying areas exceeds projected natural gas prices in 1990 (high demand case). As noted above, these costs may be reduced as the independent extensions are incorporated into the total district heating system. (Table 11).
- the cost of delivering hot water to outlying areas is slightly more expensive for indirect than direct routes (Tables 10 and 11).

Energy Analysis of Cooling Options

A preliminary analysis of various cooling options for the Acme plant is presented in Appendix E. The results of this analysis are as follows:

- The amount of energy savings possible with a central cooling facility depends heavily on the distribution of building sizes in the service area (see Figure E-1). A good break point appears to be about 100,000 ft^2 of floor area. Buildings under this size would tend to use less efficient reciprocating air-cooled equipment whereas larger buildings would use more efficient centrifugal water-cooled equipment.

- The preferred configuration for a central cooling facility is electric-driven centrifugal chillers. This appears to be true until steam extraction pressures get down around 10 to 20 psig at which point steam absorption may have a slight edge.
- Use of steam for cooling at the point of end use does not appear justified in any case.

Impact of Results on Selection of Service Areas

The foregoing results of the subdistricts analyzed indicated that none should be excluded from the energy market survey. A significant factor considered is that the real price of natural gas over the twenty year life of the system will excalate in accordance with oil prices and increase the relative attractiveness of district heating to potential user.

The analysis also indicates that the Davis-Besse plant, (because of low thermal densities in contiguous areas), and the Bay Shore plant, (because of the cost of delivering and using thermal energy relative to the Acme plant), are not as attractive as the Acme plant in terms of providing thermal energy to customers at a cost competitive with alternate energy sources.

There should, however, be a priority and phased system established for surveying potential customers to maximize time and resources. For instance, it is appropriate to sample potential new customers within the existing system, as well as in subdistricts 1-21 and 34-37. Outlying areas should be sampled so that those large customers critical to system viability are sampled prior to additional surveying in that area.

The potential for district cooling will be explored during interviews with respondents who are selected on the basis of heating requirements.

REFERENCES

1. Wallace, McHarg, Roberts and Todd, "Projections of Regional Growth Trends," 208 Report No. 16, prepared for Toledo Metropolitan Area Council of Governments, Philadelphia, Pa.(October 1976).

2. National Oceanic and Atmospheric Administration, Environmental Data Service," Local Climatologic Data-Annual Summary With Comparative Data for Toledo, Ohio", Ashville, N.C. (1975).

3. U.S. Department of Energy, Federal Energy Data System, "Statistical Summary," Washington, D.C. (February 1978).

4. State of Ohio, Department of Economic and Community Development, "Ohio Manufacturers Industrial Directory," Cleveland, Ohio (1978).

5. Lentz, C., "ASHRAE 90-75: Impact on Energy Use and Economics," ASHRE Journal, (April 1976), pp.23-28.

6. Energy Information Administration, USDOE, "Annual Report to the Congress--Volume II," Washington, D.D. (1977).

7. American Gas Association, "Consumer Impact of the National Energy Act(NEA) Natural Gas Pricing Compromise, Arlington, Va.,(June 16,1978).

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APPENDIX A

LUCAS COUNTY DATA

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APPENDIX A

LUCAS COUNTY

The following tables present data utilized in this study for Lucas County. Assumptions and data sources are referenced appropriately.

Tables A-1 and A-2 represent energy consumption by sector and end-use. Figure A-1 summarizes energy consumption by sector for the county.

Building floor area (ft^2), which formed the basis for deriving energy density figures, is provided in Table A-3. A brief discussion of the methodology and assumptions utilized in developing this data base is presented below.

District area size, commercial floor area (ft^2), and the number of residential dwelling units were available through the TMACOG data base. Information on the residential sector was transformed into building floor area through the following procedure.

Dwelling units are defined as single family homes and multi-family units. Multi-family units include apartments and duplexes. The average of housing mixes for townships in Lucas County is 74% single family and 26% multi-family. These figures were applied to the total number of dwelling units to obtain the number of single family homes and multi-family units.

U.S.Department of Commerce (1971) data were utilized to obtain total building area. For multi-family dwelling units, data were available for the North Central Region and provided information on the number of units in a building size range. Multi-family dwelling units for Lucas County were assigned to these ranges and multiplied by the mean square footage for a building size category to obtain total building area. These were then summed across building size categories to achieve total multi-family building area for Lucas County.

Data for single family homes were obtained through a similar procedure. U.S.Department of Commerce (1977) presented data in a similar format for new housing. BCL assumed that similar characteristics apply to existing housing stock.

The total building area for single and multi-family units was aggregated and divided by the total number of dwelling units to obtain an estimated number of dwelling units to obtain an estimated ft^2/dwelling unit. This factor was applied to each district to approximate residential floor area.

No comparable data were available for the industrial sector. The Ohio Industrial Directory (1978) provided data on 753 industries by SIC category, location, employment size, and building floor area. These industries were characterized by the number of employees and building area (ft^2). Average building floor area per establishment was estimated for different employment size categories based on a sample of industries. The 253 industries and associated building areas were located in planning districts. The remainder were pro-rated according to location of similarly sized industries. Average building area/establishment was used where building area was not provided. Table A-4 illustrates the characteristics of the industrial sector and the sampling characteristics.

A similar approach for estimating building floor area was utilized in obtaining data for Wood and Ottawa counties. This approach allowed for a development of a consistent set of data.

TABLE A-1. 1974 ENERGY CONSUMPTION (LUCAS COUNTY): 10^9 Btu[a]

Energy Source	Residential	Industrial	Commercial	Total
	SECTOR			
Coal	122	21408	210	21740
Natural Gas	22923	20759	10289	53971
Electricity	3619	7966	2918	14503
Petroleum	3238	3966	1582	8786
Total	29902	54099	14999	99000

(a) Energy consumption figures (1970) were projected to 1974 by applying State historic energy consumption figures to Lucas County. Transportation was excluded from this analysis.

Sources: Mathmatica, Inc., "Ohio Energy Profiles," prepared for Ohio Energy Emergency Commission, 1970, p.II-48.

U.S.Department of Energy, Federal Energy Data System, "Statistical Summary," February 1978.

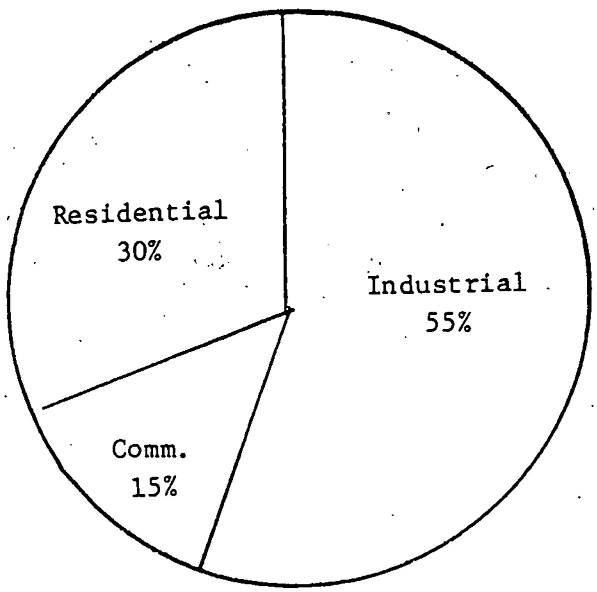

FIGURE A-1. CONSUMPTION OF ENERGY BY SECTOR (LUCAS COUNTY)

Source: Table A-1.

TABLE A-2. 1974 ENERGY CONSUMPTION BY END USE AND SECTOR (LUCAS COUNTY)[a]

SECTOR Energy & Source	SPACE HEAT 10^9Btu	AIR COND. 10^9 Btu	WATER HEAT 10^9Btu	OTHER 10^9Btu	GRAND TOTAL 10^9 Btu
Residential					
Coal	122	0	0	0	122
Natural Gas	16046	1605	4814	458	22923
Electricity	434	399	579	2207	3619
Petroleum	3043	0	162	33	3238
Total	19645	2004	5555	2698	29902
% of Total	66	6	19	9	100
Commercial					
Coal	210	0	0	0	210
Natural Gas	6791	515	2366	617	10289
Electricity	0	992	234	1692	2918
Petroleum	1123	0	0	459	1582
Total	8124	1507	2600	2768	14999
% of Total	54	11	17	18	100

TABLE A-2, (Con't)

SECTOR Energy & Source	SPACE HEAT (b)	DIRECT HEAT	PROCESS STEAM	FEED-STOCK	AIR COND. (c)	OTHER (d)	TOTAL
Industrial							
Coal	3897	8861	7719	642	0	0	21119
Natural Gas	3500	4743	11173	1038	541	0	21045
Electricity	81	291	0	0	1050	6527	7949
Petroleum	477	581	1422	1428	0	79	3987
Total	7955	14526	20314	3108	1591	6606	54100
% of Total	15	27	38	6	2	12	100

(a) End-use consumption by sector was completed by applying U.S. end-use patterns to Ohio Counties.

(b) The use of fuel and energy for industrial space heating is not separately identified but is included in "direct heat" and "process steam" and is a "relatively small share" of these uses. (SRI) BCL assumed 18% of the total direct heat and process steam (43000 x 10^9 Btu) could be assigned to space heat. (This value approximates the space heating share of total end-uses in the U.S. as reported by SRI). This amount was subtracted according to their share of the total energy consumed in these uses. Commercial space heating characteristics were applied to industrial space heating to determine disaggregation by energy source.

(c) Industrial cooling demand was not available. This was estimated by assuming commercial space heating/cooling ratios of 5:1 are applicable to industry. Commercial air conditioning energy source percentages were applied to determine industrial energy consumption figures.

(d) Commercial "other" category: lighting, merchanical drive, refrigeration.
Residential "other" category: Cooking, dryers, refrigeration, appliances lighting.
Industrial "other" category: Electric drive, electrolytic processes, lighting.

Sources: Table A-1
SRI, Patterns of Energy Consumption in the U.S., Prepared for Office of Science and Technology, 1972.

TABLE A-3 BUILDING FLOOR AREA (LUCAS COUNTY): 10^3 ft^2.

PLANNING DISTRICT	ACRES	COMMERCIAL ft^2	INDUSTRIAL ft^2	RESIDENTIAL ft^2	TOTAL ft^2
1	850	8178	1135	2836	12149
2	1475	1159	367	13941	15467
3	1631	936	1040	11633	13609
4	2159	900	4430	7683	13013
5-6	5917	1849	3572	18668	24089
7	5111	2160	5355	28575	36090
8	3392	1396	10046	12334	23776
9	2014	995	660	12494	14149
10	2625	1134	2796	8442	12372
11	4031	389	9480	827	10696
12	2601	510	0	8028	8538
13	17195	626	1269	7389	9284
16	5171	1128	623	14077	15828
17	6946	2019	531	7407	9956
18	10312	2405	3604	13007	19016
19	4096	3399	412	8490	12301
20	1960	1404	196	10497	12097
21	4656	1043	2696	14308	18047
23	5720	1116	0	6541	7657
24	8320	915	0	8642	9557
28	14249	145	0	840	985
34	1506	231	0	2715	2946
35	14734	71	0	1572	1643
36	16941	17	0	1012	1029
37	14385	114	0	1359	1473
38	22025	149	52	2951	3152
39	19221	43	330	883	1256

Sources: State Of Ohio, "Ohio Industrial Directory," 1978.
TMACOG, "Independent Variable Data Base," 1974.

TABLE A-4. LUCAS COUNTY-INDUSTRIAL SECTOR CHARACTERISTICS

Employment Category	Number of Establish-ments	Average Building Floor Area Established	Total Estimated Area 10^6 ft^2	Sampling Characteristics No Estab.	Sampling Characteristics 10^6 ft^2	% of Total ft^2
0-10	308	5200	1.602	38	0.665	42
11-50	286	36000	10.296	93	6.790	66
51-100	76	90000	6.840	54	4.224	62
101-200	37	115000	4.255	23	2.514	59
201-300	9	183000	2.439	9	2.439	100
301-400	9	295000	2.949	9	2.949	100
401-1000	18	262000	6.557	18	6.557	100
1000	9	1444000	12.998	9	12.998	100
	753		48.226	253	39.14	81

Source: State of Ohio, "Ohio Industrial Directory," 1978.

APPENDIX B

OTTAWA COUNTY DATA

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OTTAWA COUNTY

Energy density indicators for Ottawa County are provided in Table B-1. Supporting data, assumptions and information sources are presented in Tables B-2 to B-4.

Tables B-2 and B-3 display energy consumption by sector and end-use. Figure B-1 summarizes energy consumption by sector for the county.

The methodology employed for Lucas County for developing building floor area in Table B-4 was applied to Ottawa County. Although the total building floor area for the commercial sector was not available, the total number of commercial firms was. (Ottawa Planning Commission). This number was assigned to districts by assuming a positive correlation between labor force and the location of commercial establishments. An average building floor area per establishment was derived from an actual sample of two townships and their associated commercial building area. The building floor area was then aggregated across districts to achieve a total for Ottawa County.

The Ottawa Regional Planning Commission provided information on single family dwellings. Multi-family dwellings are insignificant in number. U.S.Department of Commerce (1977) information was applied through the procedure utilized in Lucas County.

Industries were located in districts by employing similar data from the Ohio Industrial Directory (1978). All industries were located with estimates of building floor area made where data were not available. Table A-4 provided the necessary input for these approximations.

TABLE B-1. ENERGY DENSITY INDICATORS BY SECTOR (OTTAWA COUNTY)

			ENERGY DENSITY INDICATORS (10^6Btu/acre)												
	AREAL SIZE	LINEAR DIST. FROM DAVIS BESSIE	COMMERCIAL			RESIDENTIAL			INDUSTRIAL		Cooling[(a)]		TOTALS		
PD	(acres)	TO DIST. CTR.	Heat	H.W.	Cool.	Heat	H.W.	Cool.	Heat	Process	Case 1	Case 2	Heat & H.W.	Process	Cool. (Case 1)
40	27066	13.4	4.7	1.8	1.0	2.4	0.6	0.2	0	0	0	0	9.5	0	1.2
41	16908	15.0	1.6	0.6	0.3	4.7	1.1	0.4	4.7	10.8	0.9	0.5	12.7	10.8	1.6
42	17581	13.0	7.9	3.0	1.6	3.1	0.7	0.3	2.6	6.0	0.5	0.3	17.3	2.6	2.4
43	23205	2.8	3.3	1.2	0.7	3.2	0.7	0.3	0	0	0	0	8.4	0	1.0
44	17721	7.5	1.3	0.4	0.3	3.1	0.7	0.3	2.5	5.7	0.5	0.2	8.0	5.7	1.1
45	11518	8.6	3.9	1.5	0.8	2.4	0.5	0.2	0	0	0	0	8.3	0	1.0
46	6486	11.6	14.4	5.4	3.0	12.0	2.8	1.1	2.1	4.9	0.5	0.2	36.7	4.9	4.6
47	11366	16.4	1.8	0.7	0.4	23.4	5.4	2.1	3.3	7.7	0.6	0.3	34.6	7.7	3.1
48	3610	13.7	4.3	1.6	0.9	10.1	2.3	0.9	0	0	0	0	18.3	0	1.8
49	15685	14.4	1.0	0.4	0.2	5.0	1.1	0.5	0.8	1.8	0.1	0.1	8.3	0.8	0.8
50	8107	5.9	1.0	0.4	0.2	7.5	1.7	0.7	7.5	17.4	1.5	0.7	18.1	17.4	2.4

(a) See Table A-4 for assumptions.

TABLE B-2. 1974 ENERGY CONSUMPTION (OTTAWA COUNTY)

Energy Source	SECTOR			Total
	Residential	Industrial	Commercial	
Coal	13	874	22	909
Natural Gas	1064	1173	479	2721
Electricity	546	451	288	1285
Petroleum	729	224	356	1309
Total	2357	2722	1145	6224

(a) Energy consumption figures (1970) were projected to 1974 by applying state historic energy consumption figures to Wood County. Transportation was excluded from this analysis.

Source: Mathmatica, Inc., "Ohio Energy Profiles," Prepared for Ohio Energy Emergency Commission, 1970, p. XII-62.
U.S. Department of Energy,"Federal Energy Data System, Statistical Summary," February 1978.

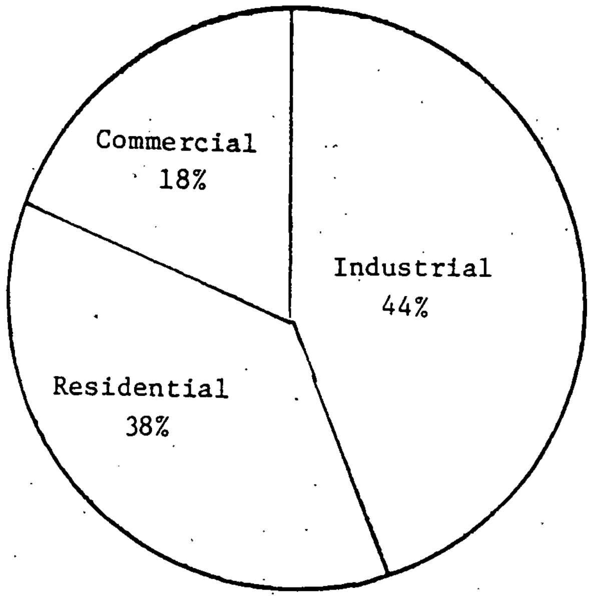

FIGURE B-1. CONSUMPTION OF ENERGY BY SECTOR (OTTAWA COUNTY).

Source: Table B-2.

