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DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES
THROUGH POWER PLANT RETROFIT AND DISTRIBUTION
NETWORK, CITY OF PIQUA, OHIO

September 18, 1979

Work Performed Under Contract No. EM-78-C-02-4976

City of Piqua
Piqua, Ohio

Georgia Institute of Technology
Atlanta, Georgia

Hanselman Eskew & Associates
Piqua, Ohio

U. S. DEPARTMENT OF ENERGY

Division of Industrial Energy Conservation

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CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

September 18, 1979

U.S. Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

Attention: Mr. Charles Frazier

Gentlemen:

The Piqua, Ohio Demonstration Team, which is comprised of the City of Piqua, Hanselman-Eskew and Associates and the Georgia Tech Engineering Experiment Station has completed Phase I of the study designed to assess the feasibility of district heating in Piqua, Ohio through power plant retrofit. This initial phase does not reveal any technical, legal, institutional or economic obstacles to the successful implementation of district heating. Subsequent phases of the project will rigorously examine the economic; technical and financial aspects to insure the most beneficial and cost effective implementation process.

The City of Piqua, as well as the entire Demonstration Team is eager to continue work on this program and recognize the valuable contributions and savings to be realized through the successful implementation of District Heating in Piqua and are therefore prepared to commit themselves to this goal.

Sincerely,

James Henderson
Mayor

JH/ms

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1.0 DEMONSTRATION TEAM

The goal of the Piqua, Ohio District Heating and Cooling Demonstration Project is to demonstrate the feasibility and efficiency of using cogenerated thermal energy from the City's Municipal Power Plant to provide residential, commercial and industrial space heating and cooling and satisfy other community energy needs as appropriate.

Specifically, the objectives are to:

- (1) analyze and evaluate the technical, economic market and institutional feasibility of supplying cogenerated thermal energy to the City's potential customers;
- (2) identify and evaluate alternative power plant and distribution system retrofit schemes;
- (3) ultimately design and implement identified, feasible retrofit solutions;
- (4) demonstrate the transferability of the system and the approach to other communities throughout the nation;
and
- (5) efficiently utilize limited energy resources and further limit demand on scarce resources such as natural gas and oil.

The City of Piqua, Ohio, owns and operates its own Municipal Power System, consequently, its operation is subject to the City Charter and the City's Code of Ordinances. The Municipal Power System is not subject to statutory regulation of control of the State of Ohio. The City and its power system must however answer to the voters. There are approximately 162 municipally owned power systems in the country which currently produce some steam with 77 of these located in the northeast and midwest regions of the United States.

1.1 DEMONSTRATION TEAM STRUCTURE

In order to accomplish the Phase I work program and in order to move forward to completion of all seven phases, the City assembled a highly qualified, experienced team to carry out the technical work. The primary Phase I

Demonstration Team members include:

- * The City of Piqua Staff
- * Hanselman-Eskew and Associates
- * Georgia Institute of Technology--
Engineering Experiment Station

In addition to the Phase I Team members, the City's Bond Council and Underwriter play key roles in the analysis and evaluation. Squires, Sanders and Dempsey of Cleveland, Ohio is the City's Bond Council, Donaldson, Lufkin and Jenerette Securities Corporation of New York serve the City as underwriter. Both firms are familiar with Piqua and have worked with the city on other projects.

The Demonstration Team consists of four groups:

- 1 Management/Overview Group;
- 2 System Feasibility/Design Group;
- 3 Construction Design/Implementation Group; and
- 4 Operating, Monitoring and Evaluation Group.

The role and timing of each group's involvement is structured in order to pull together the necessary resources at the appropriate time in order to complete each phase of the project. The Demonstration Team structure is organized in order to carry out all phases of the Demonstration Project. The Demonstration Team structure is based upon assembling various applicable team members in groups pursuant to the execution of the several project phases. In most cases, Demonstration Team Group members are herein identified; however, it is recognized that additional specific team members will be necessary from Phase II forward.

As part of this Phase I analysis, and evaluation it has been determined that a second separate and distinct "detailed feasibility" analysis is not warranted. Consequently the Demonstration Team organization is being re-structured in order to accomplish a combined detailed feasibility and project schematic design as the product of Phase II. This approach is outlined in section 7.1 Proposal for Future Work (Scope of Work). The following outline

details the Demonstration Team structure which will implement the Piqua District Heating Project.

DEMONSTRATION TEAM

I. Management/Overview Group (All Phases)

- 1) Piqua Municipal Power System Director,
Mr. H.E. Hastings and City Manager,
Frank Patrizio, Jr.
 - * Official City line responsibility
 - * Policy Direction
 - * Link to City Commission
- 2) Hanselman-Eskew and Associates,
Mr. W.C. Hanselman, Project Manager
 - * Work Program Management
 - * Liason with Department of Energy
- 3) Piqua Finance Department
 - * Project Financial Management
 - * Accounting
 - * Financial Reporting

II. System Feasibility/Design Group (Phases I & II)

- 1) Hanselman-Eskew and Associates
 - * Energy Market Inventory
 - * Field/Survey Research
 - * Economic Analysis
 - * Market Analysis
 - * Social/Institutional/Political Analysis
 - * Project Financing
- 2) Georgia Institute of Technology,
Engineering Experiment Station
 - * Thermal Density Mapping and End-user
Systems Evaluation
 - * Power Plant Retrofit Analysis
 - * Distribution System Planning
 - * End-user/Community Retrofit Analysis
 - * Operating Analysis of Thermal Energy Generation
 - * Scarce Fuel Substitution/Energy Conservation Potential
- 3) The "Design and Build" Firm
Pursuant to the findings of this feasibility analysis
and the teams recommended approach/schedule, a "design
and build" firm will be brought on board as one of the
first steps in Phase II. Upon the start of Phase II
work the City including the Phase I team members will
interview, accept proposals from and select the "design
and build" firm.

- 4) Piqua Municipal Power System
 - * Power System Loading Data Information
 - * Operating Effects of Retrofit Schemes
 - * Evaluation of Proposed Retrofit and Distribution Schemes
 - * Represent the Project
 - 5) Piqua Law Department
 - * Statutory Analysis and Evaluation
 - * City Charter Analysis
 - * Draft Necessary Documents
 - * Assist in Representing the Project
 - 6) Piqua Public Works Department
 - * ROW data/information
 - * Water Resource Data
 - * Conflicts with other infrastructure
 - 7) Squires, Sanders and Dempsey--Bond Council
 - * Assist in Evaluating Alternatives
 - * Structure Financing Instruments
 - * Represent the City and Project with other Institutions
 - 8) Donaldson, Lufkin and Jenerette Securities Corporation --Underwriter
 - * Assist in Structuring Financing Plan
 - * Prepare Statements
 - * Market Bonds
- III. Construction/Implementation Group (Phase III)
- 1) Piqua Municipal Power System
 - * Owner/Operator
 - 2) Design and Build Firm (selected beginning Phase II)
 - * Construction Drawings
 - * Build
 - 3) Piqua Public Works Department
 - * Construction Monitoring
 - * Construct Supervisor as necessary
 - 4) Piqua Finance Department
 - * Rate Implementation
 - * Fiscal Control
- IV. Operating, Monitoring and Evaluating Group (Phase IV)
- 1) Piqua Municipal Power System
 - 2) Contractor
 - 3) Georgia Institute of Technology Engineering Experiment Station
 - 4) Hanselman-Eskew and Associates
 - 5) U.S. Department of Energy

The charts on the following pages graphically describe the Demonstration Team Structure.

PHASE I -- PROJECT ORGANIZATION CHART

1.2.1. RESOURCE ALLOCATION

The Piqua District Heating and Cooling Demonstration Project Phase I, feasibility analysis and evaluation is being carried out by the following members generally consistent with the outlined responsibility.

- * Piqua Municipal Power System -- Policy direction, information/data base, technical assistance capability;
- * Hanselman-Eskew and Associates -- thermal energy inventory, field/survey research, economic analysis, market analysis, institution/political analysis, financing, marketing plan;
- * Georgia Institute of Technology Engineering Experiment Station -- analysis and evaluation of technical issues related to energy analysis, power plant/distribution system retrofit analysis, analysis and evaluation of end-user energy systems, and cost estimates of alternative systems;
- * Piqua Law Department -- legal analysis and evaluation, opinion preparation
- * Piqua Public Works Department -- information/data base relative to right-of way assessment, water resource capability assessment.

Mr. William C. Hanselman of Hanselman-Eskew and Associates is the Project Manager. Mr. Hanselman directs daily project activities and is responsible for general project direction and coordination. The Project Manager coordinates the Teams efforts with the City Manager, Mr. Frank Patrizio, Jr. and with Power Systems Director Mr. H.E. Hastings. With their assistance, the Project Manager updates the City Commission relative to progress, findings, and conclusions of the analysis and evaluation. Both Georgia Tech, Engineering Experiment Station, and Hanselman-Eskew and Associates utilize internal management plans which structure the completion of their responsibilities. In both instances the internal management structure is a modified version of that which is employed by Georgia Tech and Hanselman-Eskew and Associates on a regular basis. Both Georgia Tech and Hanselman-Eskew and Associates assign key personnel to general work program areas.

The following chart identifies the scope of work tasks, relates the several Demonstration Team Members to specific tasks, and keys the varying levels of effort.

<u>TASK/WORK ELEMENTS</u>	<u>LEVEL OF EFFORT</u>			
	<u>GT</u>	<u>HEA</u>	<u>PLD</u>	<u>PCS</u>
Task 5 (Institutional Assessment)				R
5.1 Legal Implications	SE	SE	SPE	
5.2 Financial Alternatives	SE	PE	SE	
5.3 State/Local Regulatory Parameters	SE	PE	SE	
5.4 Social/Political Ramifications		PE		
5.5 Environmental Regulations	SE	PE	SE	
Task 6 (Preliminary Economic Analysis)				R
6.1 Power Cost Estimate	PE			
6.2 Annual Operating Cost	PE			
6.3 Revenue Potential	SE	PE	SE	
6.4 Economic Impact	SE	PE		
Task 7 (Proposal for Further Work)				R
7.1 Ranking Criteria	PE	PE		
7.2 Select 3 Alternatives	PE	PE		
7.3 Dem. Team Reevaluation	SE	PE		
7.4 Continued Work Proposal	PE	PE		
Project Administration/ Project Manager		PE		

PE - Primary Effort
SE - Secondary Effort
R - Resource/Technical Assistance

GT - Georgia Institute of Technology
HEA- Hanselman-Eskew and Associates
PLD- Piqua Law Department
PCS- Piqua City Staff (including City Manager, City Engineer, Power Plant Director, Finance Director, Secretary)

1.2.2 HANSELMAN-ESKEW AND ASSOCIATES MANAGEMENT PLAN

Hanselman-Eskew and Associates work in Phase I of the Demonstration Project is directed by HEA's Project Supervisor, Mr. William Eskew. The Project Supervisor coordinates HEA's work program effort pursuant to this project. The Project Supervisor assembles all work product for which the firm is responsible. Mr. Eskew, is a principal in the firm of Hanselman-Eskew and Associates and has directed many such studies for Hanselman-Eskew and Associates and in previous capacities.

The Project Supervisor coordinates Hanselman-Eskew and Associates' effort with the overall Project Manager on a weekly basis. The Project Supervisor meets regularly with the Project Manager and the Project Supervisor of the Georgia Tech Engineering Experiment Station.

Phases II-VII will be managed in a similar manner. The HEA Project Supervisor's responsibility to assemble additional key personnel as appropriate during the life of the project.

Hanselman-Eskew and Associates maintains on contract a full staff of field researchers/interviewers and computerized data processing/analysis capacity. The Project Supervisor provides daily project management in these areas. All HEA support facilities are subject to his control and direction. Hanselman-Eskew and Associates is a multi-disciplinary firm available to assist both government and business in addressing their planning, analysis and development needs. HEA offers a complete range of services including both the professional-technical functions and the necessary support capability.

The firm places special emphasis upon the economic and institutional linkages between the private enterprise and the public sector. Often both are interested in the same goal-leveraging limited resources. Today's clients include large-scale land developers, cities, small towns, special interest groups, and the federal government. Hanselman-Eskew and Associates assists these clients in many states throughout the country in developing individual solutions to specific problems. This broad set of experiences is helpful in assisting the client in formulating policy direction and program development.

Hanselman-Eskew and Associates focuses on issues and problems relative to research and analysis, feasibility planning and program development, and program implementation. Areas of interest and expertise include feasibility analysis, market analysis, economic analysis, housing, social/institutional analysis, development/redevelopment planning, program specific management, and environmental planning. In addition, HEA is active in survey research, policy planning, mental mapping, and the development and management of grant applications.

Contained on the succeeding pages are the following:

- 1) HEA Project Organization Chart;
- 2) Personnel assignments (Phase I);
- 3) Capacity statement of key personnel; and
- 4) An annotated list of HEA projects and clients.

PIQUA DISTRICT HEATING & COOLING
DEMONSTRATION PROJECT PHASE I

HANSELMAN-ESKEW AND ASSOCIATES
PROJECT ORGANIZATION

PIQUA, OHIO

DISTRICT HEATING PROJECT

PHASE I - PERSONNEL ASSIGNMENTS

HANSELMAN-ESKEW AND ASSOCIATES

	<u>Person</u>
Project Manager	W. Hanselman
Task I - Demonstration Team	W. Eskew (HEA Project Supervisor)
Task II - Thermal Sources	W. Hanselman W. Eskew J. Hanselman E. Jennings
Task III - Energy Market Analysis	W. Hanselman A. Zatik E. Jennings C. Lakotos
Task IV - Technical Review	W. Hanselman W. Eskew
Task V - Institutional Assessment	W. Eskew W. Hanselman
Task VI - Preliminary Economic Analysis	W. Hanselman A. Zatik C. Lakotos
Task VII - Proposal for Further Work	W. Eskew W. Hanselman
Additional Support:	Field Survey Research Interviewers, Coders (Task II - results to Tasks II, III, V, VI)

PROFESSIONAL PROFILE

William C. Hanselman, AEA
Principal Partner
Hanselman-Eskew and Associates

EDUCATION

Master of Science Degree
Applied Economics
Wright State University

Bachelor of Arts Degree
Wright State University

EXPERIENCE

Mr. Hanselman applies outstanding experience to the complex economic and community development issues of the 1970's. His understanding of the dynamic forces guiding urban development and structuring community life is strengthened through participation in both the public and private sectors. Combining rigorous analytical capability, process orientation and exposure to problems, solutions and projects throughout the nation, Mr. Hanselman works closely with developers, elected officials, planning/administrative staffs and business leaders to formulate productive policy direction and functional plans. An economist by training with broad experience in quantitative analysis and planning-related disciplines, Mr. Hanselman has participated in and significantly contributed to several projects and programs of national significance including the "Dayton Fair Share Plan", Title VII New Community Development and the National Wild and Scenic River Program.

Prior to the formation of Hanselman-Eskew and Associates, Mr. Hanselman was Director of Development for the Newfields New Community Authority. In this capacity, he was responsible for directing the Public Developer's planning and development program. The Newfields New Community Authority and the Newfields Development Corporation are the dual developers of the New Community, Newfields, under Title VII of the Urban Growth and New Community Act.

Previously, Mr. Hanselman served with the Miami Valley Regional Planning Commission as Special Projects Coordinator. In this position, he was responsible to the Executive Director for programs and projects which presented significant economic, financial, social or physical impact to the region. This included the responsibility to coordinate divisions within the agency and independent agencies or groups in an interdisciplinary manner.

OTHER SKILLS OR DISTINCTIONS

Board of Directors, Little Miami Incorporated
Testimony before the Housing Subcommittee of the House Banking Committee
Faculty Instructor, Urban Economics Seminar, Wright State University
Lecture and Program appearances nationally, including the National Legislative Land Use Conference, National Association of Regional Councils and the National Committee Against Discrimination in Housing (NCDH)

PROFESSIONAL PROFILE

William C. Eskew
Principal Partner
Hanselman-Eskew and Associates

EDUCATION

Master of Arts, Urban/Rural Sociology
Ball State University

Bachelor of Arts Degree, Political Science/Urban Sociology
Wright State University

EXPERIENCE

Mr. Eskew's broad academic and professional experience focuses on the social, physical and political dynamics of community infrastructure planning, analysis and management. This experience includes exhaustive knowledge of federal, state and local government, and their interaction with the citizenry and special interest groups during public strategy development, policy planning and decision-making. Mr. Eskew's analytical and community organizational skills have assisted many communities in incorporating citizen opinion as part of their community planning, development and management system. Mr. Eskew's experience and professional responsibility centers on transforming human equity and quality of life issues into implementable and manageable community development projects and programs.

Prior to the formation of Hanselman-Eskew and Associates, Mr. Eskew was Director of Urban Renewal for the City of Xenia, Ohio. In this capacity, he was responsible for directing all phases of the 3.5 million dollar downtown redevelopment program necessitated by the disastrous tornado of 1974. This responsibility also included structuring strategic negotiations with the Federal Government.

Previously, Mr. Eskew served as a Housing and Community Development Specialist for the Supportive Council on Preventive Effort (OEO), and the Miami Valley Regional Planning Commission. In this capacity, Mr. Eskew provided invaluable assistance to local governments, housing authorities and other agencies developing and administering planning and community development programs.

OTHER SKILLS OR DISTINCTIONS

Marguis Who's Who In the Midwest
Faculty Lecturer - University of Dayton, Ohio
Lecture and program appearances at the local, state and national levels.

PROFESSIONAL PROFILE

Elliot G. Jennings
Senior Staff Member & Project Manager
Hanselman-Eskew and Associates

Education

Master of Science Degree
Applied Economics, Wright State University

Bachelor of Science Degree
Business Administration, Wright State University

Experience

Mr. Jennings' background in economics and business administration provides him with broad base of training, expertise and capability to lead in the design of feasible solutions to community development problems that affect both the public and private sectors. His experience in model development, data collection/interpretation, market analysis, and statistical analysis classifies him as a valuable asset in analyzing and evaluating economic, business and marketing issues; and designing solutions to fit the need of both public sector and private sector clients. Specifically, Mr. Jennings designs financially feasible solutions to community development problems that will work within the clients' constraints. His business experience serves as a valuable tool in the assessment of private sector needs and the private sector's role in public development projects and programs. Conversely, he is able to analyze and evaluate the effect of public sector actions as they relate to private sector decision-making.

Currently, Mr. Jennings is a project director with Hanselman-Eskew and Associates. In this position he has lead responsibility for organizing and directing major projects. These projects include comprehensive community development programs, market analysis/marketing strategies, and negotiation and acquisition of real property. Recent market analysis/strategy projects directed by Mr. Jennings have served public clients and private developers; and have focused upon housing, city business districts and large scale private recreation development. His knowledge of business community and its relationship with government have proven valuable in these and other projects.

Prior to his association with Hanselman-Eskew and Associates, Mr. Jennings was a consultant to various units of local government in planning, logistical and marketing capacities. He also served in private enterprise as a marketing specialist for a number of years.

PROFESSIONAL PROFILE

Alison J. Zatik
Senior Staff Member
Hanselman-Eskew and Associates

Education

Master of Science Degree
Applied Economics
Wright State University

Bachelor of Arts Degree
University of Cincinnati

Experience

Ms. Zatik's proficiency in economics and experimental design/analysis gives her the ability to develop and deliver expeditious and definitive problem-solving techniques. Her experience in forecasting, econometrics, cost/benefit analysis, and marketing enable her to dexteriously apply these techniques to problems that affect both the public and private sectors. Combining rigorous training and experience in advanced statistical techniques with a broad knowledge of computer systems, Ms. Zatik has industriously provided HEA with both timely and cost-effective protocols. Since joining HEA, Ms. Zatik has a key role in economic development analysis and strategy formulation on a broad range of projects including alternative energy systems, housing, industrial and commercial development/redevelopment.

Prior to her association with HEA, Ms. Zatik worked for both the public and private sectors in the areas of computer analysis, model design and applications. Specifically, Ms. Zatik has participated in studies concerning the economics of migration, inflationary policy effects and monetary controls. She has created and mechanized a large data file system designed to select optimal retail outlets for particular sites in central business districts, revised and updated long-run econometric forecasts for various sectors of the economy, and designed a system to both quantitatively and qualitatively evaluate the effects of various drugs on sleep and performance.

PROFESSIONAL PROFILE

Carla L. Lakatos
Senior Staff Member
Hanselman-Eskew and Associates

Education

Master of Science Degree
Applied Economics
Wright State University

Bachelor of Arts Degree
Economics
Wright State University

Experience

Ms. Lakatos' background in economics in both the public and private sector complements the other disciplines in the firm of Hanselman-Eskew and Associates. Her experience in economic analysis and forecasting business cycles, econometrics, cost/benefit analysis, model development and pricing enable her to qualitatively assess current problems and determine appropriate courses of action for problem solution, both in a defined market area and within a broader context. Furthermore, her forecasting and model development capability provide a valuable tool in establishing cost-effective approaches in satisfying today's problems. Ms. Lakatos has participated in numerous projects since joining HEA, including analysis and evaluation of alternative energy systems and commercial development analysis and planning.

Prior to joining HEA, Ms. Lakatos worked for both the public and private sector in areas of computer analysis and model design, data processing generated from human factor studies, establishing a system for running pulmonary functions and EKG's over telephone data lines from remote stations, and cost/benefit of residential applications of wind energy.

PROFESSIONAL PROFILE

Jennifer McGinnis Hanselman
Research Associate

EDUCATION

Bachelor of Arts Degree
Wright State University

EXPERIENCE

Ms. Hanselman's special expertise in survey research and public opinion testing has been a valuable addition to the Hanselman-Eskew and Associates staff. With HEA, Ms. Hanselman has broad responsibility for survey design and questionnaire development. Working with units of government, public agencies and private interests, she smoothly translates their needs for issue-oriented information and data into valid survey research methodologies and productive public opinion testing instruments. Ms. Hanselman is also responsible for training staff interviewers and directing field operations during both telephone and field surveys. As HEA's liaison with the local computer center, Ms. Hanselman codes survey results for quantitative analysis and assists with interpretative discussions.

Prior to joining HEA, Ms. Hanselman was employed by the Public Opinion Center, Inc. The POC is a Kettering Foundation demonstration project aimed at improving public and public interest decision-making at the local and state levels. In this capacity, she participated in survey research and public opinion projects for cities, counties, schools, regional and state agencies, special purpose public agencies and political parties. Several of these projects were in cooperation with the University of Michigan Research Center. Ms. Hanselman has participated in public opinion testing throughout Ohio and as far distant as Sioux City, Iowa.

OTHER SKILLS OR DISTINCTIONS

Foreign Language Fluency

Hanselman-Eskew and Associates

Selected Studies and Projects

A. Market Analysis and Feasibility Studies

1. Office of Management and Budget
City of Dayton, Ohio
DAYTON BUSINESS DISTRICT ANALYSIS AND COMPARATIVE EVALUATION
2. Planning Division
City of Kettering, Ohio
AN ASSESSMENT OF DEVELOPMENT TRENDS AND NEEDS
3. Planning Division
City of Kettering, Ohio
COMMERCIAL AND ECONOMIC DEVELOPMENT: ANALYSIS AND STRATEGY
4. Planning/Management Division
Miami County, Ohio
CDBG RELATIVE COMMUNITY COMPETITIVENESS
5. HOUSING MARKET ANALYSIS
Confidential Evaluations
6. Planning Division
City of Miamisburg, Ohio
RIVERFRONT HOUSING DEVELOPMENT
7. Warren County, North Carolina
COMPARATIVE ANALYSIS OF WASTEWATER TREATMENT ALTERNATIVES
8. Newfields
Newfields, Ohio
PRIVATE INVESTOR INCENTIVES
9. Rossmore Leisure World
Luguna Hills, California
Montgomery County, Maryland
10. Maumelle, Arkansas
FEASIBILITY OF A MARINA ON THE MCCLELLAN-KERR RIVER SYSTEM
11. City of Lockland, Ohio
CITY WELLFIELD/INDUSTRIAL SITE: MARKET ANALYSIS AND PLAN

B. Institutional Analysis

1. City of Lockland
Lockland, Ohio
HOUSING AND ENVIRONMENTAL CODE
2. Miami Valley Regional Planning Commission
Dayton, Ohio
ZONING & DEVELOPMENT OBSTACLES
3. Village of Park Forest South, Illinois
PUBLIC LANDS MANAGEMENT
4. Maumelle, Arkansas
SECURITY DESIGN SEMINAR
5. City of Piqua
Piqua, Ohio
CODE PROGRAM
6. City of Lockland
Lockland, Ohio
FLOOD PLAIN ORDINANCE
7. City of Kettering, Ohio
HOUSING AND ENVIRONMENTAL CODE
8. Forest Park, Ohio
CENSUS AND HOUSING REPORT
9. City of Lockland, Ohio
CITY-WIDE PARK ANALYSIS/EVALUATION

C. Planning and Development Studies and Plans

1. City of Lockland
Lockland, Ohio
CITY BUSINESS PLAN
2. Shenandoah, Georgia
ERDA, ENERGY CONSERVING COMMUNITY DESIGN
3. Warren County, North Carolina
ENVIRONMENTAL IMPACT STATEMENT

4. Miami County Commissions
Miami County, Ohio
CITIZEN INVOLVEMENT STRATEGY
5. Woodlands, Texas
ENERGY CONSERVING COMMUNITY DESIGN -- ERDA
6. City of Piqua
Piqua, Ohio
NATIONAL TRUST FOR HISTORIC PRESERVATION
7. City of Lockland, Ohio
CENTRAL PARK DEVELOPMENT PLAN

D. Development Projects/Development Assistance

1. Department of Housing and Urban Development
New Community Development Corporation
Washington, D.C.
2. Patton, Boggs and Blow
Washington, D.C.
City of Canajahurie, New York
3. Warren County, North Carolina
Regional Wastewater Treatment Facility
4. I.F. Weber Development Company
Dayton, Ohio
ELDERLY MIDRISE DEVELOPMENT
5. Woodlands, Texas
PARK DEVELOPMENT FINANCING
6. Maumelle, Arkansas
INDUSTRIAL PARK DEVELOPMENT
7. Edward C. Dodds, Inc.
Architects
Dayton, Ohio
8. Shenandoah, Georgia
INDUSTRIAL PARK DEVELOPMENT

9. City of Lockland, Ohio
RESIDENTIAL URBAN DEVELOPMENT ACTION GRANT PROGRAM

E. Program/Project Management

1. City of Piqua
Piqua, Ohio
 - a. RIVERSIDE NEIGHBORHOOD IMPROVEMENT PROGRAM
 - b. COMPREHENSIVE AREA CODE ENFORCEMENT/REHABILITATION PROGRAM
 - c. ELDERLY HOUSING PROGRAM
 - d. DEVELOPER INCENTIVE PROGRAM
2. City of Lockland
Lockland, Ohio
 - a. GREENWOOD IMPROVEMENT PROGRAM
 - b. RESIDENTIAL UDAG

1.2.3 GEORGIA TECH MANAGEMENT PLAN

Georgia Tech's work in the Phase I tasks of the project is being directed by the overall Program Director, Mr. David Wade to interface with other Demonstration Team members. The short time frame of the Phase I portion of this project requires the relatively broad involvement by a number of specialists in the energy conservation, power generation and distribution system fields. Georgia Tech's effort during the analysis and evaluation is conducted by four task groups directed by an overall Program Director. The overall Program Director has the responsibility of coordinating the various groups to accomplish the tasks outlined in the detailed Work Management Plan.

The Engineering Experiment Station employs a computerized project cost accounting system which provides the project coordinator with current information about project budgets and expenditures. Additionally, in-house report generation procedures and weekly project meetings insure completion of tasks and the expeditious transfer of knowledge between groups and with other Team members.

Subsequent phases of the project will be managed similarly with the task groups being altered as appropriate to the work plan. The same key personnel will be retained in group leadership roles throughout the subsequent phases; specialists in other fields will be added to the groups as needed in order to perform the required work plan.

THE ENGINEERING EXPERIMENT STATION TEAM

The Engineering Experiment Station carries out its activities in a number of the major research buildings and many specialized laboratories located on the Georgia Institute of Technology campus in Atlanta, Georgia. These facilities include full-equipped laboratories for research in the chemical and physical sciences, electronics, high temperature materials, nuclear and biological sciences, environmental science, and in most branches of engineering. There is a complete machine shop, a photographic and reproduction laboratory, and a nuclear reactor. The Engineering Experiment Station also has a large field test site for research in radio-direction and propagation studies.

In addition to its own facilities, EES has access to all of the Institute's support facilities such as the Price Gilbert Memorial Library and the Rich Electronic Computer Center.

The corporate resources outlined above and used to support the Piqua District Heating and Cooling Demonstration Project, however, the principal resources applied to the project are those furnished by the Technology and Development Laboratory.

The Laboratory's research is conducted in four groups--Energy and Engineering, Industrial Extension, Economic Development and Chemical and Material Sciences. It also is the organizational home of the Georgia Productivity Center, a function assigned EES by the 1975 Georgia General Assembly. Activities relate to productivity of both private and public sectors at local, state, and national levels and to applications of technology. Current areas of research include:

- * Analysis of trends in manufacturing productivity in Georgia, the region, and the U.S.
- * Impact of governmental regulations on small business
- * Solar energy applications
- * Energy conservation in industry and in state and local government
- * Surveys of wastes as potential energy sources
- * Development of improved processing technology
- * Productivity in government services
- * Biomass conversion
- * Carbon technology
- * Composite materials
- * Industrial chemical processes
- * Pyrolysis technology
- * Utilization of pyrolytic products
- * Plastics technology
- * Paints and coatings
- * Carbon fiber technology

The following charts outlined the EES staff structure on this project and identify staff responsibilities. Biographical sketches of key personnel are also provided.

GEORGIA TECH ENGINEERING EXPERIMENT STATION

PROJECT ORGANIZATION

PIQUA, OHIO

DISTRICT HEATING PROJECT

PHASE I - PERSONNEL ASSIGNMENTS

GEORGIA TECH

	<u>Person</u>
Task I - Demonstration Team	D. Wade (GT Project Director)
Task II - Thermal Sources	B. Dixit (Coordinator) C. Carr
Task III - Energy Market Analysis	D. Wade (Coordinator) B. Trammell B. Dixit
Task IV - Technical Review	B. Trammell (Coordinator) C. Carr D. Wade R. Ratajczak J. Tiller B. Dixit
Task V - Institutional Assessment	D. Wade (Coordinator) R. Ratajczak
Task VI - Preliminary Economic Analysis	R. Ratajczak (Coordinator) J. Tiller
Task VII - Proposal for Further Work	D. Wade (Coordinator) B. Trammell
Additional Support:	Technician/Draftsman Secretarial/Clerical

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

WADE, DAVID W.--Research Engineer, Engineering Experiment Station

Education

B.M.E., Georgia Institute of Technology (Co-operative Degree)	1972
M.B.A., Georgia State University	1975

Continuing Education Credits: Industrial Energy Conservation,
Solar Energy Design, Value Engineering

Registration

Professional Engineer, Georgia No. 10486

Employment History

Hensley-Schmidt, Inc. - Land survey crew.	1965
Lockheed Georgia Company - Eight work quarters in the Cooperative education program.	1967-1971
Rosser, White, Hobbs, Davidson, McClellan, Kelly, Inc. - Mechanical Engineer, Project Manager	1971-1977

Experience Summary:

As project manager and mechanical engineer, has been in responsible charge of mechanical design and coordination and management of engineering design projects in the commercial, industrial and institutional fields. Additionally, has experience in applying digital computers to engineering design processes and management functions and has been involved in numerous energy related studies including energy conservation studies for commercial buildings, industrial plants, military installations, hospitals, churches, government training facilities, shopping centers and institutional facilities.