TABLE B-3. 1974 ENERGY CONSUMPTION BY END-USE AND SECTOR (OTTAWA COUNTY)[(a)]

SECTOR Energy & Source	SPACE HEAT 10^9Btu	AIR COND. 10^9 Btu	WATER HEAT 10^9Btu	OTHER 10^9Btu	GRAND TOTAL 10^9 Btu
Residential					
Coal	32	0	0	0	13
Natural Gas	748	75	224	22	1069
Electricity	65	61	87	333	546
Petroleum	685	0	36	8	729
Total	1530	136	347	363	2357
% of Total	65	5	15	15	100
Commercial					
Coal	22	0	0	0	22
Natural Gas	316	24	110	29	479
Electricity	0	98	113	167	288
Petroleum	253	0	0	103	356
Total	591	122	223	299	1145
% of Total	52	3	19	26	100

TABLE B-3, (OTTAWA COUNTY)
(con't)

SECTOR Energy & Source	SPACE[(b)] HEAT	DIRECT HEAT	PROCESS STEAM	FEED-STOCK	AIR COND.	OTHER	TOTAL
Industrial							
Coal	205	374	295	26	0	7	907
Natural Gas	184	279	595	59	29	19	1165
Electricity	5	22	0	0	55	347	429
Petroleum	25	32	79	81	0	4	221
Total	419	707	969	166	84	377	2722
% of Total	15	26	36	6	3	14	100

(a) End-use consumption by sector was completed by applying U.S.end-use patterns to Ohio Counties.

(b) The use of fuel and energy for industrial space heating is not separately identified but is included in "direct heat" and "process steam" and is a "relatively small share" of these uses.(SRI) BCL assumed 18% of the total direct heat and process steam (43000 x 10^9 Btu) could be assigned to space heat. (This value approximates the space heating share of total end-uses in the U.S. as reported by SRI). This amount was subtracted according to their share of the total energy consumed in these uses. Commercial space heating characteristics were applied to industrial space heating to determine disaggregation by energy source.

(c) Industrial cooling demand was not available. This was estimated by assuming commercial space heating/cooling ratios of 5:1 are applicable to industry. Commercial air conditioning energy source percentages were applied to determine industrial energy consumption figures.

(d) Commercial "other"category: lighting, mechanical drive, refrigeration.
Residential "other"category: Cooking, dryers, refrigeration, appliances lighting.
Industrial "other" category: Electric drive, electrolytic processes, lighting.

Source: Table B-3.
SRI, Patterns of Energy Consumption in the U.S. Prepared for Office of Science and Technology, 1972.

TABLE B-4. BUILDING FLOOR AREA (OTTAWA COUNTY): $10^3 ft^2$

PLANNING DISTRICT	COMMERCIAL ft^2	INDUSTRIAL ft^2	RESIDENTIAL ft^2	TOTAL ft^2
40	119	10	982	1111
41	25	581	1224	1830
42	131	340	840	1311
43	73	0	1146	1219
44	22	326	855	1203
45	43	0	434	477
46	88	1001	1202	2291
47	19	200	4096	4395
48	15	0	2433	2448
49	15	90	1203	1308
50	6	450	930	1386
TOTAL	556	3078	15345	18979

Sources: State of Ohio, "Ohio Industrial Directory," 1978.
TMACOG, "Independent Variable Data Base," 1974.

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APPENDIX C

WOOD COUNTY DATA

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WOOD COUNTY

Comparable estimates of energy consumption by sector and end-use were not undertaken for Wood County. For the districts under consideration in this study, however, there was information available on commercial and industrial floor space residential dwelling units.

The methodology employed in Lucas County for estimating building floor area was relied upon here for residential dwelling units. Industrial firms were located in districts with associated building floor areas. Estimates were made where actual data did not exist by utilizing the derived data for Lucas County (Table A-4).

Conversion of building floor area into energy density indicators was achieved by applying density figures (Btu/ft^2 by end-use) for Lucas County to these districts. This approach was perceived to be more reliable than one that emphasized application of county energy consumption figures.

TABLE C-1. ENERGY DENSITY INDICATORS BY SECTOR (PORTIONS OF WOOD COUNTY)

			ENERGY DENSITY INDICATORS (10^6 Btu/acre)													
	AREAL SIZE	DIST. FROM ACME	COMMERCIAL			RESIDENTIAL			INDUSTRIAL				TOTALS			
											Cooling					Cool.
PD	(acres)	(mi)	Heat	H.W.	Cool.	Heat	H.W.	Cool.	Heat	Process	Case 1	Case 2	Heat	H.W.	Process	(Case 1)
14	15211	5.4	23	8	4	29	6	3	4	5	1	neg.	70		5	8
15	8294	5.2	6	2	1	48	11	5	375	471	77	38	442		471	83
22	11508	9.2	12	4	2	41	9	4	200	251	41	20	266		251	47
31	28689	11.2	3	1	neg.	7	1	neg.	7	9	1	neg.	28		9	1
32	27331	11.2	neg.	neg.	neg.	5	1	neg.	0	0	0	0	6		0	0
33	21983	16.5	neg.	neg.	neg.	5	1	neg.	0	0	0	0	6		0	0

(a) See Table A-3 for assumptions.

TABLE C-2. BUILDING FLOOR AREA($10^3 ft^2$)

PLANNING DISTRICT	COMMERCIAL	INDUSTRIAL	RESIDENTIAL	TOTAL
14	1462	176	4843	6481
15	205	7977	4402	12584
22	563	5916	5283	11762
31	355	502	2140	2997
32	27	0	1392	1419
33	37	0	1150	1187
TOTAL	2649	14571	19210	36430

Sources: Ottawa Regional Planning Commission, "Economic Development Plan," 1978.
Ibid, "Regional Development Plan," Volume 2, 1971.
State of Ohio, "Ohio Industrial Directory," 1978.

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APPENDIX D

PRIMARY COST DATA FOR SERVICE AREA ANALYSIS

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November 2, 1978

Mr. George F. Melick, Jr.
Stone & Webster Engineering Corporation
Cherry Hill Operations Center
3 Executive Campus
P. O. Box 5200
Cherry Hill, New Jersey 08034

Dear George:

Enclosed is the list of specific data Battelle needs from Stone and Webster for the completion of Task 2. Some of the data requested is very specific and is in response to Toledo Edison's request for analysis of relatively small areas with high thermal densities and documentation supporting all retrofit schemes ruled out.

The following items are addressed in the enclosed list:

- Power plant retrofit costs
- Retrofit system fuel costs
- Transmission of thermal energy costs (except for transmission from downtown Toledo to outlying areas - centroids)
- User retrofit costs
- District heating system efficiencies.

In addition we are formulating and will be sending you cost items concerning:

- Transmission of thermal energy costs from downtown Toledo to outlying areas
- Distribution of thermal energy costs.

As has been discussed before, rules of thumb can be used where appropriate, however, we would like to know the expected accuracy of the estimates e.g. ± ______ percent on capital costs. Also, a listing of the basis for major assumptions that are not regarded as sound engineering practice.

If you have questions about these requests, please call me so that we can keep all of our time commitments to a minimum. Because of the near term draft deadline for Task 2, please let me know your expected delivery date for this data. (Telecopy will probably be most appropriate).

Very truly yours,

Jere

F. Jere Bates
Utility Economist
Economics, Planning and
Policy Analysis Section

FJB/ml

cc: Andrew A. Anastasio (Stone & Webster)
James R. Watt (Toledo Edison Co.)

TOLEDO EDISON: DISTRICT HEATING AND COOLING

TASK 2 DATA REQUEST TO STONE & WEBSTER ENGINEERING CORPORATION

I. Power Plant Retrofit Costs: dollars and peak send out in M M Btu/hr.

A. Acme for #2 turbine (76 M W_e): steam and hot water separately

B. Acme for maximum capacity available from the plant: steam and hot water

C. Bay Shore at maximum capacity available: hot water

II. Retrofit System Fuel Costs (with constant power costs): $/M M Btu

A. Prepare for each of above power plant retrofits i.e. IA, IB, and IC.

B. Miscellaneous power plant O & M costs: are there any miscellaneous O & M costs in the utility plant that are a significant addition to the fuel costs...e.g. pumping costs, extra labor, maintenance, etc.? Can we use a rule of thumb say $0.05/M M Btu or is it best to calculate for each of above power plant retrofits i.e. IA, IB, and IC?

III. Transmission of Thermal Energy: Costs and energy capacity for each.

A. Acme to Water Street (W.S.) (Including redundancies that may be required for reliability).

1. Acme to W.S. as steam from #2 turbine (76 M W_e).
2. Acme to W.S. as hot water from #2 turbine (76 M W_e).
3. Acme to W.S. as steam from #2 turbine plus excess as hot water from Acme maximum capacity.
4. Acme to W.S. as steam from Acme maximum capacity.

B. Bay Shore to Acme

1. Bay Shore to Acme as hot water from Bay Shore maximum capacity.

C. Hot Water from W.S. to Existing Steam Customers

1. Convert existing downtown steam system to hot water system (transmission and distribution piping that serves all existing steam customers).

D. Costs for Transmission Auxiliaries for Each Item Above - Capital and O & M.

1. Pumping stations as required.

2. Conversion of steam to hot water at or near W.S. (This assumes steam is broughtacross Maumee River to W.S. and some converted to hot water for transmission to more distant centroids.

3. Equipment (located at or near W.S.) required to reduce high pressure steam (265#) to low pressure steam (100#) to feed into existing steam system.

IV. User Retrofit Costs: In $/M M Btu

A. Existing downtown steam system customers to hot water.

B. Conversion of existing hot water system supplied by existing boilers to district hot water system.

C. Conversion of energy from district thermal energy system to supply end user hot air system:

Sector	Type of Thermal System	Costs
Industrial	Steam	
Industrial	Hot Water	
Commercial	Steam	
Commercial	Hot Water	

V. District Heating System Efficiencies

What are typical line losses for transmission and distribution systems that are likely to be considered in this project.

November 3, 1978

Mr. George F. Melick, Jr.
Stone & Webster Engineering Corporation
Cherry Hill Operations Center
3 Executive Campus
P. O. Box 5200
Cherry Hill, New Jersey 08034

Dear George:

Enclosed is the list of specific data Battelle needs from Stone & Webster for Task 2 concerning:

- Costs of thermal energy transmission from downtown Toledo to outlying areas.

- Costs of thermal energy distribution.

We have formulated the lists to conform with some of the various options we are studying. Therefore, the list may appear to be voluminous at first glance. However, on closer review you will find some overlap between the various items thereby reducing the actual volume of items requested.

After the list was prepared for typing it was discovered that one essential aspect was not included within its framework. Transmission piping to centroids 1 to 21; 34 and 36; and 34, 35, 37 and 37; should deliver hot water or steam at a pressure adequate to enter a distribution piping network and service commercial type users. Conversely, transmission piping to all other centroids will be used to service large industrial type users that <u>may</u> not require as high a pressure -- we are optimistically assuming that industrial users would not require an elaborate new distribution system to satisfy their needs. We welcome your judgment as to the appropriate delivered pressure for these two situations.

Also enclosed are two centroid maps for Toledo, Ohio. These may be of assistance to you in interpreting our lists.

Please feel free to call if we can clear up any points on the attached material.

Very truly yours,

Jere

F. Jere Bates
Utility Economist
Economics, Planning and
Policy Analysis Section

cc: Andrew A. Anastasio (Stone & Webster) w/o map
James R. Watt (Toledo Edison Co.)

Enc.

TASK 2: COST INFORMATION REQUEST FOR NEW TRANSMISSION AND DISTRIBUTION SYSTEMS

Note: Energy requirements in distribution and transmission are quoted in steam equivalents of 1000 Btu/lb.

I. Distribution

A. Steam and hot water distribution piping to pick up other commercial in centroids 1,2,3,4,7,8,10 and 21 and incidentals in 5 thru 20:
   144,000 MMBtu/yr at peak = 28,600 lbs/hour steam over 40 acres (Urban)*

B. Steam and hot water distribution piping to pick up commercial in centroids 34 and 36:(U)
   73,788 MMBtu/yr at peak = 14,600 lbs/hr steam over 57 acres

C. Steam and hot water distribution piping to pick up commercial in centroids 34,36,37,35 (U):
   149,820 MMBtu/yr at peak = 29,700 lbs/hr steam over 141 acres.

D. Hot water (only) distribution piping to pick up commercial in centroids 64 (U):
   12,408 MMBtu/yr at peak = 2,460 lbs/hr steam over 13 acres

II. Transmission Piping (except where specified, all lines refer to hot water lines only:

A. For centroids 1 thru 21 (City Core)*: Steam. Tentatively assume no additional transmission piping required (i.e., existing steam would be adequate-only requires 15% more throughput.)

B. For centroids 34 and 36 (U):(1) Evaluate feasibility of extending 12" Jefferson St. steam line to handle additional 14,600 lb stm/hr to distribution system for centroids 34 & 36. (2) If above inadequate, cost new steam and hot water lines from Water St. to approximate center of Centroid 34-estimated 0.8 mile from W.S.

C. For centroids 34,35,36, 37(U):
   (1) Evaluate feasibility of extending 12" Jefferson St. steam line to handle additional 29,700 lbs stm/hr equivalent.
   (2) If inadequate, cost new steam and hot water line from Water St. for about 0.65 mile from W.S.

D. Omitted here

E. For centroid 24 (U):
   0.6 mile, 62.9×10^3 lbs/hr steam equivalent

---

* "U" indicates urban, "C" indicates city core.

F. For centroid 24 plus 29 (U):
(1) 0.6 mile 83.9 x 10^3 #/hr steam equiv. then
(2) 0.5 mile, 21.0 x 10^3 #/hr stm equiv

G. For centroid 44 (U):
0.5 mile 19.0 x 10^3 #/hr steam equivalent

H. For centroids 44 plus 47 (U):
(a) 0.5 miles 38.4 x 10^3 #/hr stm equiv.
(b) 0.85 miles 19.4 x 10^3 #/hr " "

I. For centroid 100 (Suburban)*:
1.7 miles 77.9 x 10^3 #/hr steam equiv.

J. For centroids 193 etc - direct route (not Monroe St.):
(1) For 193 only (50% urban - 50% suburban): 3.9 miles for 288 x 10^3 #/hr stm (from N. bank river across from Acme to south end)
(2) For 193 + 118 + 119:
(a) 50/50 urban/surburan 3.3 miles for 356.4 x 10^3 #/hr stm equiv.
(b) /suburban 0.9 miles for 68.4 x 10^3 #/hr stm equiv.
(c) /suburban 0.6 miles for 288 x 10^3 #/hr stm equiv.
(3) For 193 + 118 + 119 + 206:
(a) 50/50 S/U 3.3 miles for 421.9 x 10^3 #/hr stm equiv.
(b) (S) 0.6 miles for 288 x 10^3 #/hr stm equiv.
(c) (S) 0.9 miles for 68.4 10^3 " " "
(d) (S) 0.8 miles for 65.5 x 10^3 " " "
(4) For centroids 193 + 118 + 119 + 206 + 209 + 223:
(a) 50/50 S/U 3.3 miles for 554.1 x 10^3 #/hr stm equiv
(b) S 0.6 miles for 288 x 10^3 #/hr stm equiv
(c) S 0.9 miles for 68.4 x 10^3 " "
(d) S 0.8 miles for 197.7 x 10^3 " " "
(e) R* 2.0 miles for 132.2 x 10^3 " " "

K. For centroid 183 etc: direct route - not Monroe St. from Water St. Station:
(1) For 183 only
(a) Leg 50/50 S/U 2.7
(b) Laterals S 0.9 }= 3.6 miles for 145.5 x 10^3 #/hr stm equiv.
(2) For 183 plus 177 + 175 + 628 + 174
(a) S 3.5 miles for 155.4 x 10^3 #/hr steam equiv.
(b) 50/50 S/U 3.6 miles for 300.9 x 10^3 MM #/hr

* "S" indicates suburban, "R" indicates rural

(3) For 183 plus 263

(a) 50/50 R/S 1.8 miles for 113.1 x 10^3 #/hr stm equiv

(b) S 0.9 miles for 145.5 x 10^3 #/hr stm equiv

(c) 50/50 S/U 2.7 miles for 258.6 MM #/hr stm equiv

(4) For 183 plus 177 + 175 + 628 + 174 plus 263

(a) S 3.5 miles for 155.4 x 10^3 #/hr stm equiv

(b) S 0.9 miles for 300.9 x 10^3 #/hr " "

(c) 50/50 R/S 1.8 miles for 113.1 x 10^3 #/hr stm equiv

(d) 50/50 S/U 2.7 miles for 569.4 x 10^3 #/hr stm equiv

L. Optional routing for prior centroids of J & K studies:

From Water Street Station up Monroe St. then split to centroids 193 and 183 (Pick up centroid 64 = 2.5 x 10^3 #/hr stm equiv)

(1) For centroids 64, 183, 193 only:

(a) S 0.9 mile for 145.5 x 10^3 #/hr stm equiv

(b) S 0.4 " " 145.5 " " " " "

(c) S 1.5 miles " 288. " " " " "

(d) S 1.5 " " 433.5 " " " " "

(e) U 0.8 " " 436. " " " " "

(2) For Main Line S:

(a) S 0.4 mile for 300.9 x 10^3 stm equiv

(b) S 0.4 " " 258.6 " " " "

(c) S 0.4 " " 569.4 " " " "

(d) S 1.5 " " 356.4 " " " "

(e) S 1.5 " " 421.9 " " " "

(f) S 1.5 " " 554.1 " " " "

(g) S 1.5 " " 1123.4 " " " "

U 0.8 " " " " " " "

(h) S 1.5 " " 780 " " " "

U 0.8 " " " " " " "

11-3-78

STONE & WEBSTER ENGINEERING CORPORATION

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Mr. F. Jere Bates
Utility Economist
Battelle Columbus Laboratories
505 Kings Avenue
Columbus, OH 43201

December 21, 1978
J.O. No. 13166
File No. M 1.2

Dear Mr. Bates:

DOE/TED DISTRICT HEATING/COOLING STUDY
TOLEDO EDISON COMPANY

Reference: Battelle Columbus Laboratories letters of November 2 and 3, 1978

Enclosed are three (3) copies of data and information in response to Battelle's letters dated November 2 and 3, 1978. We understand your Task 2 report on the above study will include, as an appendix, the data and information we have generated. As we pointed out to you in our telephone conversations, some of our answers to your questions were judgmental, in view of the lack of adequate data for detailed analyses. We nevertheless hope that the information provided will facilitate your market survey analysis.