Current Interests

Applications of engineering techniques to mechanical and electrical systems to increase efficiency and reduce energy consumption. Improvement of engineering design processes through the use of digital computers and the application of current engineering technology.

Membership - Professional Organizations

A.S.H.R.A.E. - American Society of Heating, Refrigeration and Air Conditioning Engineers	
Pi Tau Sigma - Mechanical Engineering Honorary Society	
A.S.M.E. - American Society of Mechanical Engineers	

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

TRAMMELL, BENJAMIN C., Jr.--Assistant Research Engineer,
Engineering Experiment Station

Education

B.S.M.E., Clemson University 1975

Registration

Registered with S.C. State Board of Engineering
Examiners as Engineer-in-Training, 5-75

Employment History

Georgia Power Company, Associate Plant Engineer	1975-1978
Georgia Institute of Technology	
Assistant Research Engineer	1978-Present

Experience Summary: As Associate Plant Engineer, has conducted projects in the areas of plant maintenance and operations such as testing and analysis of new products, and comprehensive performance testing of plant subsystems. Also, has maintenance engineering experience in the form of major equipment inspections (steam generators, cooling towers) and maintenance of plant instrumentation and control systems. Additionally, developed and initiated implementation of a comprehensive plant energy conservation program. As Assistant Research Engineer, has participated in various research projects in the area of Community Energy Systems including: conceptualization and feasibility investigation of applying various Integrated Community Energy System (ICES) concepts to existing and planned communities, and feasibility study and performance evaluation of a community district heating system based on cogeneration.

Current Fields of Interests

Applications of engineering techniques to mechanical and electrical systems to increase efficiency and reduce energy consumption. Feasibility of the application of various ICES concepts to existing or planned communities. Cogeneration.

Major Reports and Publications

1. Numerous Testing and Inspection reports for Southern Company (parent company G.P.C.) internal distribution.
2. "Heat Pump Wastewater Heat Recovery Scheme for Heat Pump Centered-Integrated Community Energy Systems," Concept Development and Feasibility Study, Contract No. 31-109-38-7551 for Argonne National Laboratory, December 1978, co-author.

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

CARR, WALLACE W.--Senior Research Engineer
Engineering Experiment Station

Education

B.S. Mechanical Engineering, University of Virginia	1966
M.S. Mechanical Engineering, Georgia Tech	1968
PhD. Mechanical Engineering, Georgia Tech	1973

Registration

Registered for the practice of Professional Engineering in Georgia and Virginia

Employment History

Virginia Department of Highways, Draftsman	1963-1965
Norfolk Naval Shipyard	1966
Nuclear Engineering Department, Norfolk Naval Shipyard Mechanical Engineer	1966
Georgia Institute of Technology, Graduate Research Assistant, Mechanical Engineer	1971-1972
Monsanto Textiles Company, Senior Engineer	1973-1975
Monsanto Triangle Park Development Center, Inc., Senior Research Engineer	1975-1978
Georgia Institute of Technology, Engineering Experiment Station, Senior Research Engineer	1978-Present

Experience Summary: As a draftsman with the Virginia Department of Highways, estimated materials and cost of roads. During the summer of 1966, designed a steam system for a barge servicing nuclear submarine. As a graduate research assistant at Georgia Institute of Technology, did computer programming for the optimization of a space shuttle heat rejection system. Experience in synthetic fibers has been in drawtexturizing hosiery yarn and in high speed melt spinning polyester to determine the significant parameters affecting fiber properties. Work in drawtexturizing hosiery yarn involved theoretical and experimental analysis and mathematical modeling of processes and equipment. The objective of work in high speed melt spinning polyester was to increase productivity. Developed a method of quenching that increased productivity by as much as thirty-five (35) percent.

Current Fields of Interest

Wood energy research and development; energy reclamation in industrial processes; and development and demonstration of energy conserving modifications to industrial processes, particularly drying processes.

Ph.D. Dissertation:

"The Measurement of Instantaneous, Local Heat Transfer From a Horizontally Vibrating Isothermal Cylinder Using a Differential Interferometer"

Thesis Advisor: Dr. W.Z. Black

Major Publications:

1. Black, W.Z. and Carr, W.W., "Application of a Differential Interferometer to the Measurement of Heat Transfer Coefficients," The Review of Scientific Instruments, Volume 42, Pages 337-340, 1971.
2. Black, W.Z., and Carr, W.W., "A Differential Interferometer and Its Application to Heat and Mass Transfer Measurements," ASME Paper No. 72-HT-12. Presented at the ASME-AICHE Heat Transfer Conference, Denver, Colorado, August, 1972.
3. Carr, W.W., and Black, W.Z., "Interferometric Measurement of Instantaneous Local Heat Transfer From a Horizontally Vibrating Isothermal Cylinder," International Journal of Heat and Mass Transfer, Volume 17, Pages 633-642, June, 1974.
4. Carr, W.W., and Black, W.Z., "Interferometric Flow Visualization of Free Convection From a Horizontally Vibrating Isothermal Cylinder," International Journal of Heat and Mass Transfer, Volume 18, Pages 583-587, 1975.

Papers Presented:

1. Energy Measurements on a Kuster Range - ASME Textile Conference, Raleigh, North Carolina, October 17 and 18, 1978.

Georgia Institute Of Technology

BIOGRAPHICAL SKETCH

DIXIT, BADARINATH S. -- Senior Research Engineer

Education

B.E., University of Mysore, INDIA	1951
B.S.M.E., Carnegie Institute of Technology	1958
M.S.M.E., West Virginia University	1960
Ph.D., West Virginia University	1965

Continuing Education

Intensive short course in "Solar Energy Heating & Cooling," (1 week), University of Michigan, Ann Arbor	July, 1977
Short course (2 weeks) in "Physiological Systems Analysis for Engineers," University of Michigan, Ann Arbor	Summer, 1969
Two-day Engineering Seminar (Energy) at Michigan State University, East Lansing, Michigan	April, 1969

Registration: Professional Engineer, Indiana

Employment History

Tri-state University, Mechanical Engineering, Instructor to Professor and Chairman	1964-78
House Glass Corporation, Point Marion, Pa., Research Engineer	1960-61
West Virginia University, Research Assistant	1959-60 1961-63
Walchond Industries, India, Asst. Engineer	1957
College of Engineering, Poone, India, Lecturer	1953-57
Kirloskar Machine Tools, India, Mech. Engineer	1952-53

Experience Summary: As a mechanical engineer in manufacturing industries, participated in the design and production supervision of machines; as a research assistant, conducted studies on moisture migration through structures, insulation etc.; as a research engineer with House Glass, participated as Project Engineer in a Navy Project on the research and development of fiberglass plastics; as a faculty member, have taught Thermodynamics, Heat Transfer, Airconditioning, Design & Analysis, Solar Energy, Refrigeration, Cost and Optimization and several other subjects in the Energy area; Supervised student projects

Experience Summary (Cont.): on HVAC, Heat pumps, laboratory studies, Solar energy etc; have worked individually on projects - energy-related; presently at Georgia Tech (CEES), working on Heat pump-centered Community energy systems, district heating and cogeneration.

Membership

Member, American Society of Mechanical Engineers
Member, American Society of Heating, Refrigerating
and Airconditioning Engineers
Member, Scientific Research Society of America, Sigma-xi

Current Fields of Interest

HVAC; Research and studies on energy-related projects;
Energy conservation; Heat Pumps; Solar Energy; Technical
Writing.

Major Reports and Publications

1. "Permeability Studies of Concrete", M.S. Thesis, West Virginia University, 1960.
2. "Diffusive Flow of Water Vapor Through Large Cappillaries", Ph.D. Thesis, West Virginia University, 1965.
3. Final technical report on "Research and Development of Fiber Glass Reinforced Plastics", Contract #18701 with the U.S. Navy Bureau of Weapons, House Glass Corporation, Point Marion, PA., 1961.
4. Several inhouse reports of proprietary nature.

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

RATAJCZAK, ROSALINDA R.--Senior Research Scientist, Technology and Development
Laboratory, Engineering Experiment Station

Education

B.A. in Government/Mathematics	Harvard University	1966
M.A. in Economics	Boston College	
	Graduate School	1968
Ph.D. Candidate in Economics	University of California, Los Angeles	

Employment History

Office of the Postmaster General, Planning Assistant	1966-67
Regional Office, Post Office, Boston, Planning Assistant	1968
System Development Corporation, Economist	1969
RAND Corporation, Economist	1970
University of California, Teaching Fellow and Lecturer	1970-72
UCLA Business Forecasting Project, Research Associate	1972-73
Trust Company of Georgia, Associate Economist	1973-77
Georgia Institute of Technology, Senior Research Scientist	1978-present

Experience Summary: Forecast mail volume and revenue for the nation and a sample region; studied feasibility of alternative postage collection methods; did cost-benefit analyses of capital expenditures; developed fixed-weight index of postage rates and determined elasticities of demand for types of mail. (P.O.D.) Developed a system of social accounts and wrote monograph on measures of poverty. (S.D.C.) Built a demographic-economic model of Thailand to explain joint determination of marriage, fertility, and labor force participation. (RAND). Taught principles of economics, mathematical statistics, and graduate microeconomics. Participated in the development of regional econometric models of Louisiana, Kentucky, and Southern California. (UCLA). Forecast interest rates, labor market variables, and prices; analyzed current national and regional economic trends; developed a model to forecast loans and deposits nationally and for the bank; co-authored published quarterly business outlook and made presentations at civic meetings and internal sessions. (TCG). Consulted on occupational forecasting for the Southern Association of Colleges and Schools. Served as a consultant to the Education Commission of the States setting priorities for knowledge in economics as part of general social science curriculum objectives.(1978)

Current Fields of Interest

Econometric model-building and forecasting; regional economics; demographic and labor economics; inflation; vocational education and manpower training.

Major Reports and Publications

1. "Methods of Collecting Postage: A Cost-Benefit Analysis," paper presented to the Universal Postal Union, 1967.

Major Reports and Publications (Cont'd)

2. "Differential Multipliers of Federal Government Expenditures by Type," unpublished graduate seminar paper, 1968.
3. "Measures of Poverty for a System of Social Accounts," monograph, System Development Corporation, 1969.
4. "Determinants of Labor Force Participation, Marriage and Fertility in Thailand: An Econometric Approach," RAND monograph, coauthor, 1971.
5. "The Louisiana Model," "The Kentucky Model," and "An Econometric Model for Ten Southern California Counties," monographs of the UCLA Business Forecasting Project, coauthor, 1972-73.
6. "Inflation and the Participation of Secondary Workers," paper presented to the UCLA Money Workshop, 1973.
7. The Business Outlook, quarterly publication of Trust Company of Georgia, coauthor, 1973-77.
8. "Economic Impact of the Bank Holding Company Act," The State Magazine, 1975.
9. State Planning for Vocational Education: An Evaluation of the Uses of Manpower Data in Determining Occupational Supply and Demand in the Southeastern United States. Southern Association of Colleges and Schools, 1978.
10. "The Outlook for Vocationally-trained Solar Energy Technicians," Georgia Department of Education, 1978.
11. "The Impact of MARTA Construction Expenditures on Atlanta and Georgia," Georgia Tech, coauthor, 1979.

Georgia Institute of Technology

BIOGRAPHICAL SKETCH

TILLER, JEFFREY S.--Research Engineer, Technology and Development Laboratory,
Engineering Experiment Station

Education

B.S.(Engineering Economic Systems), Georgia Institute of Technology	1974
M.S. (Industrial & Systems Engineering) Georgia Institute of Technology	In Progress

Employment History

Forecasting International, Ltd., Arlington, Virginia Research Associate	1974
Georgia Institute of Technology, Engineering Experiment Station Assistant Research Engineer	1975-1977
Research Engineer	1978-Present
Metrics, Inc. Research Consultant	1976-1978

Experience Summary: At Forecasting International, Ltd., Mr. Tiller used techniques and methods in corporate and government strategic planning, technological forecasting, technology assessment, scenario generation, and the quantification and analysis of subjective judgements on several different contracts. He performed a detailed analysis of future coal demand in the United States; in so doing, he investigated the entire future energy outlook for the U.S. He also analyzed the social costs of mining coal and attempted to determine what effects social, legal, political, institutional, environmental, and labor-management events or impacts would have on coal production. He also evaluated the European energy situation and derived a list of policy options that must be considered.

At Georgia Tech he has evaluated several anticrime programs funded in part by the Law Enforcement Assistance Administration for the Atlanta Area. Mr. Tiller helped to develop an Industrial Energy Monitoring System for the Federal Energy Agency. He has performed an economic analysis of hybrid electrical power systems and multiple-use energy systems for the National Science Foundation. Mr. Tiller evaluated environmental, economic and conservation aspects of integrated energy systems for the Environmental Protection Agency. He is a co-author of a book on environmental, economic, energy and technology assessment. He is currently involved in projects on Resource Recovery, Appropriate Technology and Wood Energy.

Current Fields of Interest

International economics, economic analysis, technology forecasting and assessment, social and political forecasting and analysis, decision theory as applied to the political process, environmental systems.

Major Publications, Presentations and Manuscripts

"Technological Forecast of the Coal Extraction Process," Forecasting International, Ltd., U.S. Bureau of Mines Contract No. S0241069, 1974.

"Report on Industrial Energy Conservation Monitoring System," Engineering Experiment Station/Energy and Environment Analysis Division (EES/EEAD), July, 1975.

"Solar Radiation-Electricity Consumption Correlation Study," Presented at Southeastern Symposium on Systems Theory (IEEE), April 26, 1976.

"Use of Cost Benefit and Net Energy Analysis as Methodologies of Technology Assessment: Assessment of Hybrid Fueled Plants," presented at the Conference on Technology Assessment of Energy Alternatives, Rensselaer Polytechnic Institute, Troy, NY, May, 1976.

"Power Systems Options for the Southeastern United States," EES/EEAD, NSF Grant (SIA-74-20662), 1976.

"Determination of Economically Attractive Locations for Steam and Electric Cogeneration Plants," 9th Annual Southeastern Symposium on Systems Theory (IEEE), 1977.

"Environmental, Economic and Conservation Aspects of Integrated Energy Systems," 12th Intersociety Energy Conversion Engineering Conference, Washington, DC, August 28-September 2, 1977.

"Cogenerating District Heating Systems," Southeastcon '78, Atlanta, GA, April 10, 1978.

1.3.1 CONSUMER INVOLVEMENT AND COMMERCIALIZATION

The task of designing the appropriate format for consumer involvement and the ultimate commercialization of district heating does not revolve around a specific committee, a single industry or rest solely with the public decision-makers. Rather, it must be approached from the same basis that all public decisions are made, i.e. the fundamental components of public decision-making. The four components are:

- 1) Information and Awareness
- 2) Discussion and Debate
- 3) Authority and Decision
- 4) Monitoring and Feedback

These four components comprise the Process Framework for public decision-making. Although straightforward, the identification and description of the four components tends to oversimplify the interrelationships that exist. Each component is not an independent, freestanding entity. The components and their functions continually overlap. Obviously, during any discussion and debate, there will occur an exchange of information and ideas. During that debate, participant's awareness of issues will be increased.

The most important key to understanding and utilizing this format is that neither the Process Framework nor its four components exist. There are not any people or machines carrying out the activities in these four delineated boxes. In reality, the components provide the basic framework in which decision-making occurs, and establish the process whereby involvement mechanisms are identified and defined. It is only at this level where involvement exists and mechanisms are operative. Here is where the real action occurs with the involvement of consumers, the assemblage of data, the addressing of issues/problems, and the final decisions made. Furthermore, the components of the Process Framework are not mutually exclusive; rather the mechanisms consistently interact, thereby providing a linkage between the components, and establishing a foundation for the mutual exchange of information, and the proper forum for community discussion and debate.

Therefore, the following illustration, PUBLIC DECISION-MAKING PROCESS, presents the Process Framework and Specific Involvement Mechanisms established and utilized for expanding consumer involvement and commercialization of the district heating feasibility study in the Study Area. The involvement mechanisms are:

- 1) Opinion Testing
- 2) Media
- 3) Project Advisory Committee
- 4) Existing Organizations
- 5) City Commission
- 6) Public Meetings
- 7) Staff Resources

These mechanisms are employed for this Phase I process in that they provide for the proper forum for consumer/decision-maker interaction, exemplify the appropriate information dissemination modes and cast the commercialization of the district heating system within the appropriate context. The remaining presentation herein delineates the involvement mechanisms and the activities which occurred, and discusses how these mechanisms will function in future phases of this study.

ILLUSTRATION

PUBLIC DECISION-MAKING PROCESS

OPINION TESTING--Opinion testing is a mechanism employed to provide baseline data for project development, assist in establishing priorities and provide a measure for analyzing and evaluating attitudes concerning specific issues e.g. marketability. Given the scope and desired information required for the District Heating and Cooling Feasibility Study, a four-set surveying process was employed that collects data concerning specific energy requirements of end-users, identifies and defines consumer attitudes, and provides the basis for the economic and marketing strategies. Separate surveys were used for the residential, commercial, industrial and institutional sectors of the Study Area. The survey results, which provide primary source data, are presented throughout this study, and in fact, create the proper data base required in establishing parameters for structuring other commercialization mechanisms. As an example, the results indicated that the local media, the Piqua Daily Call newspaper, WPTW radio station, and Channel 13 (the local CATV station) all had very high local use, and as such, establish an appropriate means for information dissemination, discussion and debate. In future phases of this project, the role of the media can be intensified and expanded.

MEDIA--The media represents one of the most important and effective vehicles for widespread dissemination of information. Specifically for this project and ones that bare geographic similarities, there are essentially two levels of media functioning in the community;

- the local media
- the regional media.

The regional media consisting of newspapers, radio stations and television stations are designed and functioned to serve the population approximating a million people. The local newspaper, radio station and local CATV station are designed to service the population ranging from 30,000 - 100,000. By the very nature of this service area, the local media is in a much better position to present issues/problems that directly effect potential consumers of thermal energy within this Study Area. While the regional media can provide broad brush reporting relative to the City of Piqua and the district heating project, the local media can and does present its customers with a more indepth discussion

of the problems and issues. The survey research results clearly indicate that the local media is the best method for informing/educating the Study Area community. Further, given the extent of readership/viewership of the local media by the general population, it is determined that the establishment of viable, working relationships between the Demonstration Team and local media is critical for the ultimate success of this project. These "institutions" provide wide-spread dissemination of the issues, problems, advantages and disadvantages of delivering central source, thermal heating. For the purpose of understanding and working with the media during the district heating project the Demonstration Team places primary emphasis on:

- the Piqua Daily Call newspaper
- the WPTW Radio Station
- the CATV Local Access Channel

The following is a descriptive analysis and presentation of how, when, where and to what extent the media is involved in this process to date, and how their involvement can continue in the future.

THE PIQUA DAILY CALL NEWSPAPER--has presented its readership with extensive coverage of the District Heating and Cooling Feasibility Study. As witnessed by the accompanying example articles, this coverage has continued from the initial decision on the behalf of the City Commission to submit a proposal for Phase I and continued thru the completion of Phase I activities. The level of newspaper coverage has been sufficiently high that community awareness has increased sharply. Working with the Demonstration Team, the Piqua Daily Call has been able to keep its readers informed during the process presenting both the advantages and disadvantages of retrofitting the community for district heating and cooling.

As part of this survey research, the following question was asked. "What newspapers, if any, do you yourself read regularly?" Fully 90.5% of the respondents indicated that they regularly read the Piqua Daily Call. Thus Piqua Daily Call readership is nearly four times as great as any other newspaper serving the Study Area. In addition, the market analysis results (Section 3.0) indicates that information about district heating and project integration within the

broader community positively influence consumers' willingness to connect to the system. Therefore, in an effort to further integrate the Study Area population with the district heating demonstration project, a newspaper supplement was produced by the Piqua Daily Call in conjunction with the Demonstration Team. Since the cost of this supplement would have to be carried by advertisers, the paper's staff was fully informed/educated on the various issues thru two meetings and numerous discussions with Hanselman-Eskew and Associates, and representatives from the Georgia Tech Engineering Experiment Station. The supplement, published April 18, 1979, was not only well received by the community, but was also supported by advertisements from financial institutions, suppliers and contractors of energy related products in the Piqua region.

This major, full color supplement entitled Piqua's Energy Future ran in the evening edition of the Piqua Daily Call. While this twelve page supplement emphasizes the District Heating and Cooling Project, numerous other topics ranging from auto maintenance measures to the National Energy Act are featured.

FEATURED ARTICLES

* District Heating has tried true history in Europe	* Coal is abundant, unwieldy energy source, needs conversion to work
* District Heating Cuts Costs	* National Energy Act seeks to reduce demand
* Georgia Tech's Service is Broad	* To Conserve: Dial down heat-keep filters clean
* Piqua Municipal Power Plant holds value for city's future	* Insulation decreases heat costs
* Is there an Energy Crisis?	* Auto Maintenance improves mileage
* Save Energy in Kitchen	* Wood burning stove helps heat home
* Solar Heat Storage	* Suds savers allow water to be reused
* Hydro-power not feasible here	* Fireplaces lose heat
* Editorial: District Heating Study Beneficial	

PIQUA DAILY CALL

April 18, 1979

PIQUA'S ENERGY FUTURE

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Stoves help heat home

Wood-burning stoves not only offer the beauty and charm of a fireplace, but are more energy efficient.

With doors closed, it uses about 80 percent of the wood's energy, while a fireplace utilizes only about 10 percent, according to Becky Powers, who with her husband Rick owns Buck Stove Exchange at the corner of Water and Wayne streets. And with its doors open the woodstove is still 50 percent efficient.

"The stoves are even more efficient than glass doors on a fireplace," Powers explained. "The glass doors only keep your home's heat from going out the chimney, while a woodstove has a fan which will push the heat it produces throughout your home."

Depending on the size of the stove and the openness of the area, woodstoves can heat up to 3,000 square feet comfortably, she said. With the doors closed, Powers said the stove is similar to a forced air heating system.

In addition, Powers said woodstoves can cut home heating costs by as much as 80 percent.

"We sold a stove to a fellow who had a total electric home, with bills of over \$200 a month. After the stove was installed, his bills dropped to \$80," she said.

District heat

Continued from page 2

wanted district heat, expansions would be necessary,"

Wade reiterated that nobody will be forced to convert their heating systems to district heat. He said that those receiving other services will be able to continue that if they choose.

IMPROVEMENTS TO THE POWER plant and its distribution system will probably be financed through bonding, Hanselman said, while those citizens wanting district heat will have to pay for changes to their present heating systems themselves.

"We're encouraging people to finance the retrofitting of their homes through local lenders," he said.

District heating, often called co-generation because heat and electricity are generated together at one plant, is not possible just anywhere, according to Wade.

"Not everybody can do co-generation. You have to have a power plant which can be converted and one which is close to the city. Cities down the road from Piqua don't have these things," he said.

"PIQUA IS ALSO a dense, compact community. This will make it cheaper to install a thermal energy distribution system," Hanselman added.

Both Hanselman and Wade stressed that district heating is not a research and development project like the nuclear reactor installed in Piqua in the 1960s.

"District heating is a demonstration project. The technology of it has already proven itself. It does work. It's not just an experiment," Hanselman said.

Wood stoves can be purchased free-standing or installed in an existing fireplace.

The only expenses involved with woodstoves are the initial cash outlay, wood costs and electricity costs for running the stove's fan, which uses about as much as a 100-watt lightbulb.

The stoves cost upwards of \$500 and with installation run as high as \$1,000, Powers estimated. She explained that they sell models which can be installed in existing fireplaces, piped into existing chimneys or left free-standing with flues of their own.

Woodstove fires are easier to get going than those in fireplaces are, Powers said. Plus, they burn longer.

"One fire will last six to eight hours without any new logs being added," she explained. "And once you've got it going, you just keep adding logs because the coals are already hot."

Maintenance procedures are the same as those for a fireplace, except ashes don't have to be carried out as of-

ten because the stove consumes less wood, Powers said.

"Of course, any time you burn wood you're going to have a creosote build-up. It just takes periodic checks and cleanings to ensure the flue is kept clean," she explained.

Some woodstoves can also be used to cool in warmer months. Ice is used in the stove instead of wood, cooling warm air sucked in through vents and pushing it out with aid of the fan. Four one-gallon frozen containers will provide reasonable cooling for about 24 hours.

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Ave. — Branch

"Your Next Door Neighbor"

District heat has tried, true history in Europe

District heating is no experiment.

Its technology has been proven, and as a result, a number of cities worldwide currently employ cogeneration to heat businesses and homes.

It utilized in Piqua, residents need not worry that someday its network will be abandoned and sit empty as does the dome built in the early 1960s for a nuclear power experiment here.

Although district heating is especially popular in Europe and the USSR, the United States and Canada have also been successfully operating thermal energy plants for a long time, with more plants still on the drawing board.

UNITED STATES

The first recorded successful district heating system was in Lockport, N.Y., in 1877, when Birdsill Holly installed a short underground steam pipe and heated a few residences.

By 1905, several steam turbine cogenerating systems could be found in New England and the South. At this time, a Lawrence, Mass., textile mill had a 5,000 kilowatt unit operating, and a Southern mill had 500 KW and 1,500 KW units working.

Development on a wider scale up until now has been impeded because the plants were not profitable. In some cases this was because of premature development, but usually it was because of a lack of proper metering devices and inadequate rates. Rates were wrongly figured on the basis that the steam was merely a by-product of electrical generation and therefore of low monetary value.

However, by 1962 over 50 American cities had district heating. Of those, the largest system was New York City's, with its 84 miles of pipelines, delivering about 11,600,000 megawatt hours. Other large cogenerating schemes in the U.S. are in Philadelphia, Detroit, Indianapolis and Minneapolis-St. Paul.

CANADA

Presently, there are just four true district heating systems in Canada.

Using steam as the heating

medium, the plants in Vancouver, Winnipeg, London and Toronto supply heat to large commercial buildings in downtown business districts. Together, customers of these plants consume 366,000 MWh comparable to the heating required for 12,000 single family houses.

The Ontario government is currently sponsoring a district heating feasibility study for the proposed new community of North Pickering, near Toronto.

This system will employ low temperature hot water heat and have a substantial residential base. The area which it will serve will eventually house about 20,000 people, and the system could be expanded in the future to serve 70,000, with accompanying commercial and industrial development.

Also, plans are being developed for the new Queen Elizabeth Hospital in Charlottetown, Prince Edward Island, to depend on four incinerators fueled by garbage as the source of heat, hot water and electricity. In addition to making the hospital self-sufficient, the system will have the capacity to produce enough steam also to heat buildings in adjacent areas.

USSR

Here, more than 30 percent of all electrical generation comes from combined heat and power stations, yielding the most economical district heating system in the world.

The cogenerating power plants usually supply users within a radius of between five and 15 miles. Networks with 20-mile radii currently are being designed.

The first Soviet station and network was constructed in Leningrad as early as 1924. By 1945 Moscow had five district heating stations, adding three more by 1959. The current Moscow system is about 200 times as large as Great Britain's largest district heating installation.

The success of cogeneration in all Communist bloc countries is largely because of the nature of the governments. Full centralized planning can be employed and appropriate coordination between power com-

panies and town planners achieved.

By 1969, the total district heating load in the USSR is expected to reach 1.2 million MW, according to a recent survey.

EUROPE

District heating is used extensively in Europe with the biggest systems at work in West Germany, Sweden, Finland, Denmark, the Netherlands, and Austria.

Other European countries with existing schemes and new plans underway are Belgium, France, Switzerland, Poland, Czechoslovakia and Yugoslavia.

West Germany's cogenerating scheme is next in size to the USSR's, with more than 100 different organizations operating 98 stations.

Over 350 group heating plants and 474 district heating networks serve a total connected capacity of more than 22,000 MW. Of that, 65 percent is hot water, 25 percent steam and 10 percent mixed.

A new coal-fired system is under construction in Essen, and by 1990, up to 1,000 MW of district heat probably will come from nuclear plants.

User attitudes toward district heating in Sweden, Finland and Denmark are decidedly favorable. All three countries have waiting lists of people anxious to be connected to the systems.

Sweden utilizes district heat in 57 localities, serving 20 percent of all buildings — about three million people. Of the 57 stations, 13 are oil or coal-fired, and 14 harness power from refuse incinerating plants.

Denmark's systems are similar to Sweden's, but operate at lower temperatures. The real difference, though, is the energy supply situation in this country.

Denmark has no coal, gas or hydro resources, no nuclear plants or gas turbines. Therefore its 450 district heating plants, serving one-third of homes, are 90 percent powered by imported oil, eight percent powered by imported coal, and the balance powered by

waste incineration plants.

Finland has 50 district heating plants serving about 840,000 people. There heat is used in several plants as the main fuel.

Holland's two biggest systems, Rotterdam and Utrecht, use combined heat and power from modified coal-fired stations which otherwise would have been phased out. The Dutch also are building a number of new plants to serve Almere and the Utrecht suburb of Nieuwegein Noord.

In Austria, an increasing number of district heating systems are using heat from refuse incinerators, producing both heat and electricity.

Growth in the district heating system at Linköping, Sweden has been rapid since 1967, as shown above. Many district heating plants in Europe have lists of people waiting to be hooked up to the system. Areas away from a central power plant (shown above as disconnected black areas) are served by small sub-stations, similar to the one pictured below.

Save energy in kitchen

Homemakers can practice a number of energy-saving techniques right in their kitchens.

First off, energy-intensive appliances, such as dishwashers, clothes washers and dryers and electric ovens, should be used in early morning or late evening hours to reduce the peak load.

According to the Federal Energy Administration, if everyone scheduled household chores during off-peak hours, the utilities' daily fuel use would be reduced, and the nation's energy would be conserved.

Cold water should always be used in garbage disposals, not only to save energy, but to get better use from the appliance. Cold water saves the energy needed to heat the water while also aiding in getting rid of grease in the unit. Grease solidifies in cold water and can be ground up then and washed away.

Water should never be boiled in open pans, and range-top burners and relectors should be kept clean to save energy. Also, matching the size of a pan to the heating element will allow more heat to get to the pan

and less to be lost to surrounding air.

If purchasing a gas range, ones with electronic ignition systems are more efficient than pilot lights. With an automatic ignition, one can save up to 47 percent in gas usually consumed by that appliance.

Gas range owners should also be cognizant of the color of the range's flames. A blue flame indicates the gas is burning efficiently, while a yellowish one indicates adjustment is needed.

Electric range owners should get in the habit of turning off burners several minutes before the allotted cooking time. The burner will stay hot long enough to finish cooking the item without using more electricity.

When using an oven, one should try to make the most of the heat from that single source by possibly making an all-oven-cooked meal. Watching the clock or using a timer is also more energy efficient than continually opening an oven door to see if the food is done. Every time the door is opened, heat- and energy—escapes.

Dishwasher owners should

always run full, but not overloaded, loads, and let their dishes air dry rather than allowing the washer to go into its dry cycle. The "rinse hold" cycle on dishwasher wastes energy, too, using three to seven gallons of hot water each time it's used.

The most energy economical refrigerators are those with power-saver switches. Most refrigerators have heating elements in their walls to prevent sweating on the outside. In most climates, this element doesn't need to be working all the time. The power-saver switch turns off the element and can save about 16 percent of refrigerator energy costs.

Refrigerators and freezers requiring manual defrosting use less energy and should be defrosted when the build-up is no more than 1/2-inch thick.

An easy test can tell you if your refrigerator door seal is airtight. Close the door over a piece of paper or dollar bill so it is half in and half out. If you can pull the paper or bill out easily, the latch may need adjustment or the seal replaced.