If you have any questions, please let us know.

Very truly yours,

A. A. Anastasio
Study Manager

Enclosures

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DISCUSSION

J. O. No. 13166

DOE/TED: District Heating and Cooling Study

Task 2: Market Survey Analysis Data

The Market Survey Data presented is in two parts. Part I, which is in response to Battelle's letter of November 2, 1978, consists of a series or curves and tables summarizing retrofit schemes. The tables summarize possible retrofit schemes and the cost associated with each scheme. The curves illustrate the relationship between fixed charges for retrofit and energy transmission for each of the retrofit schemes and the annual load factor. Other questions raised in the November 2nd letter are also answered in Part I.

Part II of the data, which is in response to Battelle's letter of November 3, 1978, consists of thermal energy transmission and distribution costs for several designated areas.

DOE/TED - DISTRICT HEATING & COOLING STUDY

Part I Data

Summary Table

Retrofit Schemes and Related Costs

Option	Description	Steam or Water Conditions	Capital Costs ($)		Fixed Charges @ 17%	BTU/Hour X $(10)^6$	Cost ($) Per $(10)^6$ BTU @ L.F.=1	
A1-(a)	Steam from Acme to Water Street. Extract from Turbines 2,5 &6. 14" transmission line	320 psia	Retrofit	531,000		195 Max Export 0 Return	0.2762	(1*)
			Transmission	2,244,000				
			Total	2,775,000	471,750			
A1-(b)	High temp. water from Acme to Water Street. Extract steam from 2,5,&6 T-G. 10" transmission lines.	400°F Supply 250°F Return	Retrofit	1,370,000		159 (NET)	0.5281	(5*)
			Transmission	2,957,000				
			Total	4,327,000	735,590			
A1-(c)	Steam from Acme to W.S. Extract from #2T-G only. 10" transmission line	320 psia	Retrofit	103,000		66 Export 0 Return	0.5596	(6*)
			Transmission	1,800,000				
			Total	1,903,000	323,510			
A1-(d)	HTW from Acme to W.S. Extract steam from #2 T-G only. 6" transmission line	400°F Supply 250°F Return	Retrofit	515,000		55 (NET)	0.9940	(9*)
			Transmission	2,302,000				
			Total	2,817,000	478,900			
A3-(a)	HTW from Acme to W.S. use new extraction turb. 18" transmission line	400°F supply 250°F return	Retrofit	5,700,000		400 (NET)	0.5212	(5*)
			Transmission	5,043,000				
			Total	10,743,000	1,826,310			
A3-(b)	Steam from Acme to W.S. use new extraction turb. 16" transmission line	250 psia 600°	Retrofit	4,900,000		527 Export 0 Return	0.2757	(2*)
			Transmission	2,587,000				
			Total	7,487,000	1,272,800			

Option	Description	Steam or Water Conditions	Capital Costs ($)		Fixed Charges @ 17%	BTU/Hour X(10)^6	Cost ($) Per (10)^6 BTU @ L.F.=1
A3-(c)	Steam from Acme to W.S. use new extraction turb 24" transmission line	175 psia 516.3^{O}F	Retrofit	5,640,000		512 Export	0.3492
			Transmission	3,564,000		0 Return	(3*)
			Total	9,214,000	1,566,400		
B1-(a)	HTW from Bay Shore to W.S. use cold reheat steam from T-G 1,2,3&4 18" transmission line	400^{O}F supply 250^{O}F return	Retrofit	1,500,000		400 (NET)	1.7853
			Transmission				(10*)
			a)B.S. toA	30,255,000			
			b)A to W.S.	5,043,000			
			Total	36,798,000	6,255,660		

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Legend

See Table D-2 Legend

Table D-2

DOE/TED - DISTRICT HEATING & COOLING STUDY

Retrofit Schemes and Related Costs

Option	Description	Steam or Water Conditions	Capital Costs ($)		17% Fixed Charges	BTU/HOUR X $(10)^6$	Cost ($) Per $(10)^6$ BTU @ LF=1
A1-(e1)	Steam from Acme to W.S. Extract from T-G 2,5,6 - use to Generate hot water at W.S.	HTW - 300 psia 350°F	Retrofit at Acme	531,000		143.6	0.5154 (5*)
			Steam Line	2,444,000			
			Add to W.S.	839,000			
			Total	3,814,000	648,400		
A1-(e2)	Same as A1-(e1) Except that portion of steam is distributed to consumers	HTW 300 psia 350°F steam @ 115 psig	Retrofit at Acme	513,000		HTW 71.8	0.4698 (4*)
			Steam Line	2,444,000		Steam 87.4	
			Add. to W.S.	879,000		Total 159.2	
			Total	3,854,000	655,200		
A1-(f1)	Steam from Acme to W.S. Extract from T-G #2 use to generate HTW at W.S.	HTW 300 psia 350°F	Retrofit at Acme	103,000		53	0.8478 (8*)
			Steam Line	1,800,000			
			Add. to W.S.	412,000			
			Total	2,315,000	393,600		
A1-(f2)	Same as A1-(f1) Except that half of steam is distributed to consumers	HTW 300 psia 350°F steam @ 115 psig	Retrofit at Acme	103,000		HTW 26.5	0.8047 (7*)
			Steam Line	1,800,000		Steam 30.3	
			Add to W.S.	452,000		Total 56.8	
			Total	2,355,000	400,400		
A3-(d1)	Steam from Acme to W.S. using non-cond. turbine generate HTW at W.S.	HTW 300 psia 350°F	Retrofit at Acme	4,900,000		440	0.3653 (3*)
			Steam Line	2,587,000			
			Add to W.S.	800,000			
				8,287,000	1,408,800		
A3-(d2)	Same as A3-(d1) except half of steam to be distributed as steam	HTW 300 psia 350°F steam @ 115 psig	Retrofit at Acme	4,900,000		HTW 220	0.3399 (3*)
			Steam Line	2,587,000		Steam 256	
			Add to W.S.	850,000		Total 476	
				8,337,000	1,417,300		

2.

Table D-2 (Contd.)

Option	Description	Steam or Water Condition	Capital Costs ($)		Fixed Charges @ 17%	BTU/Hour X $(10)^6$	Cost Per $(10)^6$ BTU @ LF=1
A3(e1)	Steam from topping Turb. to produce HTW 10" transmission line	HTW @ 400°F	Retrofit at Acme	1,470,000		237 (NET)	0.3625
			Transmission	2,957,000			(3*)
				4,427,000	752,600		
A3(e2)	Steam from Topping Turb. to W.S. 18" Transmission line	Steam at 235 psig	Retrofit at Acme	50,000		288	0.2231
			Transmission	2,930,000			(1*)
			Total	2,980,000	506,600		

Legend

T-G	Turbine Generator
W.S.	Water Street Station
HTW	High Temperature Water
L.F.	Load Factor
(*)	Refer to graph to identify scheme

12-12-78
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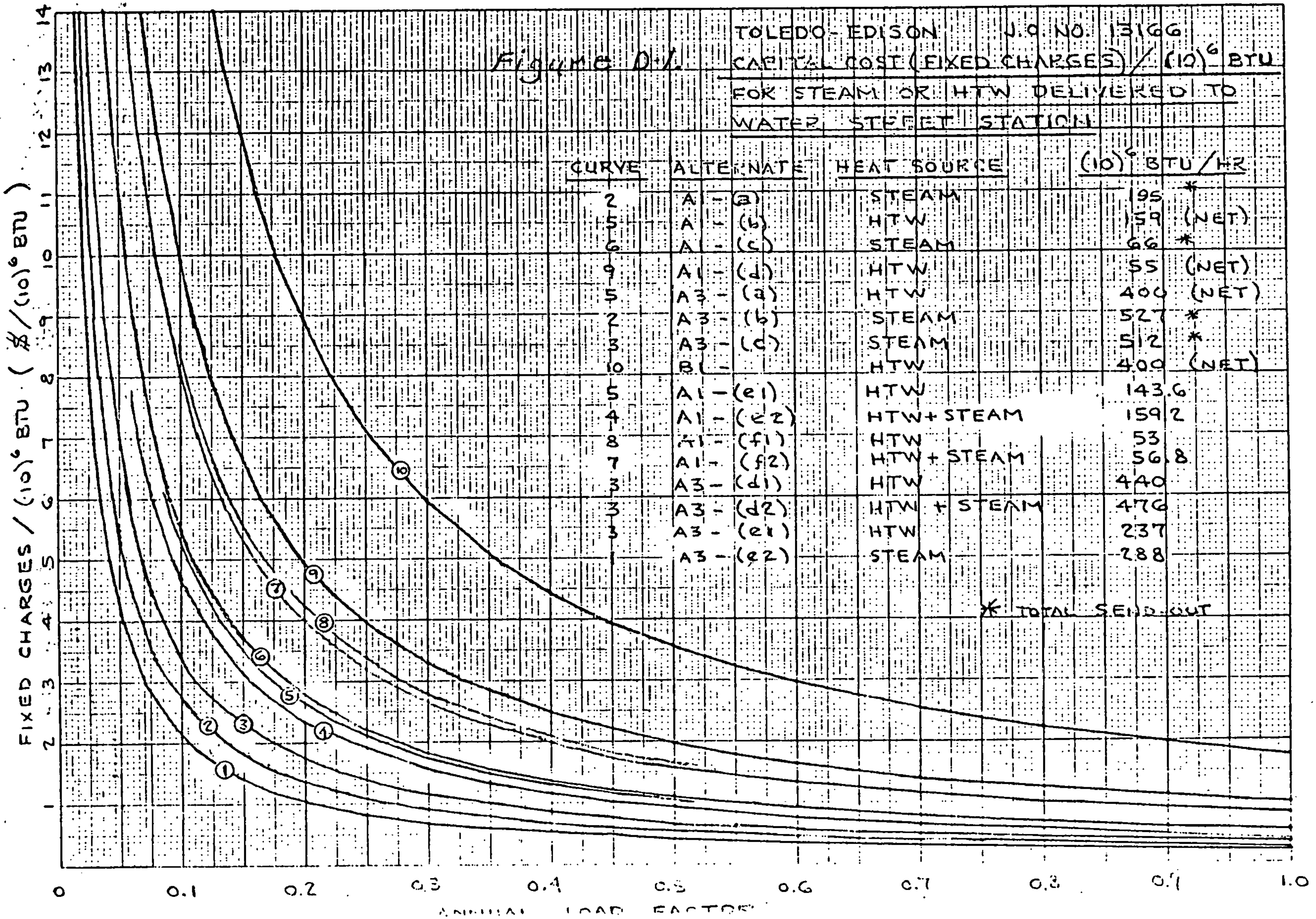

DOE/TED - District Heating & Cooling Study

Part I Data

II. Retrofit System Fuel Costs

Cogeneration involves an enthalpy differential between the turbine throttle and extraction point, h_1-h_x, which is transferred to the steam in the boiler and converted to power by the turbine. Assuming that power costs are to be constant, the steam should be credited with the thermal input which would be needed to produce this power elsewhere in the system. The net credit per pound, q_c, can be determined from:

$$q_c = (h_1-h_x)\left(\frac{1}{e_{th}} - \frac{1}{e_b}\right)$$

where e_{th} = Thermal efficiency

e_b = Boiler efficiency

At the Acme Station 1977 fuel cost was \$1.17 per 10^6 Btu. Operation and maintenance added about 40 percent to fuel costs. The following table applies to Unit No. 2

Extraction Press. (psia)	q_c (Btu/lb)	$\frac{q-q_c}{q}$	Fuel + O & M Cost (\$/10^6 Btu)
345	412	0.73	1.20
136	644	0.55	0.90

For preliminary estimation, \$1.10 per 10^6 Btu escalated from 1977 to 1978 is recommended for Acme Station. Slightly less, say \$1.00 per 10^6 Btu may be used for the Bay Shore Station reflecting lower O & M costs.

DOE/TED - District Heating & Cooling Study

Part I Data

III. Thermal Energy Transmission Costs

C. Conversion of Existing steam system to a hot water system to supply existing steam customers.

The cost of converting the existing steam system to a hot water system is estimated to be $14,000,000.

This cost does not include any allowances for:

a. Weather conditions

b. Traffic delays or interference problems

c. Zoning or balancing or system.

D. Costs For Transmission Auxiliaries

1. Pumping costs where necessary were included in capital costs.

2. See Table D-2

3. Costs of pressure reducing stations where necessary were included in overall capital costs.

IV. User Retrofit Costs

Case	Energy Delivered Per Customer (BTU/Hr.)	Capital Cost ($)
A. Conversion of existing Downtown steam system customers to hot water	1.5×10^6	50,000
B. Conversion of existing hot water system supplied by existing boilers to District hot water system	1.5×10^6	10,000
C. Conversion of energy from District thermal energy system to supply end user hot air system		
1. Thermal System: steam	1.6×10^6	11,000
2. Thermal System: hot water	1.6×10^6	51,000

In Part C, the capital cost for larger industrial or commercial loads can be determined from the following expressions:

For Steam System:

$$\text{Capital Cost (in dollars)} = 2.0 \times 10^{-3} Q + 10{,}200$$

Where Q is maximum thermal energy demand per hour (10^6 BTU/Hr.)

For Hot Water System:

$$\text{Capital Cost (in dollars)} = 10.5 \times 10^{-3} Q + 40{,}000$$

Where Q is as defined above.

V. Line Losses For Transmission and Distribution Systems

a. For existing steam system, losses run at about 20 percent.

b. For new system losses are estimated to be about 10 percent.

THERMAL ENERGY DISTRIBUTION COSTS

I. Distribution

Case No.	Heating Load (BTU/Hr Acre)	Distribution Costs Steam System ($\$/10^6$ BTU/Yr)	Hot Water System ($\$/10^6$ BTU/Yr)
A. Subdistricts - 1, 2, 3,4,7,8,10,21	715×10^3	20.0	38.58
B. Subdistricts 34 & 36	256.1×10^3	32.75	62.62
C. Subdistricts 34,36,37,35	210×10^3	32.70	62.3
D. Subdistricts 64	189×10^3	-	63.16

II. Transmission Piping

A. Omit

B. For Subdistricts 34 and 36

Feasibility of extending 12" Jefferson St. steam line to handle additional load of 14,600#/hr.

Result: Can extend steam line to handle additional load.*

C. For Subdistricts 34, 35, 36, 37

Feasibility of extending 12" Jefferson St. steam line to handle additional load of 29,700#/hr.

Result: Existing 12" steam line can be extended to carry an additional load of 29,700#/hr.*

*The conclusions in B and C were arrived at under the following assumptions:

Present steam flow in the 12" line at peak demand conditions is 90,000 lbs/ The 90,000#/hr. was obtained by assuming that the peak load in the system (180,000#/hr.) is divided equally between the two 14" supply lines which further away from the source reduce to 12" lines.

Note: Annual load factor = 0.505 (210/365) = 0.29

DOE/TED - District Heating & Cooling Study

Part II - Data (Continued)

II Thermal Energy Transmission Costs (Hot Water Lines Only)

	Case	Pipe Length (Miles)	Thermal Load Transmitted (10^6 BTU/Hr)	Installed Cost ($000)
E.	For Subdistricts 24 (U)	0.6	62.9	1,267.2
F.	Subdistricts 24 and 29			
	#1	0.6	83.9	1,489.0
	#2	0.5	21.0	686.4
G.	Subdistricts 44	0.5	19.0	686.4
H.	Subdistricts 44 and 47 (4)			
	a)	0.5	38.4	792.0
	b)	0.85	19.4	1,211.8
I.	Subdistricts 100	1.7	77.9	4,173.8
J.	Subdistricts 193 etc.			
	#1 (193 only)	3.9	288	15,444.0
	#2 (193+118+119)			
	a)	3.3	356.4	13,068.0
	b)	0.9	68.4	1,900.8
	c)	0.6	288	2,376.0

DOE/TED - District Heating & Cooling Study

Part II - Data (Continued)

II Thermal Energy Transmission Costs (Hot Water Lines Only)

Case	Pipe Length (Miles)	Thermal Load Transmitted (10^6 BTU/Hr)	Installed Cost ($000)
J. (Subdistricts 193, etc.)			
#3 (For 193, 118, 119, 206)			
a)	3.3	421.9	14,810.4
b)	0.6	288	2,376.00
c)	0.9	68.4	1,900.0
d)	0.8	65.5	1,689.6
#4 (Subdistricts 193+118+119 +206+209+223)			
a)	3.3	554.1	16,639.9
b)	0.6	288	2,376.0
c)	0.9	68.4	1,900.8
d)	0.8	197.7	2,365.4
e)	2.0	132.2	4,963.2
K. (Subdistricts 183, etc.)			
#1 (183 only)	3.6	145.5	8.933.8
#2 (183+177+175+628+174)			
a)	3.5	155.4	10,348.8
b)	3.6	300.9	14,256.0

DOE/TED - District Heating & Cooling Study

Part II - Data (Continued)

Thermal Energy Transmission Costs (Hot Water Lines Only)

Case	Pipe Length (Miles)	Thermal Load Transmitted (10^6 BTU/Hr)	Installed Cost ($ 000)
K. (Subdistricts 193, etc.)			
#3 (183 Plus 263)			
a)	1.8	113.1	4,466.9
b)	0.9	145.5	2.233.4
c)	2.7	258.6	9,266.4
#4 (For 183+177+175+628) (+174+263)			
a)	3.5	155.4	10,441.2
b)	0.9	300.9	3,564.0
c)	1.8	113.1	5,417.3
d)	2.7	569.4	13,614
L. Optional Routing For Prior Subdistricts of J & K			
#1 (Subdistricts 64, 183, 193)			
a)	0.9	145.5	2,233.4
b)	0.4	145.5	1,002.6
c)	1.5	288.0	5,940.0
d)	1.5	433.5	6,732.0
e)	0.8	436.0	3,590.4

DOE/TED - District Heating & Cooling Study

Part II - Data (Continued)

Thermal Energy Transmission Costs (Hot Water Lines Only)

Case	Pipe Length (Miles)	Thermal Load Transmitted (10^6 BTU/Hr)	Installed Cost ($ 000)
L. (Option Continued)			
#2 (Main Line S)			
a)	0.4	300.9	1,584.0
b)	0.4	258.6	1,372.8
c)	0.4	569.4	2,017.0
d)	1.5	356.4	5,940.0
e)	1.5	421.9	6,732.0
f)	1.5	554.1	7,563.6
g)	1.5	1123.4	10,494.0
g)	0.8	1123.4	5,596.8
h)	1.5	780.0	9,108.0
h)	0.8	780.0	4,857.6

APPENDIX E

ANALYSIS OF SPACE COOLING OPTIONS FOR TOLEDO EDISON, ACME PLANT RETROFIT

TABLE OF CONTENTS

THERMAL ENERGY FOR COOLING

Central Plant Concept

The concept of a central cooling plant utilizing by-product steam at an electric generating plant presents many obstacles.

First, the distribution system is expensive. Since the temperature difference for cooling purposes is limited to about 20°F, pipe sizes must be larger than for an equivalent BTU heating system.

Second, cooling is required for only a few months per year, resulting in a poor load factor. Battelle estimated that the annual load factor might be as low as 9%. This allows less time to recover more capital investment than a district heating system.

Because of the inefficiencies of the steam absorption cycle, the central plant chilled water generator must be driven by a steam turbine. Back up would be necessary to ensure a continued supply. This machinery would be additional expense over and above the district heating system source, thus increasing first costs and operating and maintenance costs.

These observations support those conclusions reached by Sweden in the treatment of district cooling system. Therefore, the establishment of a central district cooling system will not be a part of this Demonstration Project.

End User Cooling Plants

Thermal energy for cooling purposes has only token use in this locality, limited mainly to hospital operating rooms and other applications where electrical outages are critical. The primary reason for the lack of thermal energy powered cooling is the inefficiency of the absorption cooling cycle.

One document that highlights the vast differences in the efficiencies between the electric driven compression cycle and the thermal powered absorption cycle is Electricity vs. Fossil Fuels, by Harry Yopp, P.E. of Atlanta, Georgia. On page 22 of that publication, Mr. Yopp indicated the coefficient of performance (COP) for an electric driven compression unit runs from 2.20 for a 3.5 ton unit to 4.96 for units over 100 tons capacity. In contrast, the COP for absorption units runs from 0.486 to 0.623 for similar sized absorption units. For units over 100 tons capacity, the electric driven unit has an efficiency advantage of 4.96 to 0.623 or 7.96:1. This means that electricity would have to be priced at 7.96 times the price of thermal energy for absorption cooling to be competitive. Electricity at 4 cents per KWH would require thermal energy to be priced at $1.47 per million BTU which is the approximate price of coal delivered to our power plants.

A report was prepared by James R. Watt, Project Manager, entitled Central Air Conditioning Comparative Report: Electric Centrifugal vs. Steam Absorption, in September, 1965. The report addressed a specific 250 ton installation. Highlights of the report are as follows:

	Input Power		Auxiliaries	Water
	Electricity	Steam	Electric	Consumption
Electric Centrifugal	208,453 KWH	-0-	6,804 KWH	192 MCF
Steam Absorption	-0-	4,574 M-lb	25,247 KWH	406 MCF

The electric cost at 4 cents per KWH is $8,610 for the electric unit and $1,262 for the absorption unit. Assuming 1 million BTU for each M-lb of steam, steam must sell for the difference between $8,610 and $1,262 which is equal to $7,348 for 4,574 M-lbs. The price of thermal energy must then be $1.67 per million BTU to make absorption cooling competitive.

Again, coal costs alone approach this figure. It can be assumed that absorption cooling will not be a marketable concept for a district heating and cooling system.

An argument may be made for steam turbine powered centrifugal units. High equipment costs eliminate that possibility particularly if relatively low pressure steam is generated from a hot water district heating system using reboilers.

Conclusion

Because of these reasons, no customer cooling systems utilizing a thermal energy system will be considered in this project.

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DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES
THOURGH POWER PLANT RETROFIT AND DISTRIBUTION NETWORK

Task 3

Energy Market Analysis

James R. Watt
George A. Sommerfield

Toledo Edison Company
Toledo, Ohio

March, 1979
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3.3 TASK 3 - ENERGY MARKET ANALYSIS

ABSTRACT

Battelle Columbus Laboratories (BCL) is a member of the Demonstration Team employed as a subcontractor by Toledo Edison to complete the energy market analysis. The work done by BCL for Task 3 is summarized after each of the deliverables.

In Task 2, "Identify Potential Service Areas," BCL determined the energy densities for the three counties in the immediate area of the candidate power plants. Based on energy density parameters developed in Sweden, 13 planning districts in Lucas County were selected for detailed study. Only Planning District No. 1, which includes the downtown Toledo area, was identified as "very favorable." Task 2 concluded that the downtown Toledo steam distribution system could be a starting point for developing a new district heating system to serve an expanding market into areas adjacent to the existing system and into the other districts with significant thermal loads.

3.3.1 Task Deliverables

Describe methodology used to determine extent of market, determine types of inbuilding HVAC systems used in area. Supply results of evaluation including all assumptions and calculations.

3.3.1 Evaluate and Assess Market

Based on the conclusion of Task 2, it was decided that an area survey would be conducted to collect data. Since the existing downtown steam system offered the best base load starting point, the survey was structured to encompass certain apparent energy intensive firms or institutions, contiguous to or within a reasonable distance from the existing system. The reasoning behind this approach was quite simple. If the large users could be identified as valid potential district heating customers, then smaller, less energy intensive users could be addressed at a later date.

The results of the survey indicated that this approach was sound. Most large energy users already utilized low pressure steam or hot water which readily allows conversion to district heating. On the other hand, the apparent ratio of conversion-cost to energy-consumed is considerably higher in smaller customers, particulary residential, making conversion to district heating less attractive. Most customers surveyed indicated an interest in pursuing district heating.

Some of the findings are shown below:

1.	Number of customers surveyed	24
2.	Number of customers that would convert if:	
	a. District heating equaled the cost of the current source	15
	b. District heating were 15% less than the current source	8
	c. District heating were 15% more than the current source	8
	(see p. 25 of BCL report)	
3.	Number of customers expressing concern over:	
	a. Potential regulatory involvement	6
	b. Compliance with building codes	5

c. Compatibility of district heating with building system — 3

d. Variable daily, seasonal and annual heating demands — 3

4. Gross heating load--all customers — 2092×10^9 BTU/yr.

3.3.2 Task Deliverables

Describe methodology used to determine kinds of, and characteristics of thermal energy most attractive to End-Users. Classify market by types of End-Users (residential, commercial, industrial) interested in thermal service. Supply description of assumptions used and summary of reasons End-Users have for preferring thermal energy to traditional supply.

3.3.2 Establish Supply Conditions

Of the 24 customers surveyed, all but two utilized hot water or low pressure steam boilers. The remaining two used forced air furnaces (see p. 17). Most of the large customers that could be potential base loads which are necessary to support line extensions utilized steam, some at 150 psig. Hot water is easy to obtain from a steam supply. But the generation of steam at 150 psig from hot water requires more expensive inbuilding equipment as well as high temperature water, which also results in a less efficient system. The extraction of steam at a higher point on the turbine and the use of multiple reboilers account for the loss of efficiency. Although decisions are not yet final, it appears that steam is the preferred heat transfer medium.

Based on the Swedish experience and the preliminary calculations completed in Task 2 - "Identify Sources and Service Areas," the thermal density of residential areas is not favorable to the development of district heating systems. Toledo does not have any concentrated areas of high-rise residential construction. There are a few isolated mid to high-rise residential structures in the near downtown area. These loads were not surveyed since they are not concentrated and will not by themselves determine the extent of the district heating distribution system.

During our analysis in Task 2 we realized that key users of thermal energy would be required in each of several potential service areas. These high use customers are schools, hospitals, or industrial plants. The thermal loads are predominately space heating requirements, although the hot water and process requirements are also considered. If we are successful in determining that these loads could be served by a skeletal district heating distribution system, then other loads which could be added would merely add to the profitability of the proposed system.

In several cases residential loads would fall into this category. The mid to high-rise residential structures near downtown could be served from the distribution system traversing the area en route to hospitals, schools and industrial loads in the community. Because there is only minimal housing in the central business district, the residential load probably will not exceed 5-10% of the district heating load depending upon the ultimate extent of the system.

Development plans for the central business district may include some new residential areas. If these loads develop, the district heating system will be ready to serve them. However, no firm plans presently exist so we cannot estimate the future extent of residential loads.

To understand the relative magnitude of commercial and residential loads consider the following example. A hospital under consideration has an annual load of 126 x 10^9 BTU. The combined load of two high rise apartment buildings is only 10.5 x 10^9 BTU. Since the hospital has twelve times more load than the apartment buildings, the success of the district heating system is dependent on attracting the hospital load and other similar loads. Subsequent connection of the apartment buildings to the district heating system would certainly be beneficial.

The community by definition includes whatever is within the boundaries of the candidate community. Residential loads are a small part of this candidate service area at the present time. Of the customers surveyed, 50% are manufacturing, 17% are finance, insurance and real estate, and 33% are services.

The primary reasons for thermal energy preference among those surveyed were the favorable impact on environmental regulations, compatibility of the thermal energy source with the inbuilding systems, safety, a reduction of operating personnel, greater availability and reliability, and a decrease in risk and uncertainty (see p. 24).

3.3.3 Task Deliverables

Supply detailed narrative explaining problems and the approach to overcome each one.

3.3.3 Explain Problems

Only two institutional problems surfaced. One related to potential regulatory involvement and the other related to compliance with building codes. Both of these present no insurmountable barriers and will be addressed in Task 5.

The real issue is economic. While eight respondents indicated they would switch to district heating if it were 15% higher in cost than present fuel sources, eight also said they would convert only if the cost were 15% lower. With the present abundant supply of natural gas selling at $2.50 per million BTU, it will be a challenge to supply district heating energy at a competitive price. Escalation in the cost of fuels will be treated in detail as a part of the Task 6 effort.

Conclusions

The existing steam district heating system can serve as the base load for establishing a new thermal energy system using by-product heat from a nearby electric generating station. Since the central business district is surrounded by well developed areas, potential markets exist that can be served by an expanded district heating system. The Demonstration Team has developed a methodology which is outlined in the attached report to characterize the energy requirements of large users of thermal energy within a few miles of the downtown area. From the survey a number of conceptual expansion plans emerged. Sufficient loads have been identified to either double or triple the existing sales of thermal energy.

The generic evaluation of the market for district heating services indicates several factors must be considered. Areas with high energy density are the best possible potential service areas. Commercial, institutional, and industrial customers are desirable because of their large loads and the minimal retrofit requirements. Once the large loads are identified, the skeleton of the distribution system can be specified. The areas encompassed by the distribution system also contain potential district heating customers. Often these are residential areas with warm air heating systems. Converting these loads to district heating is a major challenge which should be deferred until the escalation of natural gas prices makes conversion attractive.

Once the large customer's are defined, a decision can be reached as to whether steam or hot water is the better choice. Conversion of steam to hot water at the point of use is a standard procedure. Converting high temperature water to steam is not attractive from an overall efficiency viewpoint. The need for steam at various pressures is also a consideration. A decision may be necessary for some customers as to whether all their load can be converted to the district heating system. The choice may be to maintain boiler capacity for some special uses or to use reboilers to raise the temperature and pressure of a portion of the thermal energy which is delivered.

A review of the long term development within the service areas is necessary as a part of the market assessment. Downtown Toledo is in the beginning stages of a revitalization program with several new buildings in planning stages. These new loads have been included in the potential market for district heating services. The owners involved are interested in evaluating the economics of using district heating energy and probably will compare the cost with all-electric inbuilding systems.

The market survey confirmed the belief that there is no market for centrally produced chilled water. The use of thermal energy for cooling at the point of end use is not popular either. Cost analyses have shown that the cost of thermal energy must be very low to justify absorption air conditioning with equipment presently available. Special circumstances may result in the use of thermal energy for cooling, but community based chilled water systems normally will be impossible to justify.

The potential customers in Toledo thought that compatibility, safety, reduced operating costs, greater reliability and decreased risk were primary reasons for accepting thermal energy services. The problem is to determine what these benefits are worth. Most customers indicated a willingness to convert if the total cost of delivered district heating energy were equal to or less than their present cost of space and process heating. Further incentives must be identified in the form of grants and tax advantages to encourage customers in both the non-profit and profit sectors of the economy to make the necessary retrofits. Once the detailed economic analysis is completed in Task 6, the magnitude of the incentives will be determined.

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FINAL REPORT

on

AN ENERGY MARKET ANALYSIS FOR DISTRICT HEATING AND COOLING SYSTEMS IN TOLEDO, OHIO

to

TOLEDO EDISON

from

BATTELLE
Columbus Laboratories

February 28, 1979

BACKGROUND

The potential service areas identified and characterized in Task 2 establish the framework for planning and conducting the energy market study by:

- demarcating the geographical extent of potential service areas, and
- identifying the relative attractiveness of district heating and cooling in terms of energy densities and district heating costs.

The Task 2 preliminary cost estimates for serving various combinations of planning subdistricts are the basis for identifying areas for further study in Task 3. The significant cost increases where distribution lines were required and the relatively high cost of user retrofit for small thermal energy consumers clearly indicate that this task's activities should concentrate on identifying;

- potential customers adjacent to the existing system
- more distant potential district heating customers that are large consumers of energy.

In addition the results indicate that Toledo's central business district should be a basis for expanding the existing steam district heating system to contiguous high energy density districts and more distant very high energy density districts. This type of expansion would allow considerable expansion of the existing system while possibly being cost competitive with future prices of oil and natural gas based on estimated future prices for these fuels. A time-phased plan for expansion of the existing system might be develped to incorporate both contiguous and non-contiguous areas. Power plant capabilities would be significant in delimiting plans for expanding markets beyond those anticipated in this study.

Task 2 findings also indicate that use of thermal energy for cooling does not appear justified as a potential end-use through absorption units or as part of a chilled water system. The market survey has been utilized as a mechanism for further identifying and evaluating the market potential for district cooling.

OBJECTIVES

In accordance with Task 2 findings, the objective of Task 3 was to determine the nature and extent of the market for centrally generated thermal energy. Several activities within the purview of this task were to:

- conduct a survey of current and forecasted user loads for the proposed service areas. Categorize present and future customers into residential, commercial and industrial sectors and prepare a complete inventory of the type of system, quality and age of equipment.

- establish characteristics and supply conditions for the proposed service area based on an analysis of user's particular requirements.
- examine and evaluate factors inducing end-users to switch from traditional energy supply sources to centrally-generated thermal energy. Based on survey data, an analysis of the cost of heat and cost of changes required in end-users equipment should be conducted.
- identify the generic nature of the market, characteristics, and problems as they relate to other urban areas.

This report documents the efforts involved in achieving the study's objectives and is presented in four sections. The first section describes the methodology employed. Major assumptions and criteria for identifying and evaluating market potential are also clarified. In the second section, the study's findings are presented and analyzed in terms of their impacts on selection of service areas and design of an appropriate retrofit scheme at the power plant. The market is classified by type of end-user with detailed descriptions of end-user energy requirements and in-building HVAC systems. End-user attitudes and opinions of district heating and cooling systems provide insight into variables involved in a decision to convert from conventional energy supplies to centrally generated thermal energy. The third section examines the potential application of the study's approach and findings to other urban areas. In the final section, the findings are summarized and discussed in terms of their impacts on subsequent tasks and phases. Utility and end-user problems and concerns are addressed. Recommendations are directed at resolving potential areas of concern both in the planning and implementation of a district heating and cooling system.

METHODOLOGY

Clarification of several principles establishing the context and structure for the energy market study was necessary prior to specifying the overall methodology. In this sense then, the market study was directed at fulfilling the following criteria:

- Incorporation of previous task results (Task 2) to structure and plan the energy market survey.
- Development of a methodology applicable to the proposed service area and appropriate to Phase I of this Demonstration Project.
- Specification of a generic methodology transferable to other urban areas.
- Identification of an evaluation methodology to include a consideration of economic, institutional and environmental incentives and disincentives of district heating and cooling.

With this background, the study's approach was defined to incorporate the following stages and activities:

- Preliminary Planning
  - define research objectives
  - specify information needs
  - review and evaluate Task 2 results
- Data Collection
  - specify sampling design
  - define, develop and pretest survey instrument
  - plan and conduct field operations
- Data Processing, Analysis and Interpretation
  - edit, classify and tabulate data
  - evaluate and interpret data

Each of these stages and activities are presented and discussed in terms of associated tasks, procedures and assumptions. Background material is provided for explanatory purposes wherever appropriate.

PRELIMINARY PLANNING

In this stage, research objectives were restated, clarified and discussed relative to Task 2 results. This statement of purpose was formative in translating the research problem into a study design.

Research Objectives

Briefly restated, the objectives of the market study are to:

- Identify the nature of the market for thermal energy.
- Determine the extent of the market for thermal energy.
- Identify and analyze factors affecting end-users decisions to convert from traditional energy sources to centrally generated thermal energy.
- Screen, evaluate and identify the most promising service areas for marketing thermal energy.

Information Needs

To achieve these objectives, a list of information needs was developed. To a great extent, these data needs determined the research design, that is, who would be sampled, and what, where, and how information would be obtained.