This district heating system provides heat and electricity to approximately 240 apartment units.

So ar heating requires storage

By MARGERY BALMUT
St. Paris Correspondent

ST. PARIS — Solar energy is free, plentiful and non-polluting. So why isn't it put to better use?

First, although there is a lot of it, it's spread out and must be collected. This calls for a considerable expense for the initial installation of a collection system.

Second, the sun is an intermittent energy source, even in the best climate areas. When the sun goes down at night or is sometimes behind a layer of clouds, collection is diminished. This problem can be solved by storing energy collected during sunny hours. But again, this costs money.

Eddie Luse, owner of Huffman Inc., one of several heating firms in the Miami Valley which installs solar heating systems, admitted the initial installation of a supplementary solar system costs money. But he added the long range monetary benefits outweigh the original cost and emphasized the main consideration in solar heating should be the "conservation of energy."

Luse, who in 1975 installed a solar heating system at his place of business, said, "I've been concerned for a long time about our need to conserve fuel. We are using our present energy in three ways — heating, air conditioning and water heating, transportation, and agricultural and industrial operations."

"I believe solar energy can help with the fuel crunch, first of all, by being used for domestic, industrial and public building heating."

Emphasizing the practical use of solar units as a way to conserve fuel, Luse said a primary or auxiliary heating system still is necessary during prolonged spells of cloudy weather.

He maintained, however, a solar system can assume 50 to 75 percent of a building's heating load.

Explaining his ideas on long range savings, Luse said, "The homeowner should look at the installation of solar heating on a 20-year basis. Look at it this way. If you finance your house when you build or buy, you could include installation of solar

heating as a part of the first ten years' payments. After ten years the unit will be paid for. From then on, you've got free heating, fuelwise."

He added, "With a solar system such as ours (a liquid, flat-plate collector type) there are no operation costs after the initial expense. The sunlight is free and heat is circulated by stored water. The only energy used to run the system comes from two fractional horsepower motors that operate the pumps."

Luse's first solar installation, that at his place of business, involved 20 free-standing, double-glazed collector plates and a manifold system at his building's south side, and the heat exchanger and storage area inside. It has been used to heat the building to 68 degrees for sunless periods as long as 54 hours.

The basic idea used at Huffman's is the collection of heat from the sun with flat-plate collectors. The heat is transferred to a high volume of stored water which then is circulated for heating purposes.

Luse advised the free-standing flat-plate collector system could easily be installed in a roof or as a modular unit on the ground. Located on the south side of the building, the 20 stationary panels are made of two layers of glass over a heat-conducting metal plate which absorbs the sun's heat. Annealed to the plates are

metal tubes through which an anti-freeze solution carries the heat to where it can be converted for use.

The heat is converted by being transferred from the metal tubes through a heat exchanger to a high volume of water storage which, in Luse's installation, is 1,086 gallons of water stored in multiple tanks. Once the sun's heat is transferred to the water storage area, the heated water is then recirculated through the home's heating system.

Solar collector plates behind Huffman's business on East Plum Street, St. Paris, supply partial heating for his office.

(Balmut photo)

"The plate collectors are installed according to certain proper angles to the sun, depending on the site location," Luse said. "On our modular units, we have adjustable collector plates that can be tilted to the proper altitude angle. With these we can go with the sun from summer to winter. Water temperatures can be increased by tracking the proper altitude angle."

He also noted the water storage could be one tank, a cistern, a cemented water tank or even a pond or swimming pool.

Talking about changes in solar heating aspects during the past five years, Luse said, "Since May 1975, we have installed solar systems for areas totaling close to 3,000 square feet. This includes one large commercial installation."

He added that even though today's costs for solar heating installations are

higher than they were five years ago because of inflation and rising construction prices, the per-

centage of basic solar costs, compared to solar heating input, remain about the same because of higher costs of electricity in 1979.

"I would even say it (solar heat) makes more sense today because now houses are better insulated, there's less glass to the north, multiple layers of glass are being used throughout, people are more aware of energy-saving insulation factors and more energy-efficient architecture is being demanded," he said.

"Architects, as well as consumers, are more aware of the necessity to match building construction with the solar heat aspect and to get the heat loss down when they look for ways to save and conserve energy. They're learning from experience and from things they read," Luse said. "Also, solar heating carried with it many tax deductible incentives; these will remain available until 1985."

Luse said he sees a wide-open future for solar energy in the areas of heating, electric power and crop drying.

Pointing out there are many types of solar collecting systems, Luse said he believes the flat-plate, liquid collector system is best for this area. He said there's also an air-type collector system which takes hot air directly from collectors and stores it in rock or pebble beds or cast iron pellets. This system, though, has only half as much storage capacity as the liquid type.

Also available today, ac-

cording to Luse, are semi-concentrated collectors and compound, parabolic collectors. Specialized collectors which increase collective temperatures now are being studied in laboratory test situations.

Currently, Luse said he leans heavily toward domestic water heating with solar energy in this area. "With properly constructed homes, this has great monetary recovery value — much more so than five years ago because of increased electricity costs," he explained.

"We also need to think seriously about the saving of energy by incorporating solar water heating on the levels of nursing homes, schools and other public facilities," he contended.

A confirmed believer that solar heating is bringing about definite changes in building construction, Luse admonished, "I think we'll continue to 'think south' when we construct solar gardens and solar patios and anything that will benefit from absorbing heat. These will be passive types of solar systems, using both reflective and absorbent materials."

Luse said the theory of "thinking south" is not new — the Pueblo Indians used it many years ago when they built their homes facing south in sides of cliffs with 40-inch thick walls. The heat retained in the rocks warmed their dwellings at night when the desert turned cold.

"Many such passive solar systems can be used today to

supplement collective systems," Luse affirmed. "They can be anything from all-glass greenhouses to what is called a 'trombe' wall. A trombe wall is merely a black absorbent floor or wall behind a glazed heat-collecting surface such as any large expanse of glass facing south."

"Air is then moved over the wall by natural convection or a small fan. To retain the heat, the glass should be covered at night by any of several methods of insulation," he explained. "To gain the most advantage from this simple solar system, there should be an overhang on the south exposure to eliminate excess heat in the summer. The overhang should be equal to the latitude of the basic building times the height divided by 50."

The solar-minded businessman said that one of the most revealing and interesting facts he has discovered during his study of solar energy is a statement made 2,379 years ago.

"Socrates said in 400 B.C., 'In houses with a south aspect, the sun's rays penetrate into the porches in the winter. But in the summer the path of the sun is right over our heads and above the roof, so that there is shade.' Even that far back in our past, people were being given a formula for a simple passive solar system," Luse asserted.

This solar testing facility, owned by the Department of Energy and located on the Georgia Institute of Technology campus, utilizes 550 mirrors to produce temperatures up to 3,500 degrees Fahrenheit.

Is there really

by THOMAS R. ZECHMAN

Anyone who has attempted to buy gasoline recently on a Friday or Saturday afternoon knows that something is not quite like it used to be. Anyone who has paid a utility bill for the last five years knows that something is amiss.

Anyone who reads a newspaper or news magazine knows the government and the oil companies are continually saying that there is an energy crisis. Why then is it necessary even to discuss whether or not there is an energy crisis? The obvious

"The U.S. was once the world leader in energy production. . . We no longer are in a position where we can even produce as much energy as we need ourselves, much less export any."

choices are: (1) there is indeed an energy crisis in the U.S., or (2) the entire thing is a hoax, perpetuated by those who stand to make a profit from the general acceptance of the idea of an energy crisis.

An energy crisis must be described as a situation in which the total energy demand is far greater than the available energy supply. The major sources of energy in the U.S. today are crude oil, natural gas, coal, hydro-electrical power and nuclear power.

Since World War II, the energy demand, and thereby consumption, has increased by approximately four percent annually. In 1974 and 1975, the years immediately following the OPEC oil embargo, there was in fact a drop in energy consumption. However, in 1975 and 1976 there was again an annual increase of about five percent.

The U.S. was once the world leader in energy production (natural gas, crude oil, hydro-electric power, etc.). We no longer are in a position where we can even produce as much energy as we need ourselves, much less export any. As a nation, we have already reached our peak in production of natural gas, and crude oil products. Since crude oil and natural gas account for over 75 percent of the energy we use, the obvious question becomes: how can we continue to increase our energy consumption if our two major sources of energy have peaked in production and are now actually decreasing?

Many possible answers to that question have been suggested as alternate energy sources, but few of them appear to hold plausible solutions for the near future of this country. Let us examine these energy sources.

NUCLEAR

One suggestion of an energy source to replace some of the natural gas and oil supplies has been nuclear energy. In the light of the recent Three Mile Island incident, this is hardly a popular position to take. Furthermore, it has been said that the existing known source of nuclear fuel, uranium, will be depleted about the same time we run out of oil. The disposal of radioactive wastes is another problem that has not been solved. The further development of the breeder-reactor type of nuclear power plant would help the limited fuel supply situation, but this type of reactor has even more dangerous environmental aspects.

COAL

The burning of coal to heat steam turbines and thus produce electricity is one common method of energy production. It is a fact that the coal deposits in this country are of such proportions that experts predict we can rely on coal utilization for perhaps a couple hundred more years.

Roughly one-third of all the coal in the world is in the United States. However there are vital ecological considerations involved with coal. "Black Lung" and other deep mine related

"One suggestion of an energy source... has been nuclear energy. . . (but) the existing known source of nuclear fuel, uranium, will be depleted about the same time we run out of oil."

health problems will limit the expansion of deep coal mining. Strip mining has its own ecological problems. Areas which have been strip-mined have special erosional problems due to the rainwater runoff, and also land reclamation for beauty and for agricultural use is a subject which has not yet been resolved.

All of these factors, plus the high pollution effects of burning high sulfur content coal, present situations which must be dealt with before a major emphasis is made toward an increase in coal energy production. One other future implication is that thus far we have mined the low sulfur, easy-to-reach coal, leaving the high sulfur, difficult-to-mine coal for our children.

OTHER ALTERNATIVES

There are many areas which are being investigated for application to energy supply problems. The most common and visible on today's market is solar energy. Other possible sources are large scale wind power, coal gasification, which is turning coal underground into gas, and ocean thermal energy conservation.

It has been suggested by some that all of our available resources be focused on developing any or all of these technologies, and then implementing them as soon as possible. The only problem here is that even if we had the

technologies available today for these types of electric power generation, it would take one or two or more decades before such a source could make a significant contribution to our overall energy picture.

Look at nuclear energy as an example of this lead time situation: We have had the technology to produce electricity from nuclear power for over 30 years, and for much of that 30 years there has been a great push to use this energy source, and yet nuclear energy today accounts for only 10 percent of all of our electricity and only four percent of the total energy consumed in this country.

OIL

It has been suggested that a solution to our energy problem would be to increase our oil imports, especially from the OPEC (Organization of Petroleum Exporting Countries) nations. This is a temporary solution at best.

The availability of this oil is really not in question. While the U.S. has reached its peak in crude oil production, it is estimated that the world will not reach its peak of oil production until around the turn of the next century. The problem is that this increase makes us dependent on an unstable area of

YES!

the world, and also worsens our economic problems, by giving us an even more unfavorable balance of trade.

As more oil is imported at inflated prices, our inflation problem increases, and the value of the dollar drops on world markets. We become subject to the whims of rulers of these nations, both in the price we pay and the quantity available to us, setting ourselves up for an even greater disaster than the 1973 oil embargo.

THE ENERGY CRISIS as we know it was brought into focus by the embargo, or actually by our subtle increased usage of imported oil. To suggest that the energy situation can be solved by increasing imports is in effect suggesting to solve the problem by increasing the problem.

It has already been stated that the production of oil in the U.S. has already reached its peak. This is evident from the study of past production of natural gas and crude oil. When we study energy from different sources, it is easier to compare net energy results than it is to compare quantities of different materials. Therefore, even though electricity is measured in kilowatt hours, and even though natural gas is measured in cubic feet, we shall refer to each of them as the energy equivalent of a barrel of oil. A common unit of measure for energy is the energy equivalent of one million barrels of oil

Thomas R. Zechman, 26, is an instructor of civil engineering technology at Edison State Community College. A graduate of Southern Methodist University, Dallas, Tex., he worked as an engineer before coming to Piqua two years ago. At Edison State, he teaches a course in energy conservation and alternatives.

per day (MBPD), and this is the expression which will be used for all forms of energy for the remainder of this article.

In 1950, the U.S. was producing natural gas at the rate of 3.0 MBPD. In 1960, production was up to the energy equivalent of 6.0 MBPD. In 1970 it was 10.5, and in 1973 natural gas production reached a peak of 11.0 MBPD (ironically the same year as the OPEC embargo). In 1977 we produced 10.0 MBPD. Therefore, while natural gas reserves still exist in abundance,

"Even if we had the technologies available today for these (alternative) types of electric power generation, it would take one or two or more decades before such a source could make a significant contribution to our overall energy picture."

we have reached our maximum production level of natural gas, and we can no longer keep pace with the increased need for energy.

THE U.S. CAPACITY for crude oil production is somewhat similar to the natural gas situation. The production of oil taken from deposits in the continental United States for the years 1950, 1960 and 1970 respectively were about 6.5, 8.0 and 10.5 MBPD. By 1977, the amount of oil produced from the U.S. was down to 9.0 MBPD. It should be noted that by 1977 we were also receiving an additional 0.3 MBPD of oil from the Alaskan pipeline. When the Alaskan pipeline is operating at 100 percent capacity, it will be able to supply us with about 1.5 MBPD of oil.

We have in the past, and will continue to discover new locations and methods for drilling oil. One example of this is the increase in off-shore drilling which has occurred in recent years. One important fact which this points up, however, is the oil we have obtained thus far has been the easiest to reach. Therefore we must use more money and energy than in the past to get the same energy result. The net value of the new energy is less than the net value of the energy of oil from the past.

A barrel of oil which has been transported through the

"The energy crisis as we know it was brought into focus. . . by our subtle increased usage of imported oil. To suggest that the energy situation can be solved by increasing imports is in effect suggesting to solve the problem by increasing the problem."

Alaskan pipeline or a barrel of oil taken from an off-shore drilling platform, from a deposit hundreds of feet below the ocean floor, does not have the net energy of a barrel of oil taken from the oil fields of Oklahoma. If the point is reached where it takes more than one barrel of oil to secure one barrel of oil, there will be no point in securing it. Not only is our production dwindling, but the net worth of the product we receive is decreasing.

One way to gauge the seriousness of the problem is to project our energy supply, and our energy requirements to a given year in the future. We already know we may have to wait in line at the gas pump to pay 75 cents for a gallon of gas, but we also know if we paid our heating bill each month last winter that apparently the energy was available, and we could indeed stay warm.

LET US LOOK at the year 2000, which is not too far off. If we projected the annual energy consumption growth rate of four percent to the current 37.8 MBPD energy consumption, we find that 92 MBPD will be required by 2000. However, it is safe to assume that we will not continue at an annual increase of four percent, due to government regulations on energy efficient construction, better gas mileage for automobiles and increased efficiency of energy use in industry. A more probable growth rate for the future can be shown to be 2.6 percent, which would leave us requiring about 70 MBPD of energy in the year 2000. The question is: where will the 70 MBPD come from?

To answer this question, we must make our best guess as to the availability of present energy sources, as well as any new

"The oil we have obtained thus far has been the easiest to reach. Therefore we must use more money and energy than in the past to get the same energy result. . . If the point is reached where it takes more than one barrel of oil to secure one barrel of oil, there will be no point in securing it."

energy source which may contribute significantly in the year 2000. The types of energy prevalent today have been listed above, and in addition to these, it is possible that solar energy and perhaps oil shale will contribute reasonable amounts of energy to this country by 2000.