The information needs developed are categorized and outlined below:

- Characteristics of Market
  - number and type of existing and potential customers
  - size and location of market
  - current and prospective competitive position with alternative energy sources with respect to price and quality
  - prospects for growth or contraction of market

- Technical
  - end-use building system characteristics
  - annual, seasonal and daily energy demands
  - current and forecasted energy requirements
- Economic/Financial
  - respondent's method of financial analysis
  - availability of capital
  - cost differential between thermal energy and conventional energy sources
  - user retrofit costs
- Barriers and Incentives to District Heating and Cooling
  - economic/financial
  - technical
  - environmental
  - institutional/legal

Review and Evaluate Task 2 Results

In Task 2 efforts were directed at identifying where and to what extent the market opportunity for district heating and cooling existed. As previously stated, this initial approach emphasized energy density indicators and preliminary estimates of the cost of delivering and using thermal energy. From an analysis of Task 2 data several important criteria for Task 3 activities were identified. First, the existing downtown district heating system should serve as a base from which to expand service because of the relatively low cost to serve this load as well as its proximity to Acme. Second, attracting new customers who are adjacent to the existing district heating system should represent the first step in expansion. Third, attracting new customers who are located more distant from the existing system will depend on initially serving one or a few large thermal energy consumers thereby reducing distribution costs and minimizing customer retrofit costs per million BTU's delivered. Based on these criteria, BCL screened and recommended a number of potential service areas for further study. These areas, defined as planning districts and subdistricts, are identified below and depicted in Figures 1 and 2:

Planning District	Planning Subdistricts
1	All subdistricts (Figure 2)
2	63, 624, 143
4	29, 44, 47
8	174, 175, 177, 183, 263, 628
9	193
11	118, 119, 206, 209, 223

The results also indicated that a priority and phased system be established for surveying potential customers to make best use of budgeted time and other resources. For instance, it seemed appropriate to sample potential new customers within the existing steam system, as well as in conterminous subdistricts. Outlying areas, such as planning districts 2, 8, 4, 9, and 11 should be sampled so that large customers critical to system viability were sampled prior to additional surveying in that area.

This philosophy prevailed during the energy market study and provided substantial guidance in structuring the research design. From a planning standpoint then, the subdistricts defined above provided the geographical boundaries of the energy market survey.

DATA COLLECTION

The basis for the marketing analysis was data collection from surveys. In addition to the planning and pretest aspects, the survey required specifying sampling design and selection of data collection methods; preparation of appropriate data collection forms; and planning and conducting field operations. Each of these basic steps are addressed in the following discussion.

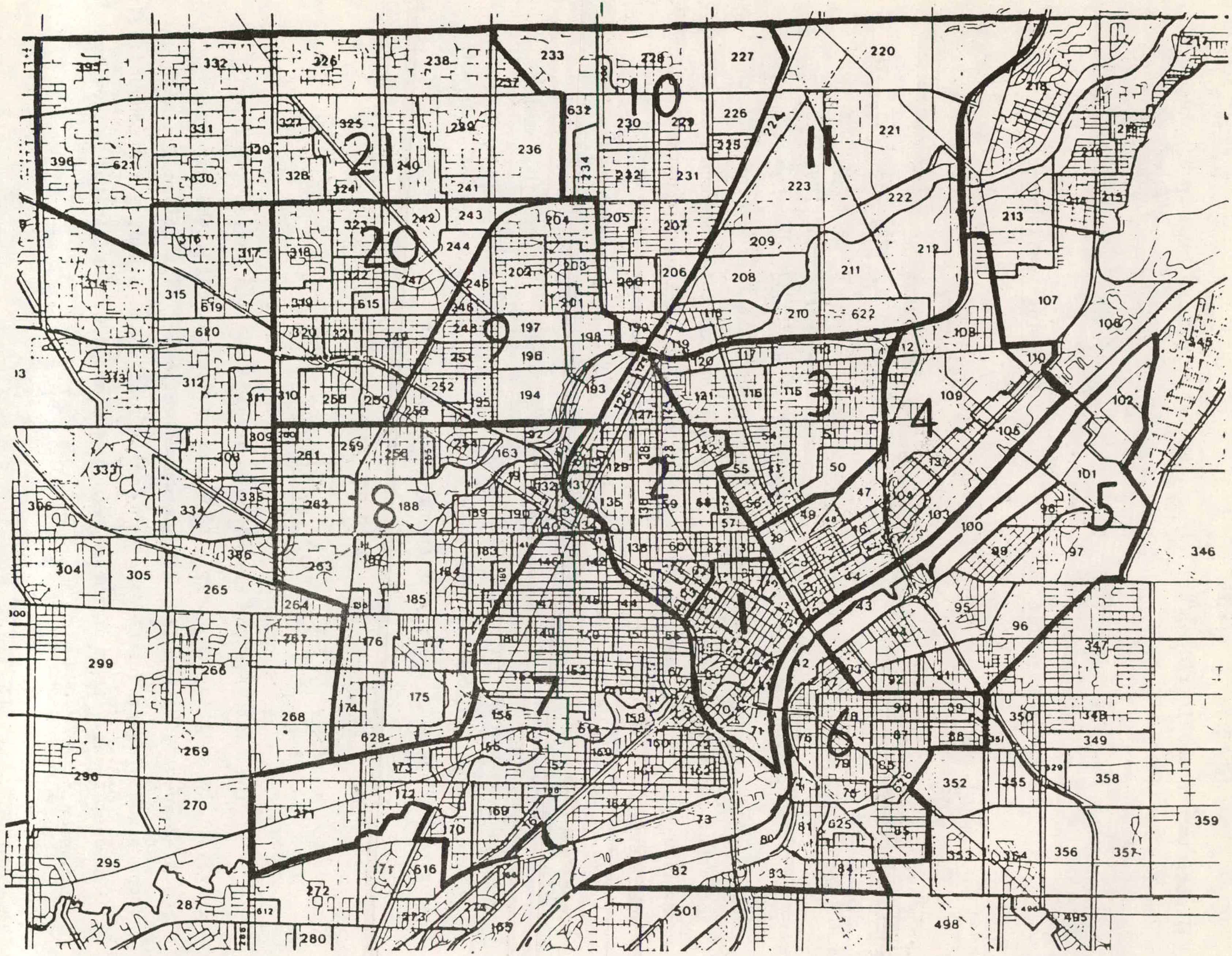

FIGURE 1. LOCATION OF PLANNING SUBDISTRICTS WITHIN TOLEDO METROPOLITAN AREA

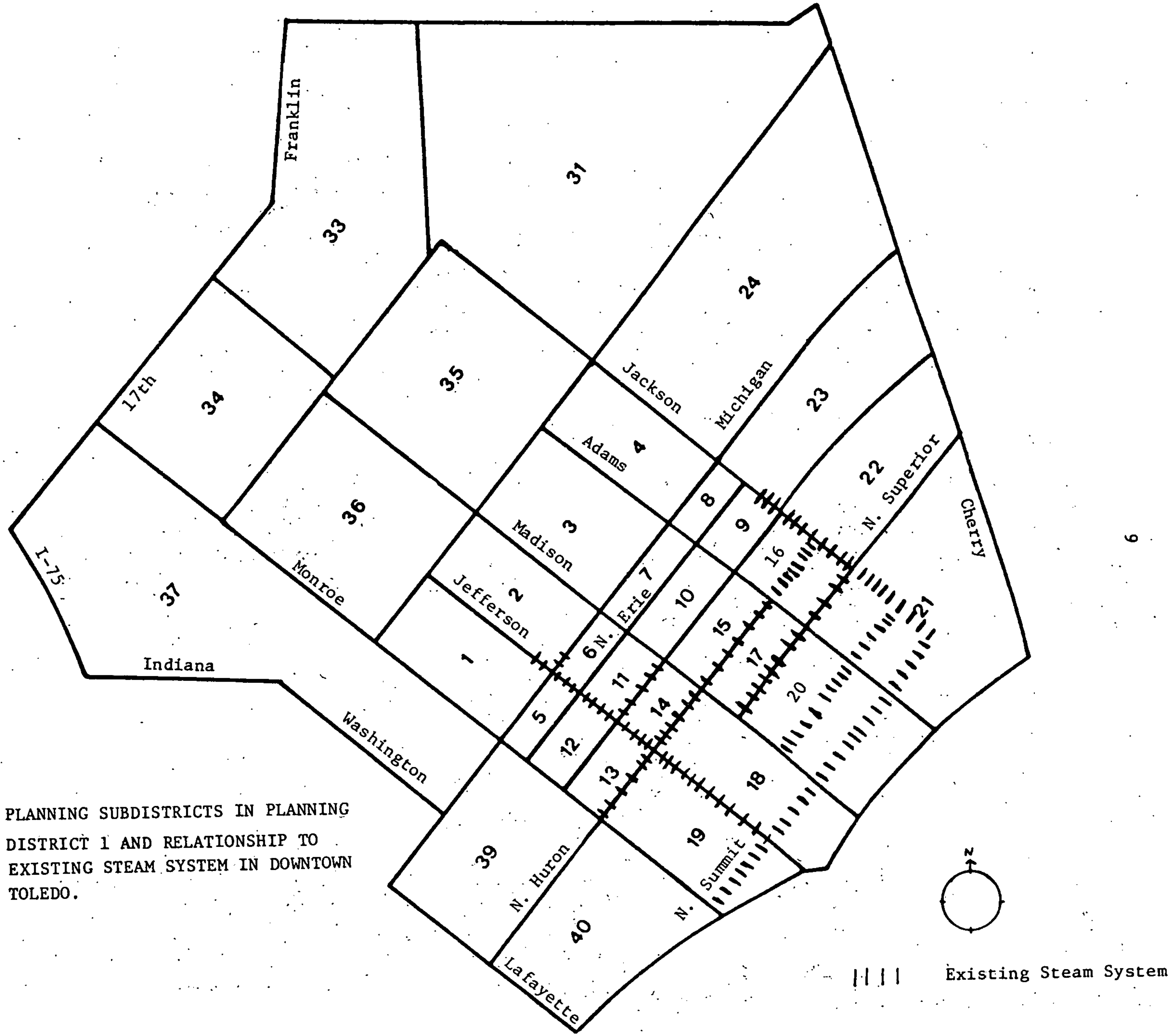

FIGURE 2. PLANNING SUBDISTRICTS IN PLANNING DISTRICT 1 AND RELATIONSHIP TO EXISTING STEAM SYSTEM IN DOWNTOWN TOLEDO.

Specify Sampling Design

The population from which the sample was drawn was initially defined as all large industrial and commercial firms and companies within the boundaries of the potential service areas identified in Task 2. More rigorous definition of sampling units was then made in order to structure the survey instrument appropriately. The proper sampling unit, or survey respondent, for the purposes of this study was determined to be a person(s) responsible for business decisions and/or building energy management for the company or firm being interviewed.

The framework for specifying the location of all such sampling units, known as the sampling frame, was the Ohio Manufacturers Industrial Directory, supplemented by city maps, site observation, city development plans and informed judgement of BCL and Toledo Edison staff. Comprehensive lists of samples for each proposed area were developed and reviewed for accuracy and completeness.

The sampling technique relied upon for the survey was area sampling. This technique is based on prior subdivision of potential service areas into regions of high energy densities with feasible district heating costs. Sampling units were therefore restricted to these areas. Subsequent sampling within these areas was on the basis of the size of the company or firm (building floor area) and/or known or estimated energy demands.

The accuracy, or reliability of a sample is affected by sampling and non-sampling errors. Because of the non-random basis of sampling procedures, the marginal error could not be estimated. Non-sampling errors, or bias, involving such factors as prejudicial question wording, faulty editing and interviewer bias, were controlled through initial emphasis on sampling design. Accordingly, every effort was made to train interviewers properly, collect and verify respondent's information, structure the survey forms in a concise, understandable fashion and edit survey forms as they were completed.

Define, Develop and Pretest Survey Instrument

The primary data for this study could have been collected through a variety of ways: mail questionnaire, personal and telephone interviews, and internal records. The nature of the energy market study, in terms of technical and business-related data needs, as well as the type of respondent to be surveyed, necessitated that each approach be carefully evaluated as to its advantages and limitations. Consequently, each approach was examined in terms of the type of data (quality and quantity) that could be collected, the potential for sample bias; cost; time to administer, complete and process results; and applicability.

As a result of this evaluation, it was determined that a combination of these approaches would be preferable to any one of them individually. For existing customers, Toledo Edison's internal records were relied upon for existing steam customers. A two-part questionnaire was found to be appropriate for sampling potential customers. It is on the latter survey instrument that this discussion focuses.

The design of the questionnaire involved consideration of a number of aspects, of which the principal ones were the content approach, organization, physical layout and question form and wording. Each of these aspects are addressed in the following paragraphs.

The content of the questionnaire was defined primarily by the type of data to be collected (factual information, information on consumer behavior, opinions and attitudes); the data collection method (self-administered questionnaire and personal interview); and on the ultimate use of the data (estimation of market potential and user retrofit costs, evaluation of incentives/disincentives of district heating and cooling). On this basis, a structured two-part questionnaire was developed involving approximately two to three hours of the respondent's time. Part A, the energy audit, was a technically-orientated, self-administered questionnaire designed to obtain factual information regarding the company's building(s), its HVAC equipment and energy consumption by source and end-use. Part B was primarily a business-oriented, personal interview involving a structured questionnaire that was administered subsequent to completion and review of Part A.

In the preparation of this questionnaire, detailed consideration was given to organization, physical layout and question wording. With regard to Part A, it was important to ensure the questionnaire was simple, easy to follow and self-explanatory. In Part B, emphasis was given to the type and wording of questions to be used in obtaining information on factors affecting a decision to convert from existing energy sources to centrally generated thermal energy. The type of respondents being surveyed in both questionnaires permitted use of some technical language and allowed greater precision in question wording. An uncompleted version of the survey is provided in the Appendix for reference.

Subsequent to the design and formulation of the questionnaire, it was screened and reviewed by BCL and Toldo Edison staff. The survey instrument was then pretested and revised to its final form.

Plan and Conduct Field Operations

The procedures for administering and completing the questionnaires involved the following series of steps:

Step 1
- Initial telephone contact
- Identify purpose of call, explain approach, determine willingness of respondent to participate
- Set up appointment for interview, approximately five working days from call. Confirm date, time, location, person(s).
- Mail Part A with cover letter

Step 2
- Respondent completes Part A

Step 3
- Conduct follow-up interview
- Review data in Part A
- Obtain responses from questions in Part B.

This approach permitted timely completion of the energy audit portion of the survey (Part A) by an appropriate person (for instance, a plant manager) within a company. Review of Part A at the time of the interview provided an opportunity for screening responses for completeness, accuracy and consistency. Completion of Part B with an individual having decision-making responsibility was vital to ensuring credibility of initial commitments to district heating and cooling.

The interviewers selected had the technical background and expertise necessary to conduct the interviews. A training session prior to the initiation of the survey entailed presentation of survey objectives, discussion of procedures and review of the questionnaire. Practice interviews were conducted on a role-playing basis.

DATA PROCESSING, ANALYSIS AND INTERPRETATION

In this stage, two major tasks were accomplished, processing of data and the analysis and interpretation of the survey results. Each of these activities are addressed in the following discussion.

Edit, Classify, and Tabulate Data

Data processing entailed editing, classifying, coding and tabulating survey results. Additional opportunity for sample validation existed throughout these activities by screening questionnaires for internal consistency and completeness. Interviewers were requested to provide explanations where data gaps were evident and answers were amended or deleted whenever the interviewer or respondent (through a follow-up telephone call) could not clarify ambiguities or provide appropriate responses.

Evaluate and Interpret Data

The review and evaluation of survey results was predicated on the assumption that an iterative process was essential to achievement of an optimum supply and demand situation for a district heating and/or cooling scheme. This required parallel examination of alternatives for marketing action with power plant retrofit schemes by the Demonstration Team. Major criteria relied upon from both the end-user and system perspective were:

- end-user interest in district heating and/or cooling applications
- technical compatibility
- economic feasibility
- geographical locations of service areas
- load profiles
- redevelopment and growth plans for the surrounding service area

FINDINGS

In this section survey data is presented, discussed and evaluated. Alternatives for a district heating and/or cooling systems are explored and specified. The final alternatives formulated by members of the Demonstration Team are then examined in greater detail. Customer mix, load profiles, potential for energy substitution, and user retrofit costs are specified for each alternative identified.

SURVEY DATA

Overview

A summary of the survey sample by business category is depicted in Table 1. Of the twenty-five companies and firms requested to be surveyed, there was only one refusal to participate. The remaining twenty-four companies fully cooperated and completed the questionnaire as requested.

TABLE 1. SUMMARY OF SURVEY SAMPLE BY BUSINESS CATEGORY

Major Category	Number	Percent
Manufacturing	12	50
Finance, Insurance and Real Estate	4	17
Services	8	33
	24	100

In Table 2, a characterization of the sample by location and building-related characteristics illustrates the distribution of the potential customers within the Toledo Metropolitan Area. Information relative to the existing steam customers is provided for comparison purposes. Potential market penetrations in terms of building floor area and average annual thermal loads are also indicated. Note that if all existing and potential customers were combined in planning district 1, a 50 percent market penetration of the total building floor area would be achieved. Figure 3 further clarifies the location of the sampled potential customers relative to the planning subdistricts with high thermal density and large base load users. Annual potential thermal loads for each surveyed company located on Figure 3 are listed on Table 3.

TABLE 2. CHARACTERIZATION OF SURVEY SAMPLE BY GEOGRAPHIC LOCATION AND BUILDING-RELATED CHARACTERISTICS

Planning District (PD)	Planning Subdistricts (PSD)	Number of Existing/ Potential Customers	Number of Buildings	Gross Building Floor Area (10^3 ft^2)	Percent of Total Building Floor Area in PSD's	Customer Annual Energy Consumption 10^9 Btu/yr.*	Percent of Annual Energy Consumption in PDS's
EXISTING SYSTEM							
1	ALL PSD's	105	100	2592	28	453.7	30
POTENTIAL ADDITIONS TO EXISTING SYSTEM							
1	ALL PSD's	11	15	2114	23	79.9	5
2	63, 143, 624	3	13	1754	89	243.4	75
4	29, 44, 47	5	7	739	61	61.6	31
8	174, 175, 177, 183, 263, 628	2	23	2595	32	390.5	35
9, 11	118, 119, 206, 209, 223, 193	3	10	6092	56	773.0	43

* For potential additions the column represents energy consumption at end-use that could be served by the district heating system.