We currently import about seven MBPD of crude oil. It is likely the government will place a ceiling on oil imports to protect the country from the effect of another embargo, or other world situation which would curtail oil imports. An

an energy crisis?

assumption of nine MBPD would be a good guess for this figure, since that is the highest we have received. Domestic oil production is currently about 10.1 MBPD, but since we have already reached our peak of production, we would certainly be doing well to produce 8.0 MBPD. If new reserves were discovered in Alaska and a second pipeline constructed we could conceivably obtain 3.0 MBPD from Alaska.

SIMILAR TO THE domestic oil situation, a liberal estimate for the production of natural gas would be 8.0 MBPD energy equivalent units.

Coal is admittedly a somewhat untapped source of energy in this country. It is conceivable that with the addition of a quarter of a million miners and many new power plants, the current coal production of 6.5 MBPD could be increased 130 percent to roughly 16 MBPD. Though this would be difficult to attain, it is possible.

The hydro-electric power generation in the U.S. is currently at a level of about 1.4 MBPD. While there is no reason this amount should be reduced, it probably will not increase much, and we would be safe to assume that in the year 2000 we will generate 2.0 MBPD of hydro-electric power.

It is likely that solar energy will make a significant contribution to the energy available in 2000, but how much? If 200 solar power electricity generation plants each with a capacity of 1000 megawatts were fully operating, solar energy could provide five MBPD. Oil shale is another unknown quantity which may be able to contribute by the year 2000. If any contribution is made, it will be small, perhaps on the order of one MBPD.

"Coal is admittedly a somewhat untapped source of energy in this country. It is conceivable that with the addition of a quarter of a million miners and many new power plants, the current coal production... could be increased 130 percent..."

The last energy source to predict is nuclear energy. Nuclear energy currently accounts for about 1.5 MBPD of energy equivalent units. Is it conceivable that the number of nuclear power plants in operation by the year 2000 will double or triple? If four times as many power plants were in operation in 2000 as there are today, nuclear energy would provide a total of about 6.0 MBPD energy equivalent units.

The total amount of energy we have been able to supply by the year 2000 using best cases for each entity is 58.0 MBPD. This leaves us 12.0 MBPD short of a conservative estimate requirement of 70 MBPD, or 17 percent shy of all our energy needs. And what if we do have enough for 2000, what about 2001? This 17 percent begins to represent an energy crisis.

Are we doomed to returning to a stone age society? I think not. The question we are trying to answer is, "Is there an energy crisis in the U.S.?", not, "Is the U.S. doomed?" One place which has not been mentioned to look for energy is in your own home. The cheapest source of oil may be found by "drilling" in the attic — by insulating — and other forms of conserving energy. It stands to reason that an adage can be just as true when slightly reworded, and that is, "A barrel of oil conserved is worth a barrel of oil produced," and in some cases it is probably cheaper, especially when it amounts only to altering one's lifestyle slightly.

The other side of the question is this: Is the energy crisis a hoax? Much of the material I have used here is material which I presented in an Energy Conservation and Alternatives course offered in the winter quarter. I certainly did not measure the amount of oil that the U.S. received on any given day, and so figures that I used are only what I have read.

However, I have no reason to believe the information was deliberately falsified. It was not information published by oil companies.

If the oil crisis is indeed a hoax, it is a tremendous lie perpetrated knowingly by thousands in the oil industry, related energy industries and the government for some monetary gain. I guess I just have enough faith in the American system to believe this did not happen.

Furthermore, if it has happened, we have on our hands a problem of a magnitude much greater than the energy crisis.

NO!

By ANDREW J. WINNICK

Many legitimate crises face the people of this country and the world, but a "real" shortage of energy is not one of them. The so-called energy crisis is a fabrication and a manipulation by large energy corporations in the pursuit of higher profits and tighter control over the market and our lives, and by oil-producing nations who now are attempting — with a good deal of legitimacy and justice — to correct for the virtual theft of their oil over the last half a century.

These comments may seem to be harsh and polemic. After all, hasn't the President of the United States declared the energy crisis to be real? Indeed he has, and his behavior, in fact, is part of the problem and proof of what I am arguing.

Andrew J. Winnick, 39, is an associate professor of political economy at Antioch College, Yellow Springs. A 1961 graduate of the University of California at Berkeley, he received his master's degree and doctorate from the University of Wisconsin, Madison, in 1967 and 1971, respectively. (Photo courtesy of the Antioch Record)

Let me try to document some of the relevant facts and analyses, looking briefly at each of the major sources of energy. Then we can come back to re-examine my conclusion, and some proposed solutions to the real energy-related problem that faces us.

OIL

There is currently no shortage of available oil. Even before the shutdown of the Iranian fields (which at their peak provided only five percent of the oil consumed in the U.S.), the Middle Eastern countries are producing at only 40 percent of their capacity. That is, they could produce two and a half

"President Carter is proposing to deregulate the price of oil produced in the U.S. . . . What the President is admitting by his action is that the blackmail by the oil corporations has worked. He has agreed to pay the ransom."

times as much per day if they chose. When the Iranian shutdown occurred, the others said that they increased their production to make up for at least half of the Iranian oil; and the CIA has announced that in January and February, world wide production of oil actually increased. There was, and is, no shortage.

President Carter is proposing to deregulate the price of oil produced in the U.S. and has publicly stated he hopes this will accomplish two things: higher prices so consumers will buy less, and production of more domestic oil. Economists agree the first expectation will be met half way, prices (and oil company profits) will go up, but consumption is unlikely to drop much. But far more important and revealing is the expectation of more domestic oil production.

Currently, only the price of oil which is being pumped from old wells — those in operation before 1973 — is being regulated to keep it at about \$6 per barrel, while oil from newly discovered wells is near or at the world price of about \$13 to \$14 per barrel. What the President is admitting by his action is that the blackmail by the oil corporations has worked.

He has agreed to pay the ransom. Now, the oil companies,

"Nuclear power is a disaster. . . (and) extraordinarily expensive. Electricity from a new nuclear plant is equivalent in cost to using oil priced over \$100 per barrel, which is more than six times higher than the latest world price of \$15 per barrel."

at the deregulated higher price for old oil, will increase production. Their costs of producing from these old wells will not have changed a penny, so the result will simply be a windfall of higher profits, exactly what the oil companies have

been waiting for and why they have artificially been holding back production.

Even Carter acknowledges this will happen and has been forced to give lip service to the need for a special windfall profits tax. However, it is broadly agreed there is little likelihood of this tax ever actually being implemented, and he knows it.

Moreover, with the expanding oil production from Alaska, England, Norway, Mexico, China, and Vietnam, to say nothing of Venezuela, Nigeria and Angola, the likelihood of any real shortage over the next half century is slight indeed. As a footnote, the largest oil producing country in the world is the USSR, which supplies Eastern Europe, and the second largest is the U.S. About half of our oil produced in Alaska is sold to Japan, which is what the oil companies said would not

"The . . . energy crisis is a fabrication and a manipulation by large energy corporations in the pursuit of higher profits and tighter control over the markets and our lives."

happen when they fought for the right to build the Alaskan pipeline.

NATURAL GAS

Two winters ago, people in Ohio and New England died from the cold because of a so-called natural gas shortage in the U.S. The price of natural gas was regulated at that time by the government to prevent the gas companies (most of which are owned by or linked to the oil companies) from making exorbitant profits at the expense of the American people. Again their blackmail worked. The President and Congress agreed to deregulate the price of natural gas, and lo and behold the actual amount of gas available for production and sale was suddenly discovered to be two to five times as much as the corporations had previously admitted. We suddenly have a glut of natural gas and all talk of a shortage has ended.

COAL

We are the largest coal producing country in the world. No one, not even the coal companies (many of the biggest of which are owned by the oil companies), even pretends that there is now, or will be in the next century or more, any shortage of coal. There are humanly and environmentally safe ways to mine it and to burn it, if we are willing to force the corporations to do it that way. Moreover it can be liquified and made into gasoline (that's how Germany fueled its tanks in World War II — it had little or no oil), and coal can even be gasified and burned like natural gas.

SOLAR ENERGY

Even though the President's office tried to suppress it, a government study a year ago revealed that for about \$1 billion dollars a year for a five-year development effort, this country could meet 20 to 25 percent of its energy needs from solar power, mostly for home heating. By comparison, our defense budget is currently running at more than \$100 billion a year.

And this does not even begin to tap the potential of solar power to directly produce electricity (which is how all our space vehicles get their electricity).

NUCLEAR

Nuclear power is a disaster. We do not need it, and we should not want it. This country currently has the electrical generating capacity to produce 32 percent more electricity than we use on the peak load day of the year. Nuclear power produced only about 13 percent of our electricity. Hence, we could eliminate it and survive nicely.

On the other hand, if we continue to operate and build nuclear power plants, the dangers from their operation, such as at Harrisburg, and from the disposal of their radioactive wastes, for which there is no known or envisioned safe han-

"... for about \$1 billion a year for a five-year development effort, this country could meet 20 to 25 percent of its energy needs from solar power..."

dling, are liable to end the survival of a great many of us making the energy or any other crisis irrelevant.

Moreover, nuclear-produced electricity is extraordinarily expensive. Electricity from a new nuclear plant is equivalent in cost to using oil priced over \$100 per barrel, which is more than six times higher than the latest world price of \$15 per barrel. But the utility companies are guaranteed they can set whatever rates they need to provide, so it is we who end up paying for this insanity.

HYDROELECTRIC

Far more electricity can be produced from the energy in our moving rivers by more efficiently using dams, especially the myriad of small dams, which already exist. These small dams represent an almost untapped source of electricity, especially for many of our smaller communities.

Energy for heating or electricity can be provided safely and more cheaply, after initial development costs, from wind, geothermal sources, tides, chemical and waste burning. Many other countries are way ahead of us in the development and use of many of these alternative energy sources.

Alcohol can be extracted from crops, such as alfalfa.

Continued on page 8

The Piqua Municipal power plant has grown a great deal since it was constructed in 1933 and had no customers whatsoever. Since that time, it has undergone several expansions to its

present appearance (at right). If district heating is implemented with it, more expansions are likely, and it will continue to be an integral part of the lives of Piqua's citizens.

Piqua Municipal Power Plant holds value for city's future

District heating probably means as much to the future of the power plant as the power plant means to the future of the city.

And just what do they mean? According to Power Systems Director Elmo Hastings, district heating and the power plant may help draw industry to Piqua.

"If we have a power plant which can provide high process steam, it will help draw industry here and put money back into the community," he said. "And district heating gives us the opportunity to operate more

efficiently."

Hastings explained that after steam is sent out to industry and its condensate returned to the plant it has to be cooled before being released into either the river or the air. "And we lose money doing that," he said.

With district heating, the condensate return will be used to heat homes and businesses, thereby decreasing the amount it has to be cooled before being released into the atmosphere.

"District heating could stabilize the cost of electrical energy here and conceivable

have some reduction effect," Hastings said.

Hastings added that within the next year city officials must begin making some long-range plans for the power plant to handle ad-

ditional growth. "We're going to have to either buy power from somewhere else or install some extra equipment," he explained.

And with the installation of new equipment, the ad-

vantages of a municipally-owned plant become more apparent.

"Not only does local control make the rate structure more responsive, but the real crux of it is what the effect of

municipal ownership is on capital expansion. We can borrow at interest rates of six or six and a half percent, while investor-owned facilities must borrow at 11 or 12 percent," he said.

Suds savers allow water to be reused

A considerable amount of energy can be saved in the laundry by conserving hot water and using appliances less and more efficiently.

Clothes should be washed

in warm and cold water and rinsed in cold unless hot water is an absolute necessity. Washers should be full, unless they have small-load attachments or

available water levels, but not overloaded.

Suds saver attachments allow one tubful of hot water to be reused several times. If one doesn't have a suds saver, instructions on the detergent box should be followed. Oversudsing makes a washing machine work harder and use more energy.

Clothes dryers should be filled but not overloaded, and lint screens should be cleaned after each load.

Outside exhausts for dryers should be checked regularly, too. A clogged exhaust lengthens the drying time and increases the amount of energy used.

Drying loads should be separated into heavy and lightweight items. Also, if doing more than one load, the lightweight load should be done last. They may dry in the dryer after the power is turned off with heat retained by the machine from earlier loads.

Clothes which will be ironed should be removed from the dryer while still damp, saving energy and dampening later on. Often, if wrinkled clothing is hung in the bathroom while a family member is showering or bathing, the wrinkles will be steamed out and ironing won't be necessary.

Hydro power not feasible here

Hydroelectric power from Piqua's low-head dam on the Great Miami River is not feasible, according to Val Maxim, project engineer for R.W. Beck and Associates.

The \$77,500 Department of Energy-funded study begun last fall determined that such a use of the dam would be uneconomical for several reasons.

"It's a complex of several problems," Maxim said. "First of all, the existing dam and reservoir does not

have pondage, that is, storage. We initially thought we could create pondage, but we can't modify the existing dam to do it. According to Department of Energy standards, the dam would have to be raised at least three feet, and this alone wouldn't solve the problem."

Maxim added that hydroelectric power produced on the existing dam would not be dependable nor would it be the prime energy source for the city.

"It can replace some coal, but not enough to make it a worthwhile undertaking," he explained.

The second major problem with the dam, according to Maxim, is its low, eight-foot head. He estimated that adjusting such a low-head dam to generate electricity would cost about \$7,000 per kilowatt hour. This is approximately \$5,800 more than the norm.

The third problem with the dam is its great variation in flow, Maxim said. "The flow is not constant. Sometimes

the water is still, sometimes it is not," he explained.

The dam currently is used for cooling purposes. Hot water generated in the production of electricity at the municipal power plant is emitted on its north side, runs through the dam and comes out its south side cooler.

Piqua's power system was one of 50 nationwide to obtain the DOE grant to study the feasibility of hydroelectric power.

Zechman

(Continued from page 6)

without the loss of the protein needed for animal feed, and can then be used in place of gasoline to run the engines in our cars or to turn turbines to produce electricity.

If indeed there is plenty of energy available now and in the future, why do we keep hearing about an energy crisis? The answer is because there is so much energy available.

Does that seem crazy? It's no crazier than our economic system where corporations run by a few for the profit of a few, control the lives and futures of the many. An abundance of energy means the price of energy would fall, energy would be relatively cheap, hence not very profitable for the large corporations. To maintain their profits and their control over our lives, they must create artificial shortages by withholding oil or natural gas from the market, by blocking the development of alternative energy sources — except the very expensive and dangerous nuclear source, and by pressuring the government to let them charge the highest prices possible and to keep their costs down both by avoiding safety and environmental regulation and through a complex of special tax breaks.

An important and very relevant example of the latter is the "foreign tax credit." When one hears the oil producing nations (OPEC) are charging \$14 per barrel for their oil, what one is not told is that on the average \$7 to \$9 of that is in the form of taxes those governments levy on the oil taken from their nations, in order to provide funds for their economic

development.

The U.S. oil corporations pass those taxes on to us in the form of higher prices. But, in fact, they never really pay them. For the oil companies are allowed to deduct from the taxes they would otherwise pay to the U.S., every penny of taxes they pay a foreign government. That is, they get the foreign taxes back as a U.S. tax credit.

So we, the U.S. consumers and taxpayers, really are forced to pay twice — once for the high price of oil and gas and a second time in taxes to make up for those not paid by the oil corporations.

How do we end the energy crisis? We do so by ending the control over energy exercised by the energy corporations. We get their hands off our throats and out of our pockets. We do this by recognizing that much of our available oil, gas, and coal is on federally-owned land and under off-shore waters.

We recognize that the U.S. is the only oil producing country in the world without a publicly-owned, federally-operated and managed, oil-producing company. That is, we use our governments — local, state and federal — to produce oil, gas, coal, and electricity and then distribute and sell it as a vital public service, at prices that cover costs, but do not produce profits for a few wealthy, elite individuals.

A bill to create just such a Federal Oil Corporation, introduced by Rep. Dellums of California, has been sitting in Congress, virtually ignored, for three years. Perhaps now we can begin to move.

Fireplaces lose heat

Fireplaces, while beautiful and enjoyable, can often be the culprits when it comes to a loss of heat.