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TABLE 3. ANNUAL ENERGY CONSUMPTION FOR END-USERS SUBSTITUTED BY THERMAL ENERGY FOR COMPANIES SURVEYED AS NOTED ON FIGURE 3.

Company Code	Annual Energy Consumption for End-Users Substituted By Thermal Energy (10^9 Btu) *
1	920.0 (644.0)
2	2.3 (1.8)
3	10.8 (8.3)
4	2.7 (2.1)
5	1.1 (0.9)
6	~~167.0~~ (127.0)
7	126.0 (89.5)
8	4.5 (3.4)
9	13.4 (10.3)
10	13.6 (10.5)
11	379.1 (291.9)
12	20.1 (14.2)
13	17.5 (16.6)
14	5.1 (3.9)
15	186.3 (143.4)
16	128.0 (98.6)
17	17.1 (16.2)
18	10.2 (9.7)
19	6.5 (6.2)
20	2.6 (2.0)
21	4.6 (3.7)
22	37.4 (28.8)
23	14.8 (11.0)
24	6.3 (4.4)

* Consumption in parentheses represents energy at end-use that could be served by the district heating system.

FIGURE 3.
AVERAGE HEAT DENSITIES OF PLANNING SUBDISTRICTS WITH LARGE BASE LOAD USERS AND POTENTIAL USERS SURVEYED

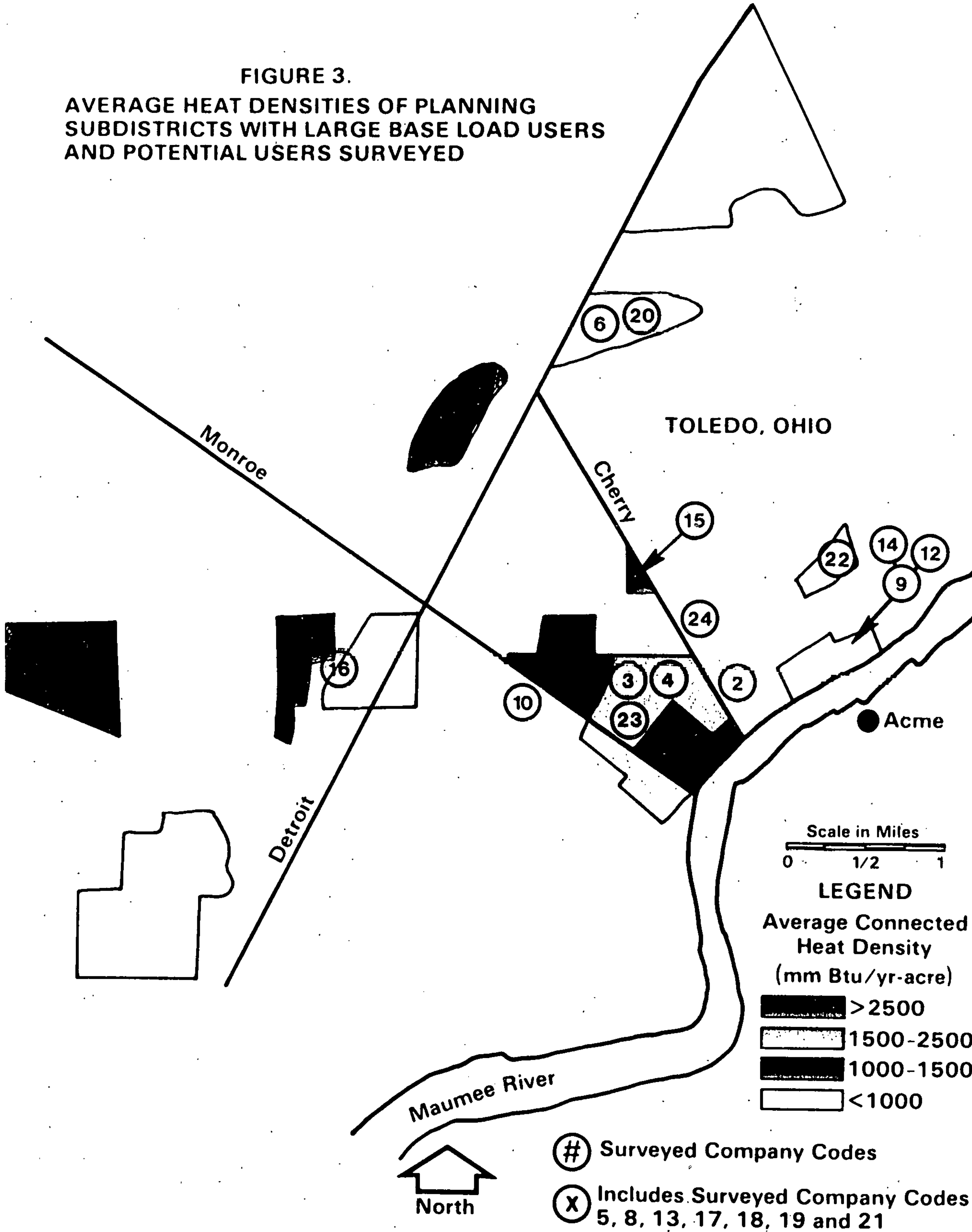

TABLE 4. BUILDING HEATING EQUIPMENT INVENTORY[(a)]

				HEATING SYSTEM CHARACTERISTICS				
Company Code	Building Type(s)/ Number at Site	Location: PD(PSD)[(b)]	Gross Building Floor Area (10^3 ft^2)	(Boiler/Furnace) and Number	Capacity/Unit (10^6 Btu/hr)	Age (yr)	End-Use Application	Distribution System
1	Plant and offices/4	9(193)	5500	Boiler, 10	N.D.(308)[(c)]	60	Space heat, process steam	Steam
2	Office/1	1(23)	87	Boiler, 2	N.D.(<10)	(30)	Space heat	Steam
3	Office/1	1(24)	71	Boiler, 2	4	8	Space heat	Hot air, hot water
4	Plant/1	1(31)	10	Boiler, 1	4	18	Space heat	Steam
5	Office/1	1(21)	19	Furnace, 3	<1	6	Space heat	Forced air
6	Plant/5	11(119)	564	Boiler, 9	4	10	Space heat, process steam	Steam
7	Hospital/8	2(63)	568	Boiler, 3	15	23	Space heat, domestic hot water, other	Steam
8	Office/1	1(7)	62	Boiler, 3	<2	20	Space heat	Steam
9	Plant and office/2	4(44)	40	Furnace, 10	<2	1-15	Space heat	Forced air
10	Museum/2	2(143)	353	Boiler, 3	3	13	Space heat	Hot water
11	University/22	8(263)	2000	Boiler, 12	5-65	1-75	Space heat, domestic hot water, absorption air conditioning	Steam, hot water
12	Plant and office/1	4(44)	70	Boiler, 4	<5	7-25	Space heat, process steam and hot water	Steam
13	Office/1	1(20)	100	N.A.[(d)]	N.A.	N.A.	N.A.	N.A.
14	Plant and office/1	4(44)	60	Boiler, 1	3	18	Space heat	Steam
15	Hospital/3	2(624)	833	Boiler, 3	25	30	Space heat, other	Steam, hot water
16	Plant and office/1	7/8 (146)	595	Boiler, 3	1-12	20-30	Space heat	Steam
17	Office/1	1(21)	880	Boiler, 2	15	0	Space heat	Hot water
18	Office/1	1(20)	294	Boiler, 3	1-5	8	Space heat, domestic hot water	Hot water
19	Office/1	1(7)	198	Boiler, 3	<1-3	3	Space heat, domestic hot water, other	Hot water
20	Plant and office/1	11(118)	29	Boiler, 1	<1	14	Space heat	Hot water
21	Offices/4	1(3)	140	Boiler, 4	<1	20-25	Space heat	Hot water and steam
22	Plant and office/1	2(147)	477	Boiler, 3	4-20	2-35	Space heat, process steam	Steam
23	School/2	1(37)	295	Boiler, 4	9	35	Space heat	Hot water, forced air
24	Plant and office/2	4(29)	92	Boiler, 2	(<5)	8-26	Space heat, process hot water and steam	Steam, hot water

(a) Data presented in this table are based on the survey sample.
(b) Planning districts (PD) and planning subdistricts (PSD) are depicted in Figures 1 and 2.
(c) Data on a per unit basis were not disclosed (N.D.). Numbers in parentheses indicate total capacity.
(d) Information was not available (N.A.) since building plans are not finalized.

Building Inventory

Heating and cooling system data collected from the survey are presented in this section. Coding of data was necessary because of the sensitivity of releasing or publishing information that would identify the organization and/or his nature of business.

Heating System Equipment

In Table 4, selected heating system characteristics of the sample are presented on a company-by-company basis. For each company interviewed, the following information is provided:

- location in planning districts (PD) and subdistricts (PSD)
- building type, number and size
- heating equipment type (excluding service water heaters), number, capacity, and age
- end-use application (space heat, domestic hot water, process steam/hot water, other)
- distribution system type (hot water, steam or forced air).

Of the twenty-four companies interviewed, nineteen rely on natural gas and/or fuel oil to meet the end-use demands indicated in this table. Coal and electricity-fired boilers are utilized by only one and four firms, respectively. When boiler/furnace capacities are compared by age, it is evident that smaller-sized units have a mean age less than that of larger-sized ones as shown in Table 5.

TABLE 5. BOILER/FURNACE CAPACITY VERSUS AGE

Capacity(10^6 Btu/hr)	Number	Mean Age (years)
1-10	65	13
10-100	23	43

Extensive data collection on existing steam customers was limited to identifying the number and mix of customers, total building floor area, and steam load profiles. The average age of buildings served by the existing steam system is approximately 40-45 years with a range of 10-70 years. The older buildings have typical radiator systems using low pressure steam. A few of the new buildings are hot water perimeter systems.

Air Conditioning Equipment

Table 6 summarizes pertinent information by chiller type for the sample surveyed. In terms of total capacity (ton), 71 percent of the total air conditioning requirements are met by centrifugal chillers, even though reciprocating units account for 76 percent of the total number of units interviewed. Information on the number of companies and buildings served by electric or absorption chillers indicates the degree of reliance on these system types. (Self-contained window units were excluded from this analysis since they accounted for less than four percent of the capacity indicated in Table 6.)

TABLE 6. BUILDING CENTRAL AIR CONDITIONING INVENTORY

Chiller Type	Number of Units	Total Capacity (Tons)	Number of Companies Served	Number of Buildings Served
Electric				
Reciprocating[1]	68	1264	14	25
Centrifugal	16	8104	10	10
Absorption	5	2024	2	25
Total	89	11392	26	60

1. Assumes all units <100 tons are reciprocating

The distribution of central air conditioning units within specified capacity ranges illustrates the high number of smaller-sized units (Table 7).

TABLE 7. RELATIONSHIP BETWEEN NUMBER AND SIZE OF AIR CONDITIONING SYSTEMS WITHIN CAPACITY RANGES

Capacity Range (tons)	Number of Units	Mean Capacity (tons)
1-15	39	6
15-100	29	35
100-200	6	153
200-500	11	380
500	4	1289

When the age of these units are defined within these ranges the mean age was determined to be less than 12 years (Table 8).

TABLE 8. AGE OF AIR CONDITIONING UNITS WITHIN CAPACITY RANGES

Capacity Range (tons)	Number of Units	Mean Age (years)
1-15	27	7
15-100	23	12
100-200	6	6
200-500	11	10
7500	4	4

The geographic location of the cooling capacity is noteworthy. Approximately 78 percent is located within the downtown area (planning district 1) with 92 percent of that capacity accounted for by electric driven centrifugal chillers.

Only a few (four-five) of the downtown buildings which are presently served by the existing steam distribution system have central air conditioning. The other buildings use window air conditioners and unit air conditioners which serve part of a building.

Incentives and Discentives to District Heating and Cooling

A number of variables affecting a company's decision to switch from traditional energy supply sources to centrally generated thermal energy were examined and evaluated through the survey. The discussion in this section focuses on two discrete areas:

- energy supply and demand characteristics of traditional energy sources, and
- factors affecting the feasibility and acceptability of district heating and cooling

Energy Supply and Demand Characteristics of Traditional Energy Sources

A company's perspective on its current and forecasted energy supply and demand situation was an important basis for evaluating the potential feasibility of district heating and cooling. In this regard, it was necessary to ascertain:

- expected annual inflation rates and changes in energy prices over the next fifteen years
- anticipated problems with current energy sources meeting present or future requirements
- projected changes in energy demand.

Over the next fifteen years, 75 percent of the sample believe that the national annual inflation rate will be in the range of 7-10 percent. Twenty-one percent believe it will be greater than 10 percent. When annual inflation rates are compared with expected changes in energy prices, some interesting relationships emerge. Table 9 depicts the responses

TABLE 9. PERCEIVED ANNUAL CHANGES IN ENERGY PRICES VERSUS INFLATION RATE

Energy Source	Number of Responses	Less than Inflation rate		Equal to Inflation rate		Greater than Inflation rate	
		Number	%	Number	%	Number	%
Electricity	23	4	18	10	43	9	39
Natural Gas	19	4	21	6	32	9	47
Fuel Oil	11	3	27	3	27	5	46
Coal	5	2	40	2	40	1	20
Purchased Steam	1	-	--	--	--	1	100

obtained by energy source. For natural gas and fuel oil, 47 percent and 45 percent of the companies, respectively, believe that energy prices will exceed the annual inflation rate, that is, that there will be a real increase in the price of energy. Slightly under 40 percent of the sampled companies believe electric prices will increase in real terms. For coal, prices are expected to rise above the inflation rate by only 20 percent of the sampled firms.

Eight organizations (33 percent) forsee problems with current energy sources meeting present or future requirements. Most responses related potential problems with oil and natural gas availability. Some expressed concern with uncertainty over oil and gas prices. Only one organization indicated a potential problem with coal supply in the long-term.

Annual growth rates in energy demand ranged from 8 percent to 25 percent for 33 percent of the firms interviewed. Major reasons for increased demands included building expansions and increased production. All other firms project no change in their energy demand except for one that indicated a decreased annual growth rate in energy demand through conservation.

It is apparent that there is some concern over the availability and pricing of energy in the near-to mid-term. These issues, moreover, are expected to affect decisions regarding future growth and the degree of reliance on current energy sources.

Factors Affecting the Feasibility, and Acceptability of District Heating and Cooling

Table 10 depicts which variables would impact, and how, on a decision to convert from current energy sources to centrally generated thermal energy. Of the institutional variables specified, some concern was elicited with regard to potential public utility commission and building authority involvement. Issues relate directly to setting of rates, establishing the quality and type of service, and complying with building codes. From an environmental viewpoint, reliance on centrally generated thermal energy was perceived to offer distinct advantages over current end-users' equipment.

TABLE 10. IMPACT OF VARIABLES ON A DECISION TO CONVERT TO CENTRALLY-GENERATED THERMAL ENERGY (NUMBER OF FIRMS INDICATING TYPE OF IMPACT)

Variable	Favorable Impact	No Impact	Unfavorable Impact
Institutional			
• Potential regulatory involvement in setting rates, and establishing quality and type of service	3	15	6
• Your corporate image	3	21	0
• Compliance with building codes	1	18	5
• Impact of environmental regulation	11	13	0
• Nature of contracts with your current energy supplies	1	22	1
Technical			
• Compatibility of thermal energy source with building system and energy uses	14	7	3
• Variable daily, seasonal and annual demands	5	16	3
• Safety	11	12	1
• Change in number and expertise of your operation and maintenance staff	11	12	1
Economic			
• Availability of current energy supplies	12	12	0
• Reliability of thermal energy supply	11	12	1
• Risk and uncertainty (damage and maintenance, insurance and security costs)	10	12	1
• Nature and extent of market for thermal energy in Toledo area	14	8	1
• Availability and type of financing	6	7	6

With regard to technical issues, respondents indicated the favorable impact centrally generated thermal energy would have over current end-users equipment. In general, this energy source was advantagous from a compatibility, safety, and operational standpoint.

Economic factors highlighted as having a potentially favorable impact over current end-users systems were availability, reliability, risk and uncertainty, and the nature and extent of the market in Toledo. Financing aspects were emphasized as a concern in several cases, a point corroborated in the latter part of the survey questionnaire.

More detailed consideration of economic factors was critical to determining the degree of interest in district heating and cooling. One question focused on determining at what point the respondent would switch energy sources by comparing the cost of current energy sources with centrally generated thermal energy. Figure 4 diagrams the results. Sixty-three percent of the sample indicated that if the delivered cost of thermal energy were equal to current energy sources, they would switch. Of that amount, 53 percent would still convert if the delivered cost were 15 percent more than their current energy source. For the 38 percent of the sample who indicated they would not convert if the delivered costs of centrally generated thermal energy were equal, 89 percent would switch if the delivered costs were 15 percent less. These results confirm the positive nature of responses to the numerous variables affecting this decision.

Further consideration of financial/economic factors was directed at determining financial analysis techniques and criteria relied upon for energy related investments. Approximately 80 percent of the organizations interviewed rely on payback period, with 90 percent using a criteria of 1-5 years. Even with a favorable financial analysis, however, 71 percent of the sample forsee a problem in obtaining capital for energy-related investments. The most often cited response was limited capital availability. In many instances proposed projects within a

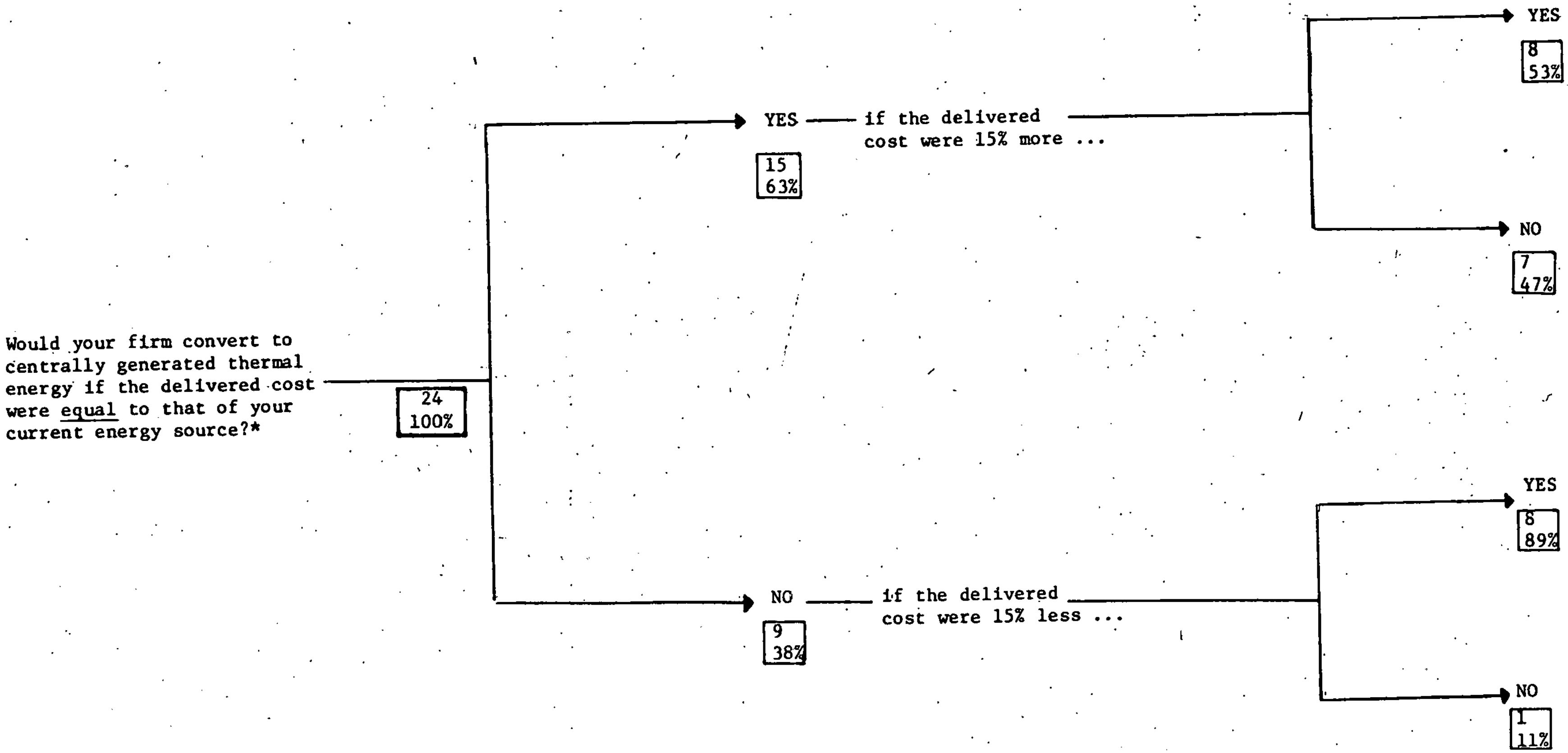

FIGURE 4. ECONOMIC DECISION TREE FOR CONVERSION TO CENTRALLY GENERATED THERMAL ENERGY

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* Numbers in the upper half of the box represent the number of respondents answering yes or no to the question. The percentage of responses to that question is indicated in the lower half of the box.

firm are prioritized with certain projects (e.g. production-related) receiving preferential treatmant. Two respondents qualified that energy conservation projects received high priority, especially if they involved a small initial investment.

One factor cited as a disincentive was the potential conflict with current company plans. One respondent noted their plans to build a coal-fired plant while another indicated plans to implement a waste heat recovery project. Both activities would affect the competiveness and attractiveness of district heating and cooling if plans were to be realized. One other disincentive noted by two firms was the potential interruption of production processes and/or daily activities during conversion to the district heating system.

Ten firms forsee potentially significant barriers to relying on a district heating and cooling system. The barriers specified may be categorized as follows:

- economic- six firms perceived first cost as an inhibiting factor
- technical- four firms forsee retrofit problems in their buildings. Two companies anticipate a problem in planning and constructing the distribution system from the Acme power plant.
- institutional- One company indicated that compliance with building codes would be a significant problem. One other firm noted that acceptance and understanding of district heating and cooling by administration personnel might be an issue.

Respondents offering recommendations as to how barriers might be overcome ranged from provision of grants to in-service training for operation and maintenance personnel. When asked which financial incentives would be most effective in promoting a connection to a district heating and/or cooling system to the organization, the results were as follows:

TABLE 11. ATTRACTIVENESS OF FINANCIAL INCENTIVES

Financial Incentive	Numbers of Response	%
Income tax credit	2	8
Grants	8	33
Accelerated depreciation	2	8
Loan guarantees	2	8
Tax exempt bond financing	1	5
Other*	6	25
Don't know	3	13
Total	24	100

* Includes cases where more than one incentive was noted.

In general, organizations in the public sector emphasized grants, while those in the private sector specified income tax credits or accelerated depreciation as a preferred alternative.

The relative attractiveness of district heating and cooling when evaluated from the results presented above indicate that economic factors are significant to a company's commitment. Other variables, such as institutional and technical factors, were of concern in selected cases. In terms of expressed interest in heating applications, all respondents indicated a willingness to consider conversion as more information becomes available. For cooling applications, interest was limited to only seven firms, three of which had potentially large cooling loads.

Summary and Interpretation of Results

The survey results presented above were the basis for specifying several options for expansion of the existing market. Examination of these results, in conjunction with power plant retrofit and distribution system possibilities, was undertaken as a joint effort by Demonstration

Team members.* Prerequisite to this process was the specification of several criteria to serve as a basis for delineating potential district heating and/or cooling schemes. As stated in the methodology, these were:

- end-user interest in district heating and/or cooling applications
- technical compatibility
- economic feasibility
- geographical location of potential source areas
- load profiles
- redevelopment and growth plans for surrounding service area.

Based on this process, cooling options were excluded from further analysis. The energy efficiency aspects of cooling options explored in Task 2 was an additional criteria incorporated into this decision.

A district heating scheme was developed for the Acme power plant reflecting an order of priority for developing and connecting additional service areas to the existing steam system. Relevant aspects of these schemes are presented in the following section.

POTENTIAL DISTRICT HEATING SCHEMES

The district heating system specified is based on a time-phased build-up of the existing steam system. Four power plant retrofit schemes were specified to reflect modifications at the power plant to accomodate additional loads. Preliminary plans call for a combination system supplying both steam and hot water. Figure 5 illustrates the location of the identified service areas.

* (Toledo Edison, Battelle and Stone and Webster)

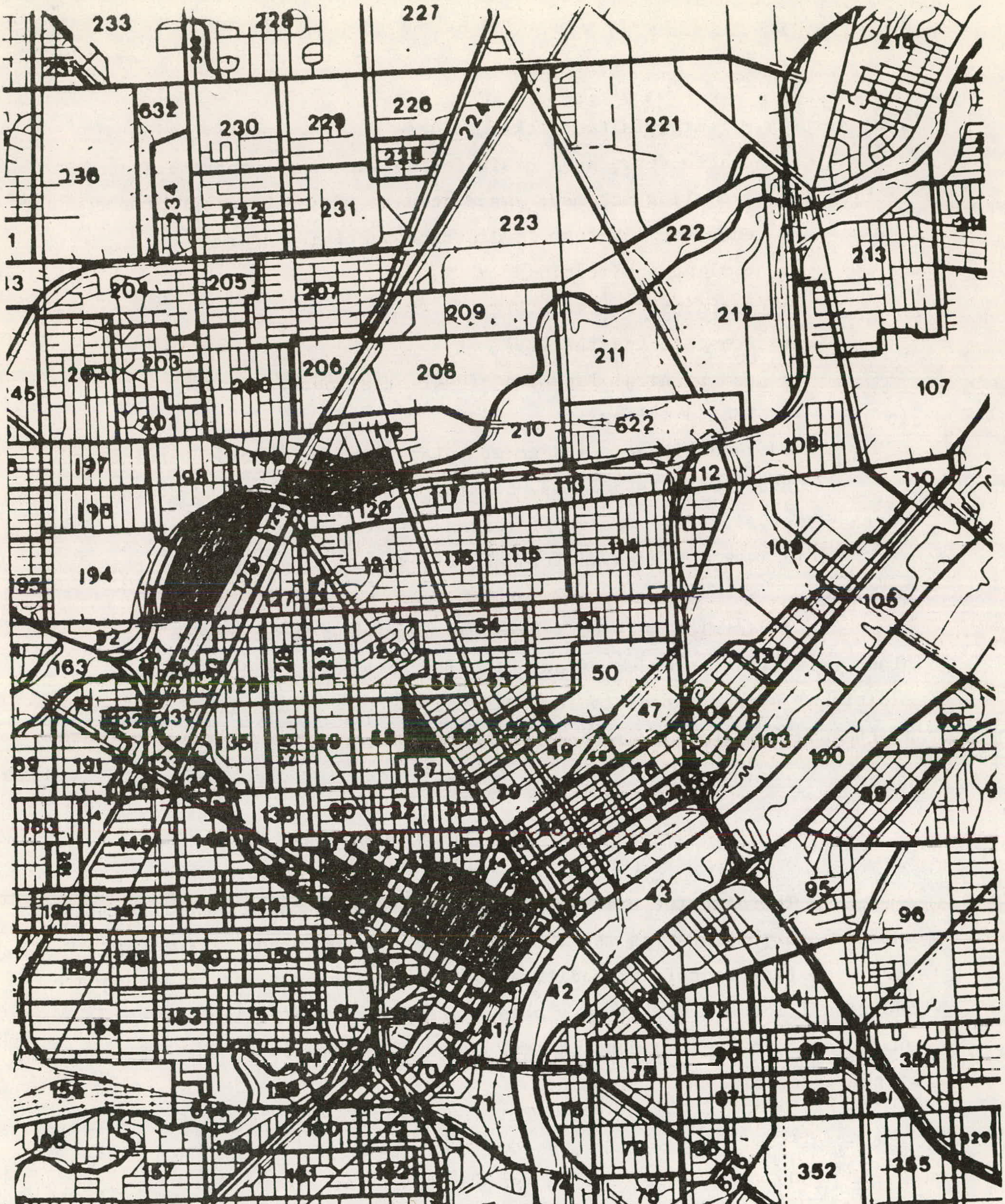

FIGURE 5. SERVICE AREAS WITHIN PROPOSED DISTRICT HEATING SYSTEM

Customer Mix and Load Profiles

When the district heating system is fully operational, 118 customers will be serviced. Peak energy consumption is expected to increase by over 300 percent of that experienced in the current steam system. The number and mix of customers are provided below:

Type	Number of Customers	Peak Consumption (10^6 Btu/hr)
Commercial	115	300.381
Industrial	3	309.091
	118	609.472

A listing of gross heat loads by power plant retrofit scheme and customer is provided in Table 12. Reference to Table 2 will assist the reader in identifying relevant characteristics of the customer's building and heating systems.

Figure 6 shows the average monthly gross heat demand over a typical year for the district heating system. Preliminary estimates indicate that the load shape will not vary significantly from that of the existing system, even when constant thermal energy loads, such as those for domestic hot water and process requirements are taken into account. On this basis, daily profiles of the existing steam system, as depicted in Figure 7, are expected to correspond closely to those of the expanded system. These preliminary profiles can be a basis for refinement in Phase 2.

Customer Retrofit Costs

Preliminary end-user retrofit costs are provided in Table 13 for potential new customers. Estimated costs (1979 dollars) ranging from $4,000-$113,000 are for converting existing end-user systems to district steam and/or hot water systems. The cost of energy to the end-user will be analyzed in Task 6.

TABLE 12. GROSS HEAT LOADS BY POWER PLANT RETROFIT SCHEME AND CUSTOMER

	GROSS HEAT LOAD, (10^6 BTU/HR) Retrofit No.			
Customers	1	2	3	4
Existing[(a)]	220.500	220.500	220.500	220.500
#2,3,5,8,13,17 18,19,21 (b)	25.285	25.285	25.285	25.285
#7[(b)]	-	38.210	38.210	38.210
#15[(b)]	-	-	61.228	61.228
#1[(b)]	-	-	274.940	274.940
#6[(b)]	-	-	-	54.220
10% growth	24.579	28.400	62.016	67.438
losses[(c)]	8.244	13.373	40.839	45.038
TOTAL	278.608	325.768	723.018	786.860

(a) gross load = 180,000 lb/hr x 1225 Btu/lb

(b) gross load = net load ÷ 0.92

(c) losses to existing customers included in line 1

Source: Stone and Webster Engineering Corporation.

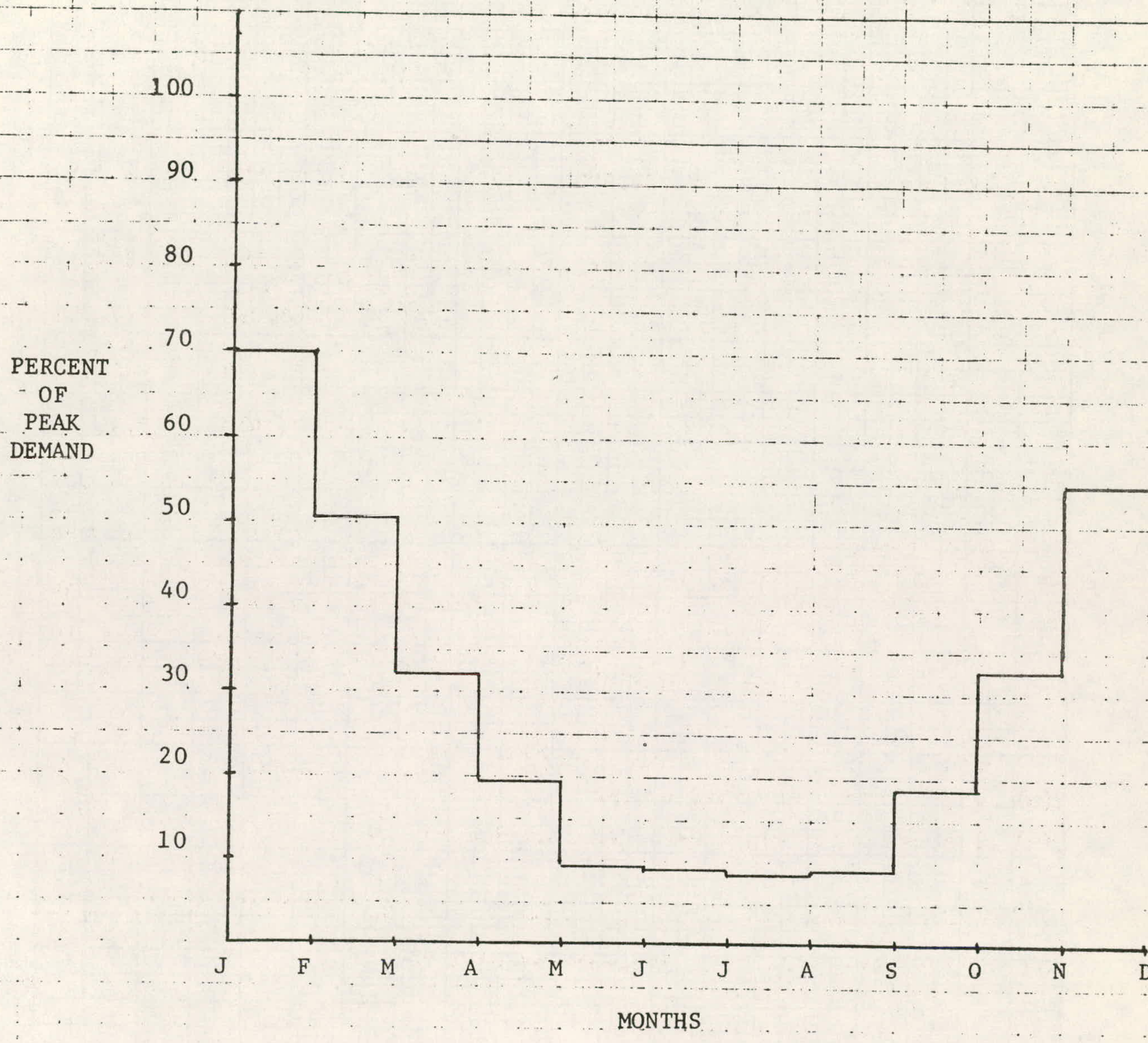

FIGURE 6. AVERAGE MONTHLY GROSS HEAT DEMAND AS A PERCENT OF PEAK DEMAND FOR EXISTING STEAM SYSTEM (1977)