To conserve energy with a fireplace, the damper should be kept closed unless there is a fire going. An open damper in a 48-inch square fireplace can let up to eight percent of a home's heat out the chimney.

Using a fireplace also can cause heat loss. However, there are certain measures which can be followed while the fireplace is in use to lessen the loss:

— Lower the thermostat setting to 50-55 degrees. Some warmed air still will be lost, but the furnace won't have to use as much fuel to heat the rest of the house to these temperatures as it would to raise the heat to 65 or 70 degrees.

— Close all doors and warm air ducts entering the

room with the fireplace and open a window near the fireplace about 1/2 to one inch. Air needed by the fire will be provided through the open window, and the amount of heated air drawn from the rest of the house will be reduced.

— If the fireplace is a simple masonry one, consider installing a glass front or a glass screen. This will cut down on the loss of warmed air through the flue.

Maintenance improves mileage

Altogether, our private automobiles consume some 70 billion gallons of gasoline each year.

That's about 4.5 million barrels a day or about two-thirds of the amount of petroleum currently being imported into the United States.

There are more than 100 million cars registered in this country. A typical car, with an average fuel economy of less than 15 miles per gallon, travels about 10,000 miles each year and uses well over 650 gallons of gasoline.

So, it's easy to see that the

importance of individual gasoline savings cannot be overemphasized. If, for example, the fuel used by the average car were reduced just 15 percent through fewer trips, better driving practices and better maintenance, the nation's use of petroleum would fall by

nearly two-thirds of a million barrels per day — about 3.5 percent of demand.

The driving technique of the person behind the wheel is the most important single element in determining the fuel economy of any car. A careful driver may get 20

percent more miles per gallon than the average driver and 50 percent more than a wasteful one.

Speed is an important factor in gasoline conservation. Most automobiles get about 20 percent more miles per gallon in the highway at 55 mph than they do at 70 mph.

Smooth and moderate acceleration and then just enough pressure on the accelerator to maintain speed also saves gasoline. A driver should anticipate speed changes, thereby minimizing braking.

A motor idling for more than a minute uses more gasoline than turning the car off and restarting.

Good car maintenance and a wise selection of accessories also can mean fuel economy and dollars saved.

A car should be tuned as often as its manufacturer recommends. A poorly tuned car will use as much as three to nine percent more gasoline than a well-tuned one. The tune-up will pay for itself in gasoline savings and car reliability.

Clogged filters waste gasoline, as do underinflated tires. Car owners can lose

about two percent in fuel economy for every pound of pressure under the recommended pounds per square inch.

Radial tires, which are more energy efficient, can mean from three to four percent improvement in city and highway mileage. Seven percent on the highway and 10 percent at 55 mph after the tires are warmed up for 20 minutes. Radial tires also last longer.

The lighter the car, the less gas it uses. An extra 100 pounds will decrease fuel economy one percent on the average car and 1.4 percent on a small car. Therefore, car accessories should be chosen wisely.

Items like air-conditioning, automatic transmission and power steering require considerable energy to run. Other equipment, such as power brakes, electric windows, seats and radio antennas, require less energy but still add to the vehicle weight, thereby reducing fuel economy.

An air-conditioner by itself reduces fuel economy from 10 percent on the highway to almost 20 percent around town.

Insulation decreases heat loss

No matter how a home is heated, a few hundred dollars investment in insulation can reduce the load on heating and cooling equipment by as much as 20 to 30 percent.

And benefits from such an investment — lower utility costs — will continue for years.

To begin with, a homemaker should check the amount of insulation already in his home and consult with a reputable dealer or local building inspector to see how much more he needs.

One should find out what R-value the home needs. R-values are insulation efficiency ratings and stand for resistance to winter heat loss or summer heat gain. The higher the R-number, the more effective the insulating capability.

R-numbers should appear on packages of all insulation materials. If the package does not contain such information, consumers should ask the salesperson to write

the R-value on the receipt for future references.

Most homes have little or no insulation in attics. If insulation were added to the 15 million single-family homes in need, an eight percent savings per day could be realized.

It is difficult to judge the R-value of old insulation, but if a homeowner has less than six inches currently in his attic, he probably needs to add more.

Investment costs could range from \$80 to \$600, but savings could range from five percent to as much as 30 percent if one currently has no insulation.

Insulating exterior walls can save homeowner's 16 to 20 percent in their utility costs, even though installation costs for this type are higher and require the services of a contractor.

Insulating floors over unheated spaces such as crawl spaces and garages can save about eight percent and cost anywhere from \$200

to \$400.

Drafts around windows and doors can cause higher heating bills in winter and higher cooling bills in summer.

If every gas-heated home in the nation were properly caulked and weatherstripped, enough extra natural gas would be saved to heat an additional four million homes.

Homeowners can test windows and doors for air-tightness by moving a lighted candle around frames and sashes. If the flame dances, caulking and/or weatherstripping is needed.

Also, if a quarter slides underneath a door easily, weatherstripping would be a wise addition.

The addition of storm windows can also reduce heating and cooling costs by as much as 15 percent a year.

Combination screen and storm windows are the most convenient and energy efficient because they can be opened easily when there is no need to run heating or cooling equipment. They cost about \$30 each.

Alternatives range from single-pane storm windows — about \$10 each — which have to be removed to admit outside air, to taping clear plastic film tightly to the inside of window frames — about \$10 total for the average home.

An editorial:

Study beneficial

MUCH HAS BEEN said in various places concerning the federal grant obtained by Piqua from the Department of Energy to study what, for America, is a revolutionary energy concept. Little has been said, however, in one place.

The Daily Call hopes this special section will answer citizens' questions about this unique study and what it can mean to the city in coming years. It can mean a savings in individual and business heating costs. It can mean more efficient use of the power plant.

But, it also can mean (should the project be completed) that Piqua will have played a key role in developing a process that could be of nationwide importance in solving the nation's energy crisis, as outlined by President Carter in his recent energy address.

PIQUA WAS A pioneer in nuclear energy, a thought on everyone's minds during the recent Three Mile Island nuclear crisis. Now the city again can be a power pioneer.

This special section hopes to explain the program and more. It hopes as well, through other articles, to again highlight the more immediate and day-to-day steps we all can take to conserve energy. There is no "one" answer to the problem.

President Carter said he was going to "give it to you straight" about energy. He did. It's a problem that won't go away and the impact of the energy crisis will be felt by us all. At least, here in Piqua, we are part of a pioneer effort to solve the problem.

City government and citizens have cause to take pride in that and we join in explaining, and saluting, the project.

The generation of electricity from boiler to bulb is similar to the diagram above.

Coal is abundant, unwieldy energy source, needs conversion to work

Coal is one of the most abundant sources of energy in the United States. Unfortunately, it is also one of the most unwieldy.

Thus, early power plant designers had to add several intermediate steps to the energy conversion process so that coal would generate electricity.

The first piece of equipment they designed to do this was the boiler, which can be thought of as a tea kettle and fire. The boiler converts the

coal into energy in a transportable form — high-pressure, high-temperature steam — much the same way water boiled inside a tea kettle turns to steam.

From the boiler, the steam travels to the turbine, which is similar to a windmill. The energy from the steam goes into the turbine, hitting against its fan blades in a manner which causes them to rotate. This rotation converts the steam into mechanical energy or

torque.

In actuality, turbines have many rows of blades. For example, Piqua's largest turbine has 17 rows or stages.

After leaving the turbine, the mechanical energy travels to the generator. Generators contain small bar magnets, which rotate from the torque supplied by the turbine, inside a stationary coil of wire. As the magnetic field issuing from the ends of the magnet moves across the turns of wire in the

stationary coil, an electric current is induced in the wire.

By winding a number of turns of wire into a ring or doughnut, the current induced in each turn is added to the current induced in the other turns, producing one powerful electric current.

The conversion is now complete. Coal has been converted to electricity which can be easily and efficiently transported and utilized wherever it's needed.

Georgia Tech's service is broad

Currently involved in the District Heating and Cooling Project in Piqua are several Georgia Institute of Technology engineers.

They are part of Tech's energy experiment station which employs about 800 people — sometimes called the largest non-profit corps of engineers.

The engineers working in Piqua are determining what needs to be done to the Piqua power plant, its distribution system and residents' homes to convert to district heat. They also will develop cost estimates for the conversions.

But Georgia Tech's services to Georgia and the nation extend far beyond the project in Piqua. In addition to providing outstanding educational programs in engineering, science, management and architecture, Georgia Tech provides technical assistance to companies and cities.

For example, one Georgia company wanted to find a supplier of lawnmower blades closer than its existing vendor in Michigan. When a search for one proved fruitless, Tech engineers explored the possibility of the company manufacturing its own blades.

The study indicated that the company could save money if it did so, and it began manufacturing the blades along with other lawn-

mower parts.

Georgia Tech has also taken the lead in addressing problems dealing with water supply systems and municipal solid waste disposal. The former is involved in generating simplified cost estimating procedures, planning guides, a synopsis of pertinent environmental regulations and their impact, and innovative approaches to financing the cost of water supply systems.

The solid waste disposal project includes an analysis and evaluation of alternative resource recovery systems for local governments in specified Georgia localities.

Georgia Tech's Industrial Energy Extension Service, sponsored by the Georgia Office of Energy Resources, provides assistance to industry in finding ways to conserve energy.

Their goal is to reduce Georgia's projected 1980 industrial energy usage by 10 to 20 percent, and their services are available to any Georgia firm upon request.

During the most recent year of activity, Industrial Extension Service staff members made approximately 300 direct plant contacts, visited some 160 industrial plants, completed 58 energy audits, investigated 152 energy savings measures and conducted 11 workshops and seminars in addition to continuing an active

program of technical information transfer.

It is estimated actual energy savings for those Georgia firms audited and those participating in energy conservation workshops will total almost 6.5 trillion British thermal units per year.

Driving the wrong way on expressway ramps is dangerous, and Georgia Tech is involved in work to eliminate this problem also.

In conjunction with the Georgia Department of Transportation, Tech engineers are researching inexpensive solutions for the problems. For example, on one Atlanta expressway ramp, the wrong-way movement was three per day and \$7 per month — considered extremely high.

Georgia Tech studies found that by installing eight-inch ceramic yellow buttons along the center lines on the road leading into the rampway and by having an oversized 18-foot long white arrow on the ramp pavement, the number of wrong-way entries has been reduced to three per month.

In addition, Tech provides assistance to Georgia textile industries by developing new materials, studying ignition characteristics of flame resistant fabrics, investigating advanced yarn spinning systems and improved cotton handling

In addition to its widely recognized educational facility, Georgia Tech's engineering experiment station offers a wide variety of technical assistance to Georgia businesses. Full-scale, in-plant trials involving dye-bath reuse for energy conservation by the state (shown below) are one of many services offered by its Industrial Energy Extension Service.

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PIQUA

Act seeks to reduce demand

Signed into law in November 1978, the National Energy Act has as its purpose the immediate and significant reduction of demand for nonrenewable energy resources such as coal and natural gas.

The act contains policies which deal with natural gas pricing, utility rate reform, general conservation techniques, coal conversion and energy taxation.

Of prime concern to the Ohio Department of Energy is a section of the act which deals with encouraging energy conservation in buildings, such as schools, hospitals and local government buildings. Such in-

stitutions have been severely burdened by rising energy costs, and it is hoped that procedures outlined in the act will help them cut down.

The first step which will be taken according to the act to help these institutions cut energy needs is an energy audit. Inspectors certified by the state will survey the building, determining its energy consumption characteristics, consolidating information on the ways it consumes energy and noting its major energy-using systems.

Results of an audit will detail ways a building's operational procedures can be modified to conserve. The final step will be initiating

the suggestions for which grants will be available on a 50-50 matching basis.

ODOE already has begun the school audit program, contracting with the Ohio Department of Education and the Ohio Board of Regents to conduct preliminary and final audits on schools and universities throughout the state.

Another part of the act which is important to Ohio consumers deals with utility rate reform. The act charges state regulatory authorities, in Ohio's case the Public Utilities Commission of Ohio, with examining utilities to make sure certain federal standards documented in the act are being followed.

The legislation provides for increased federal and

consumer intervention into rate-making procedures, allowing a mechanism to assure the consumers' interests will be represented at the state level and in

proceedings concerning standards.

In some instances, it places an obligation upon utility companies to pay for consumer representation

To conserve:

Dial down heat, keep filters clean

With heating costs going up and up, consumers need to learn what measures they can employ to cut consumption.

The first and most obvious measure to cut consumption is to turn the thermostat down. Recommended levels are usually 65 degrees during the day and 55 degrees at night.

According to the Federal Energy Administration, a homeowner can save about three percent on his fuel costs for every degree he reduces the average temperature in his home. Dialing down only at night can save about one percent per degree.

Windows near thermostats

should be tightly closed, otherwise the furnace will keep on working long after the rest of the room has reached a comfortable temperature.

Having an oil furnace serviced annually could save the consumer 10 percent in fuel consumption. And to make it a little easier on the pocketbook, most servicing firms offer off-season reduced rates.

Oil furnace owners also should have their furnaces checked to see if the firing rate is correct. Chances are, it isn't. A recent survey found that 97 percent of furnaces are overfired.

Filters in forced air heating systems should be cleaned or replaced monthly

and duct work should be checked for air leaks yearly.

To check for duct leaks, the homeowner should feel around duct joints for escaping air when the fan is on. Relatively small leaks can be repaired by simply covering holes or cracks with duct tape. More stubborn problems may require caulking as well as taping. Heating fuel costs could be reduced nine percent by religiously checking these items.

Dust and grime also impede the flow of heat. Therefore, radiators should be dusted or vacuumed frequently. If they need painting, flat paint, preferably black, should be used, since

flat paint radiates heat better than glossy.

Draperies and shades should be kept open in sunny windows and always closed at night.

The best insulation of all is proper clothing. The human body gives off heat, and dressing wisely can help retain that heat.

Closely woven fabrics add at least a half a degree in warmth. Slacks are at least a degree warmer than skirts, while a light, long-sleeved sweater will add about 3.7 degrees, and two lightweight sweaters will add about five degrees in warmth because the air between them serves as insulation to keep in more body heat.

**We Salute
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CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

May 2, 1979

EXAMPLE OF LETTERS SENT TO
SENATORS AND CONGRESSMEN.

Honorable Howard Metzenbaum
United States Senator
121 East State St.
Columbus, OH 43215

Dear Senator Metzenbaum:

As you may know, the City of Piqua, Ohio, in conjunction with the United States Department of Energy, is currently conducting a Preliminary Feasibility Analysis in preparation of demonstrating the feasibility and efficiency of District Heating and Cooling in the community. District Heating and Cooling utilizes co-generation, i.e., the production of electricity and simultaneous use of the wasted or rejected thermal energy to heat and cool businesses, homes and industries in the community.

Piqua's District Heating and Cooling Project will utilize the municipally owned, coal fired, power plant located within the city. Piqua's circumstances are not unlike those of other Ohio cities and consequently co-generation or District Heating and Cooling could be utilized on a broad scale throughout the state.

In addition to Piqua, Toledo Edison is also pursuing District Heating and Cooling in the City of Toledo. With this initiative already underway, and considering Ohio's coal resources, we believe that serious emphasis should be placed upon co-generation.

For your information, and in order to provide your office with a better understanding of Piqua's effort, I have enclosed a copy of Piqua's Energy Future which ran in the Wednesday, April 18th edition of the Piqua Daily Call. I hope to have the opportunity to meet with you in the near future to discuss District Heating and Cooling, specifically Piqua's Demonstration Project.

Sincerely,

James E. Henderson, Mayor

JEH/km
Enc.

Survey shows Piquads informed

By SUSAN J. CLARK
Call Staff Writer

Piqua is a stable, informed, energy-conscious community, according to a public opinion survey taken here recently.

The systematic survey, done in January, was in conjunction with the United States Department of Energy to determine the cost of initiating district heating and cooling here and to determine whether Piqua residents would be receptive to such a change.