Source: Toledo Edison

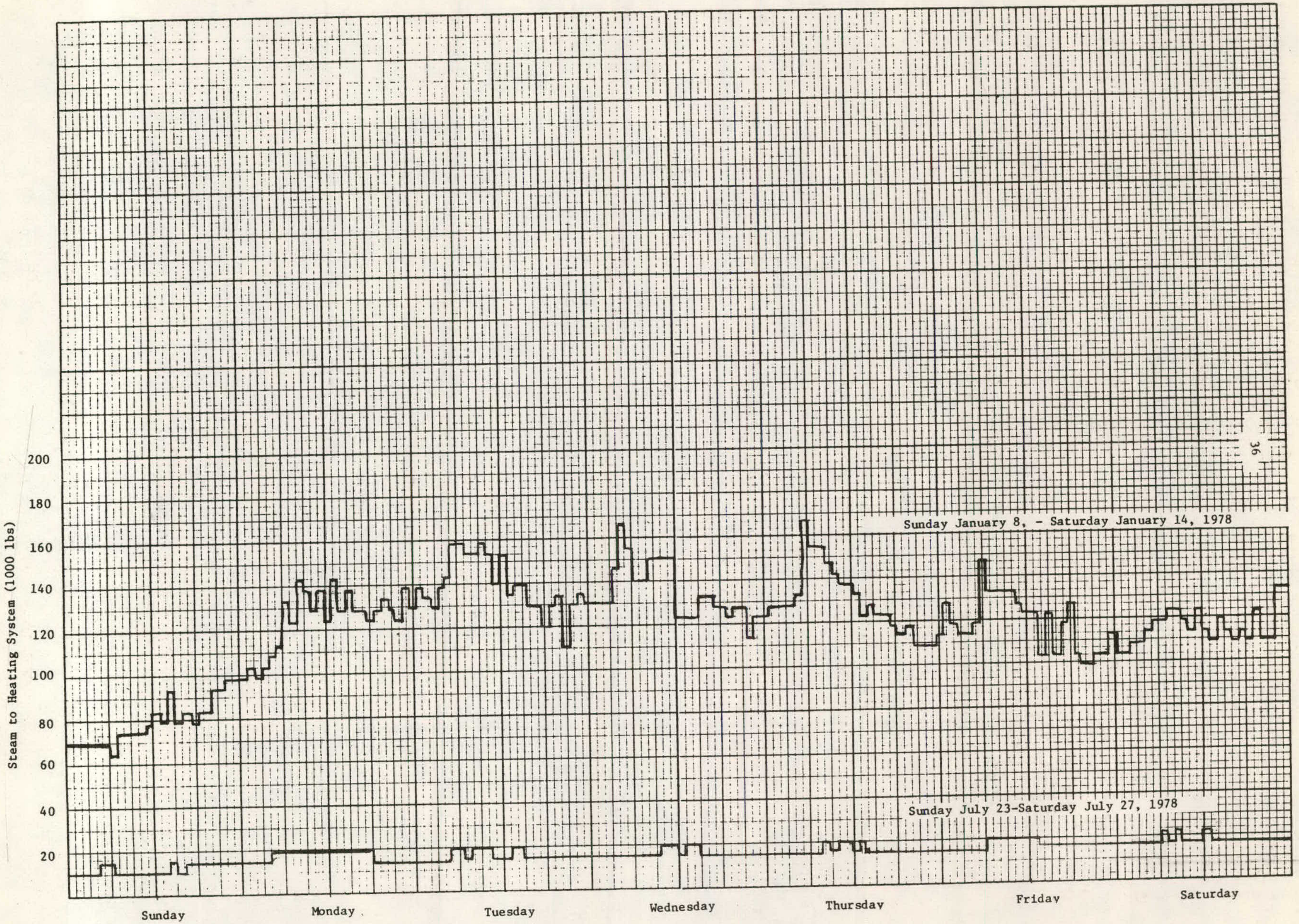

FIGURE 7. HOURLY STEAM SEND OUT FOR ONE WINTER AND SUMMER WEEK FOR THE EXISTING STEAM SYSTEM (1978)

Source: Toledo Edison.

TABLE 13. SUMMARY OF USER RETROFIT COSTS--1979 DOLLARS

Company	Annual Energy Consumption * (10^9 Btu)	Peak Thermal Demand 10^6 Btu/hr	Estimated Retrofit Costs ($\$10^3$)
#1	644.0	252.945	113.00
#2	1.8	0.702	4.00
#3	8.3	3.264	17.00
#5	0.9	0.339	9.00
#6	127.0	49.882	42.00
#7	89.5	35.153	26.00
#8	3.4	1.352	7.50
#13	16.6	3.535	9.00
#15	143.4	56.330	42.00
#17	16.2	6.368	22.50
#18	9.7	3.821	13.50
#19	6.2	2.420	13.00
#21	3.7	1.461	9.00

* Represents energy consumption at end-use that could be served by the district heating system.

Source: Stone and Webster Engineering Corporation and Surveys.

Opportunity for Energy Substitution at the End-User

For the district heating scheme specified, the opportunity for substituting centrally generated thermal energy for current energy sources at the end-user has been specified on an annual basis. The addition of new customers to the existing steam system are the basis for this calculation. As Table 14 indicates, scarce fossil fuels (oil and natural gas) account for 34 percent of the total energy substituted.

TABLE 14. ENERGY SUBSTITUTION AT THE END-USER

Energy Source	Number of Customers (a)	Energy Substituted (10^6 Btu/year)	Percent of Energy Substituted
Coal	1	920,000	62
Oil	2.5	316,935	22
Natural Gas	5	183,897	12
Electricity	4.5	52,074	4
	13	1,472,906	100

(a) For two customers energy substitution will involve more than one energy source.

APPLICABILITY TO OTHER URBAN AREAS

The applicability and transferability to other urban regions are addressed in this section:

- generic nature of the market
- methodology

GENERIC NATURE OF THE MARKET

The non-random nature of the market survey defines the limits within which generalizations about other urban areas can be made. Several trends emerging in the study with respect to the nature of the market and the characteristics, however, may be noted. Comparison with other urban areas having similar urban structures and energy supply and demand situations could serve as a basis for confirming or expanding on concepts and results provided in this report. These trends are as follows:

- selection of potential service areas on the basis of energy densities and estimated district heating costs is a reliable method for initial screening of a large metropolitan area.
- a priority and phased system of sampling potential large customers is instrumental to not only establishing a system's viability but also conserve time and resources. Through subsequent study phases and system design, the opportunity for expanding heat loads through addition of smaller commercial and residential customers can be explored.
- redevelopment and expansion plans, such as those envisioned in Toledo, provide an excellent opportunity for future growth for the district heating system. Basing a district heating system on these high density areas enhances the feasibility of a cogeneration project in terms of offering additional market potential in future years.
- the attractiveness of centrally generated thermal energy is contingent upon its competitiveness with current energy costs. Institutional and other factors were not found to be major deterrents in a decision to convert from existing energy sources.
- the preferred energy media was either steam or hot water for space heating and domestic hot water applications. The low pressure and temperature requirements for most customers

introduces no major complications in system design. The potential for district cooling, in terms of potential cooling loads and customer interest, was minimal. Development of district cooling may require unique conditions in an urban area for a chilled water system to be attractive.

- major problems from the end-user perspective relate to obtaining adequate capital for energy related investments. Financial incentives, the type dependent on the end-user involved, may be critical to inducing end-users to switch from their traditional energy sources. Removal of uncertainty over such areas as district heating costs and user retrofit costs through provision of information and extensive marketing may be necessary to encourage participation.

METHODOLOGY

The procedures employed for the definition of potential service areas (Task 2) and the conduct of the energy market study are directly transferable to other urban areas. With respect to the energy market study, the following aspects are appropriate for use with minor modifications to reflect local circumstances and project objectives:

- adoption of the overall methodology employed
- reliance on similar information sources to obtain input data
- definition of service areas on the basis of energy density and estimated district heating costs
- utilization of the survey questionnaire
- comparison of this study's findings with those obtained in the area being investigated

CONCLUSIONS AND RECOMMENDATIONS

The energy market study findings indicate the receptiveness of potential customers to district heating concepts as well as the existence of heat loads sufficient to support a district heating system. Recommendations center on three specific areas that should be the focus of activitv in subsequent project phases:

- Provide information to potential and existing customers on a periodic basis on the status of the project. Additional information on user retrofit costs is also appropriate. This continuous marketing activity is crucial to maintaining credibility with customers as well as alleviating skepticism and uncertainty over a customer's specific problems.

- Investigate further the potential market for growth of the district heating system within established service areas and along distribution corridors
- explore opportunities for financial incentives that might be provided to customers. These incentives would be formative in encouraging potential end-users to connect to the system.

APPENDIX A

SURVEY QUESTIONNAIRE

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TOLEDO EDISON

DISTRICT HEATING AND COOLING SURVEY

PART A

ENERGY AUDIT

(1) Respondent Information

Date ____________________

Name(s) ________________________ Title(s) __________________________

________________________ __________________________

Organization ____

Address ____
Unit Street City State Zip Code

Telephone ____________________

Kind of Business (specify 4-digit SIC if possible) ________________

____

____

Each of the following items (2-9) relates to information about your organization's building(s) and its energy consumption. Please fill in the blanks where appropriate for the building(s) at this site.

(2) General Information

- Total number of buildings at the site ____________________
- Floor Area (ft^2)________________

Building identification by name and/or location	Gross Area	Heated Area	Cooled Area

- Work Schedule

_____ 5 days/week, hours _________

_____ 7 days/week, hours _________

_____ Other, hours _______

(3) Building Energy Profile in 1977 or Other Base Year (_____) for Total of All Buildings At Site

	A	B	A x B	
Energy Source*	Total Energy Consumption (1977)	Average Unit Energy Costs ($/Unit)	Total Energy Costs (1977)	Energy Suppliers
Electricity (kwh)				
Natural Gas (mcf)				
Fuel Oil (gal)				
Distillate				
Residual				
Coal (tons)				
Purchased Steam (mlbs)				
Other (specify)				

* kwh = Kilowatt hour (wattage consumed in thousands per hour)
mcf = thousand cubic feet
gal = gallon
tons = tons
m lbs = thousand pounds

(4) Energy Sources and Energy Uses for All Buildings At Site

Energy Use	Current Energy Source(s)*	1977 Energy Consumption (specify unit)
Space heating		
Air conditioning		
Process hot water		
Process steam		
Other (specify)		

* Electricity, natural gas, fuel oil, coal, purchased steam, other (specify)

(5) Boiler/Service Water Heaters

- Total numbers of boilers/heaters in building(s) ____________

Type (Boiler/service water heater) in a Building*	Steam Pressure (psig) or Hot Water Temp (°F)	Energy Source(s)	Capacity (specify units e.g. Btu/hour)	Operating Schedule: Hours/Week System Is In Active Use	Use of the Steam or Hot Water	Age (Yrs)	Remaining Life Expectancy (Yrs)

* Indicate building location and name only if more than one building exists at your address.

(6) Central Air Conditioning

- Total numbers of systems in building(s)
- Type(s)

☐ Electric

☐ Absorption

System Type and Building Location*	Energy Source	Capacity (specify units, e.g. Tons or Btu/hour)	Operating Schedule: Months/Years System is In Active Use	Age (Yrs)	Remaining Life Expectancy

* Indicate location only if more than one building exists at your address.

(7) Self-Contained Units (If information is not readily available, estimates are helpful)

Type	Number of Units	Energy Source(s)	Average Capacity (specify unit, e.g.,Btu/Hr)	Average Age
Unit gas heating				
Gas infrared heating				
Baseboard heater				
Window air conditioner				

(8) The waste heat from electric generation can supply district heating, cooling and other energy services. For which of the following uses might this heat be applied in your building(s)? Indicate which energy form (steam, hot water and chilled water), temperature and pressure would be compatible with your existing system.

Energy Use	Energy Form	Temperature °F	Pressure psig
Heating			
Air Conditioning			
Process hot water			
Process steam			
Other			

(9) How is heat currently distributed in the building(s) (hot air, hot water, steam). Please specify systems when more than one building is involved.

____

____

____

(10) Are there any technical aspects not highlighted in the previous questions that should be discussed further during our interview.

____

____

____

TOLEDO EDISON
DISTRICT HEATING AND COOLING SURVEY

Interviewer(s) ____________

____

Date ____________

PART B
BUSINESS INTERVIEW GUIDE
QUESTIONS 10-23

Respondent(s) ____________ Title(s) ____________

____________ ____________

____________ ____________

____________ ____________

Organization ____________

Address ____________

(11) What do you believe the national annual rate of inflation will be over the next fifteen years?

______ Annual percentage change

(12) What do you believe the annual change (or pattern of change) in the price of your current energy sources will be over the next fifteen years? Include the rate of inflation in your answer.

Energy Source	Annual Percentage Change(or pattern of change)
Electricity	____________
Natural Gas	____________
Fuel Oil	____________
Coal	____________
Purchased Steam	____________
Other (specify)	____________

(13) Does your organization foresee any problems with current energy sources meeting present or future requirements?

☐ Yes ☐ No

If yes, please explain ____________

____

____

(14) A number of variables could affect your organization's decision to use centrally generated thermal energy for heating, cooling or other services. What impact would each of the following variables have on this decision.

Variable	favorable impact	no impact	unfavorable impact
Institutional			
• Potential regulatory involvement in setting rates, and establishing quality and type of service			
• Your corporate image			
• Compliance with building codes			
• Impact of environmental regulation			
• Nature of contracts with your current energy supplies			
• Other ________________			
Technical			
• Compatibility of thermal energy source with building system and energy uses			
• Variable daily, seasonal and annual demands			
• Safety			
• Change in number and expertise of your operation and maintenance staff			
• Other ________________			
Economic			
• Availability of current energy supplies			
• Reliability of thermal energy supply			
• Risk and uncertainty(damage and maintenance, insurance and security costs)			
• Nature and extent of market for thermal energy in Toledo area			
• Availability and type of financing			
• Other ________________			

(14) (a) Would the net impact of these variables be favorable enough for your firm to convert if centrally generated thermal energy could be delivered at a cost equal to that of your current energy service? (Assume the delivered cost of district heating and cooling energy includes the utility charge for thermal energy, operating and maintenance costs, and a reasonable charge for the capital costs of the retrofit. Assume the cost of your current energy source includes fuel costs and operating and maintenance costs associated with the existing system.)

☐ Yes ☐ No

if yes, go to 14b

if no, go to 14c

comments: ______________________________

____

____

(b) Would the net impact of these variables be favorable enough for your firm to convert if centrally generated thermal energy could be delivered at a cost 15% more than that of your current energy source? (Assume the delivered cost of district heating and cooling energy includes the utility charge for thermal energy, operating and maintenance costs, and a reasonable charge for the capital costs of the retrofit. Assume the cost of your current energy source includes fuel costs and operating and maintenance costs associated with the existing system.)

☐ Yes ☐ No

if yes please indicate the principal reasons why:

____

____

(c) Would the net impact of these variables be so unfavorable that your firm still would not convert if centrally generated thermal energy could be delivered at a cost 15% less than that of your current energy source? (Assume the delivered cost of district heating and cooling energy includes the utility charge for thermal energy, operating and maintenance costs, and a reasonable charge for the capital costs of the retrofit. Assume the cost of your current energy source includes fuel costs and operating and maintenance costs associated with the existing system.)

☐ Yes ☐ No

if yes, please indicate the principal reasons why:

____

____

(15) Are there any of the variables in question 14 that your organization foresees as significant barriers to utilizing a district heating and cooling system?

☐ Yes ☐ No

If yes, what are these barriers? ____________________

____

____

Do you have any recommendations as to how they might be overcome?

____

____

____

Questions 16-18 refer to the potential uses of centrally generated thermal energy that have been identified in question 8. These are termed retrofit options.

(16) (a) For each retrofit option, let us specify and review the current energy sources, system type and location, and preferred energy form in Table A.

(b) What percent of the current energy source will be replaced for each retrofit option? (note in Table A)

(c) What were the estimated 1977 operating and maintenance costs associated with the energy systems currently satisfying each retrofit option? These are non-energy costs and include operating labor, maintenance labor, and materials. Where actual figures are not available, please estimate.

(17) The amount of energy your organization consumes varies with the time of day and year. For each retrofit option please identify times of peak demand. (Assume 1= peak demand). Also indicate relative levels of demand for other times of day or year.

DEMAND	RETROFIT OPTIONS			
Daily (specify ranges or shifts over 24 hrs.)	______	______	______	______

MONTHLY

Winter	DJFM
Spring	AM
Summer	JJAS
Fall	ON

Table A: Retrofit Options

EXISTING SYSTEM				POTENTIAL SYSTEM					
				Energy Form			Energy Substituted		
Energy Source	Energy Use	Type and Location	Annual O&M Costs	Chilled Water °F	Steam psig °F	Hot Water °F	Percent	Quantity/yr (specify unit)	

(18) For each of the retrofit options, do you foresee any changes in demand over the next 15 years? Consider such factors as future expansion/contraction of markets, energy conservation and energy availability.

☐ Yes ☐ No

if yes, please indicate annual growth rate(s)

Retrofit Option	Annual Growth Rate
________	________
________	________
________	________
________	________
________	________

(19) Which of the following possible techniques of financial analysis would your organization use to determine the economic viability of investing in thermal energy?

- ☐ Payback period
- ☐ Average income on cost
- ☐ Internal rate of return (or discounted rate of return)
- ☐ Discounted payback period
- ☐ Net present value
- ☐ Other ____________

(20) For the method(s) chosen, list the parameter and minimum parameter value(s) required to justify any retrofitting investment.

	Method	Relevant Parameter	Hypothetical Parameter Value
Example:	Payback	Required payback period	4 yrs
Example:	Net present value	Discount rate investment life	12% 20 yrs.
Your Organization's method(s)	________	____________	________
	________	____________	________

(21) Assuming a favorable financial analysis, would your organization foresee a problem in obtaining capital for energy-related investments?

☐ Yes ☐ No

If yes, please explain: ____________________________________

____

What other factors might prevent implementation of a financially justified project? ____________________________________

____

____

(22) Which of the following financial incentives would be most effective in promoting a district heating and cooling system to your organization. Assume that the financial impact of each incentive is the same.

_________ income tax credit

_________ grants

_________ accelerated depreciation

_________ loan guarantees

_________ tax exempt bond financing

_________ other

(23) Is there any sensitivity to releasing or publishing the information provided in these questionaires - -

(a) providing the name of your organization and the nature of its activity are not disclosed?

☐ Yes ☐ No

(b) providing the name of your organization is not disclosed.

☐ Yes ☐ No

Indicate items of concern. ______________________________

____

____

(24) Who should we contact and what telephone number should we use in the event we need clarification of information or have additional questions?

	Name	Phone
Business		
Technical		

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