District heating and cooling is a method of utilizing hot water and steam — by products of electrical generation — to heat and cool homes, businesses and industries. Its main advantage is that it can increase the energy efficiency of a power plant from about 30 percent to 50 percent.

While the survey did determine district heat will be feasible here, it was designed to reveal also community makeup and measure how respondents function in the marketplace. Results of this portion of the survey were typical in many cases and intriguing in others.

For instance, 47 percent of those asked where they would most prefer to live said they wanted to live in Piqua. Asked whether they intended to move in the next five years, 73 percent said no.

According to the survey, most Piqua residents have been here a long time, too. On the average, respondents had lived here 30 years and had lived in the same house an average of 13 years.

According to consultant William Eskew of Hanselman-Eskew and Associates, this extremely low rate of transiency is partially due to a high percentage — 28 — of residents over the age of 61.

Eskew said the survey also reveals that Piqua is a basically working class community, which is well-informed and energy-conscious.

He said that 26 percent of the people in Piqua earn less than \$10,000 a year — a higher than normal percentage which he said is due again partially to the large elderly community.

But 21 percent of those polled have taken adult education courses, and 90 percent said they read the Piqua Daily Call regularly.

Of residents surveyed, 86 percent have installed storm windows, 88 percent have installed storm doors, 78 percent have attic insulation and another 42 percent have added it.

According to Eskew, commercial establishments polled are energy-conscious also, but in different ways.

"The businesses are energy-conscious in terms of thermostat settings," he said. He added that the percentage of businesses with storm windows and doors was not as high as that for homes, but it still constituted a majority. He explained that the difference probably is due to the different types of structures.

"The type of doors and windows on some of these

businesses may not be conducive to adding storm doors and windows. Besides, 50 percent of the business owners rent or lease their buildings, and the improvements are not really theirs to make," Eskew said.

However, 74 percent of the business owners surveyed said they would make "significant improvements" in their heating systems if they could recapture the costs within three years. Eskew said it is really too early to tell whether or not the cost for converting a business to district heat could be recaptured in three years or not, although in many cases it looks possible.

For more information on district heating and cooling, see the "Piqua's Energy Future" insert in today's Daily Call.

"We'll just have to deal with it on a case-by-case basis. However, a number of the buildings are already firing their own boilers. The city would only have to run a pipe to them, and internal retrofit costs would be minor," he explained.

District cooling, although probably not feasible on a residential basis, may be possible for downtown commercial establishments, he added.

"Some structures have their own chillers. So, if we get the hot

water to them, they can chill it themselves and distribute it throughout the building," Eskew explained.

In the residential portion of the survey, 62 percent of those questioned said they would make major improvements in their heating systems if the improvements would pay for themselves within 10 years. Those who would pay for the improvements with cash on hand and savings amounted to 46 percent.

Eskew said, however, that the 46 percent figure may not be too reliable, since no dollar amounts were tied to the question.

Of the owners of rental properties, 59 percent indicated a willingness to make energy improvements in their holdings.

Sixty-one percent of the residents said they had heard of the district heating and cooling project, while 26 percent of business owners said they knew and 47 percent said they had heard of it but didn't know a lot about it.

Eskew said most of the business owners polled said they felt using the Piqua Municipal Power System to provide thermal energy was a good idea.

"In fact, 33 percent said it was a great idea, and 24 percent said it was a good idea if it would reduce costs and be economically feasible," he said.

Eskew said a portion of the survey which also surprised him was that which dealt with shopping habits. Thirty-three percent of those queried said

they shopped in Piqua and nowhere else.

"Eighty percent of the people said they do most of their shopping here," he explained. "Of those, more of the people utilized the mall than downtown or west Piqua. The area used most for other purposes than shopping was the downtown, with 46 percent."

Piquads also have some not-so-standard views about who would make a good community leader.

"Usually, people cite the professional as the person most likely to be a good community leader. This would include doctors, lawyers and educators. However, people in Piqua — about 50 percent — said they thought the average citizen would make the best leader," Eskew elaborated.

He added that results of the industrial portion of the survey indicate industries, too, support the idea of district heating.

Overall, Eskew said he feels district heating will be feasible here. Most people heat their homes currently with gas, which is easily converted, and most heating systems are in accessible locations.

"We also found that people in this community, overall, are very concerned. It's a pretty informed community. They're supportive of new concepts, ideas and processes which will be beneficial to the city as a whole," Eskew concluded. "People here are willing to make an investment in their community."

Piqua signs pacts for energy studies

By SUSAN J. CLARK
Call Staff Writer

THE PIQUA CITY Commission adopted two contracts at last night's special session which together provide nearly \$270,000 in federal funds.

The money, awarded by the United States Department of Energy (DOE), calls for no monetary commitment by the city, according to William Eskew of Hanselman-Eskew and Associates, the city's consulting firm.

9/27/78
About \$192,500 will be used for a feasibility study on how to squeeze the most energy out of the power plant's by-products of hot water and steam, Eskew explained. The rest of the money will be used for a study on the feasibility of utilizing the "low-head" Miami River dam to produce hydroelectric power for Piqua.

CITY MANAGER HOUSTON Elmo Hastings pointed out that Piqua was one of eight power systems to receive a grant for the steam study and one of 50 to get money for the hydroelectric power study.

Of the steam study grant he said, "We appeared in Chicago in front of a committee of 15 people, competing against large municipalities."

Of the eight power systems awarded such grants, Hastings said only one other is municipally owned, and it, too, is in Ohio — the city of Dover.

He said there were about 300 people at the pre-application meeting in Chicago, but he had no idea how many of those people ultimately applied for funds.

HASTINGS SAID HE will attend another Chicago meeting in two weeks at which someone from Sweden, where steam-utilization techniques are prevalent, will talk with those who were successful in obtaining these funds.

Eskew said the study will consist of a demonstration team comprised of the city and its consultants and the Georgia Institute of Technology's Engineering corp of about 450 professionals.

The study guidelines also call for an advisory committee, which will be comprised of a broad spectrum of citizens and state environmental people, according to Hastings.

He said the project is structured like this — with community participation — so that

"the whole community becomes convinced this is a good project. This is one of the objectives of the Department of Energy."

ESKEW SAID PART of the study will involve door-to-door canvassing to determine what kind of heating and cooling units people have. The study will determine the cost-effectiveness of converting people's heating and cooling systems to utilize steam and hot water produced at the power plant.

Hastings added that steam can now be extended for longer distances, and the study "will identify how far we can go with it."

Eskew pointed out that the guidelines for the grant "are not too strict. They (DOE) want you open in your thinking to the application of this."

Hastings said the study of Piqua's low-head dam will determine the "feasibility of the project (using it to produce hydroelectric power), the capital investment it will require and a development plan for putting it on the line."

COMMISSIONER CLETUS Peltier expressed the importance of the grants. "This shows we want to make the light plant as efficient as we can. This will make it attractive for industry to come in here," he said.

City officials this morning announced a \$188,000 feasibility study grant by the federal government, aimed at utilizing the power plant by-products as energy. Present were, from right to left, Consultant William Hanselman, Mayor James Henderson, Acting City Manager H.E. Hastings and Consultant William Eskew. (Fogt photo)

City gets study grant

6/24/78

The City of Piqua now has the money to explore ways to get the most use out of the power plant and its by-products, steam and hot water.

Mayor James Henderson announced this morning the city has been selected by the U.S. Department of Energy to evaluate the feasibility of making some minor changes in the municipal power plant to use more of the steam and hot water, rather than wasting it. To do that study, the city will get about \$188,000.

Hanselman-Eskew and Associates, a Dayton consulting firm, and Georgia Institute of Technology's Engineering Experiment Station in Atlanta will assist the city in the study, Consultant William Hanselman said.

Now the city produces electricity, and the by-product is steam. Only 15 to 30 percent of that steam is used by 10 or 11 customers, primarily in industry, Henderson said.

But potentially, 80 percent of that steam could be used by industry, commercial establishments and residences, the Mayor noted.

Hanselman summed up the proposal as squeezing out the last ounce of energy that possibly can be squeezed out (of the steam and water) before they go back into the power system."

Acting City Manager Houston Elmo Hastings explained the power plant

produces steam which is used to generate kilowatt hours, and that steam can be re-used. However, to be economically feasible, the city has to have enough steam customers to cover costs. Hastings noted the city power plant has a turbine specifically designed for cogeneration — the term used in connection with the energy conservation program.

The feasibility study is the first step, which could be followed by a detailed, specific study and another step in which the system would be designed, before implementation could begin. The first step will take about eight months, Hanselman estimated.

At this point, the city is investing no money, Henderson and Hastings said. If the project proceeds, the city may have to kick in part of the cost, Hanselman pointed out. However, he said, the city is under no obligation to do so if it is not economically feasible. To be economically feasible, the city must get back its cost and be able to offer its customers something appealing, Hanselman explained.

Henderson said City Commission "has finally decided to keep the power plant." He noted a couple years ago,

Commission considered renting or selling the plant. But now that the city is going to retain its power plant, it is time to investigate ways of best utilizing it, Henderson said.

Henderson stressed his belief that this will be "the start of something in Piqua . . . the re-establishment of a growth pattern in Piqua."

Calling the entire project's potential "phenomenal."

Henderson said, "At the same time we could be using the steam and hot water, . . . we may be able to reduce the cost of generating kilowatt hours of electricity."

Hanselman noted there will be an advisory committee of local bankers, lending institution and building representatives to work with the city and its consultants on the project.

Hanselman noted many businesses in Piqua are firing their own boilers, using "scarce resources." Those businesses may possibly become city steam customers, he suggested, and that is something the study will determine.

Hanselman stressed changes in Piqua's power plant would be minor, if the "regeneration" or waste-saving project reaches implementation stage.

This shows, in simple terms, what happens to the by-products of Piqua's power system and what potentially could happen to the by-products, which are steam and hot water. If the potential becomes a reality, the city could be selling the steam and water. That potential is at the root of a \$188,000 feasibility study grant announced this morning.

DOE poll to begin

Piqua residents will be interviewed on a random basis this weekend about how they heat their homes. They survey is in connection with a study the city is conducting with Department of Energy funds.

Area businesses also will be polled, probably next week, to determine their energy needs, and interviews with local industries are already underway.

According to consultant William Hanselman of Hanselman-Eskew and Associates, the federally-funded study will determine the feasibility of district heating and cooling for Piqua. District heating and cooling is a process in which steam and hot water, by-products of electrical generation, are harnessed to heat homes, businesses and industries.

Hanselman said those interviewed will be asked about their attitudes and opinions on energy and its use. Each person will be given a brief explanation of what district heating and cooling is, he said.

Hanselman assured that the names and addresses of those interviewed will be confidential.

"All the information from the questionnaires will be coded when it comes into our office, and the sources of it lost. The answers then will be used for statistical purposes," he explained.

The results of the survey will be made public in April, Hanselman said. Interviewers will be calling on residents Saturday from 9 a.m. to 6:30 p.m. and Sunday from 11:30 a.m. to 6 p.m. Businesses will be surveyed Monday through Friday from 10 a.m. to 3 p.m.

Co-generation no experiment

By SUSAN J. CLARK
Call Staff Writer

12/1/78
"You're going to be spending money on energy. The question, then, is how are you going to spend it?"

This puzzle was put before members of the district heating and cooling project advisory committee at its first meeting Wednesday night by William Hanselman of Hanselman-Eskew and Associates, the city's consultants for the project.

Hanselman, along with William Eskew and Georgia Institute of Technology engineer David Wade, presented a slide show describing the energy crisis, its effect on Piqua and how district heating and cooling can limit its effects here.

District heating and cooling, which has been in use in Europe for about 20 years, involves utilizing hot water and steam, by-products of electric generation, for heating and cooling homes, businesses and industries. This sort of "co-generation" is not feasible just anywhere, according to Wade.

"Not everybody can do co-generation. You have to have a power plant which can be converted and one which is close to the city. Cities down the road from Piqua don't have these things," he said.

"Piqua is also a dense, compact community. This will make it cheaper to install a thermal energy distribution system," Hanselman added.

Wade said that converting

homes to use hot water and steam heat may be as simple as adding a coil to existing furnaces. In other cases, it may be more costly, and because of that, part of the federally funded study being conducted will be to explore alternative methods of financing the conversion for the consumer. Hanselman said this may take the form of assessments over long periods of time.

"Part of the study is to look at what's here and come up with cost estimates on the modifications. Whatever would be done would be staged into the community over a number of years, and we won't proceed unless we can determine by the study that there is a market for this kind of energy in Piqua. I don't think anybody's intimated we're going to do something they won't benefit from," Wade explained.

Hanselman said that while district heating and cooling will hold down administrative costs, it will not promise lower utility bills.

"We won't tell you you'll have lower utility bills, but this is a system that will hold down costs over a period of time more than conventional systems," he said.

Hanselman stressed that the project is not a research and development project like the nuclear reactor installed in Piqua in the 1960s.

"District heating and cooling is a demonstration project. The technology of it has already proven itself. It does work. It's not just an experiment," he said.

RADIO--stations can be categorized in a fashion similar to newspapers i.e. regional stations with broad markets and local stations with fewer listeners. Here again, there are radio stations within the broader market area of which Piqua is a part and whose programming is targeted to a very broad population. Piqua's local radio station WPTW, is designed and programmed for a more specific market. While WPTW obviously does not have the large listening population that a regional station would have, it does reach many residents within the Study Area, and Miami County generally. Data from the survey research indicates that approximately 44% of the persons within the Study Area are obtaining their daily radio news from WPTW. This is further confirmed by another public opinion survey that was administered several years ago which indicated approximately 42% of residents within Miami County generally received their news from WPTW. Thus, WPTW is another avenue for information dissemination and commercialization available within the Study Area. The station is active, and has carried "district heating programming" during Phase I. Therefore, it is determined by the Demonstration Team that securing air time with this station will prove beneficial in terms of broadening the information base on behalf of future district heating customers. The station has a fixed programming schedule that includes a five minute program which is run weekly entitled "Your Community and You". This program is well received by the community and is accessible to the Demonstration Team.

The Demonstration Team participated in a two-program series with the local radio station. William Eskew and William Hanselman of Hanselman-Eskew and Associates represented the City Team. The first program dealt primarily with the preparation and submission of the District Heating and Cooling Feasibility Study to the Department of Energy. The program explored the various details contained in the proposal; established the overall goals and objectives that the project was designed to meet; and discussed generally the ramifications of the Study Area. The second program dealt primarily with the results of the survey research, the data, analysis and evaluation, that was evolving over time and as a result of the feasibility study; set the parameters for completing the Phase I study; publicized a list of meetings that were upcoming not only with the general community and the PAC, but also the City Commission. Further

reporting was done by WPTW as part of their daily news coverage of the Piqua City Government.

In general, the feedback received by the City of Piqua, the Demonstration Team and the City Commission has been quite positive and very informative. In future phases of this project, the relationship that has developed between WPTW, the Demonstration Team and the City of Piqua will be continued and expanded to further inform the consumers/customers within the service area of the status and progress of the district heating project. Cooperative efforts with WPTW provides an excellent means of furthering the task of information dissemination to the consumers/customers.

TELEVISION--Piqua, is part of the CATV cable system and has had cable television for a number of years. As part of that system the community has access via Channel 13 for local programming. As with any local programming option, the station is continuing to expand use of this capability over time. Recently, City Commission meetings and other meetings of general community-wide interest have been taped and presented to the community on a delayed broadcast basis. Thus, when the project was announced at a commission meeting and adopted, the general population of the Study Area became aware of the new initiative. It was determined by the Demonstration Team that, although the survey results did not indicate as high a viewership as that of the radio station or the local newspaper, the ability to broadcast special presentations concerning the project would be exciting. Channel 13, the Joint Vocational School TV Department and the Demonstration Team produced, directed and televised a four part documentary. The four programs were taped, with each running twice on Channel 13. The newspaper encouraged viewers to tune in. The following is a capsule summary of the programs presented.

Program #1--Program number one was basically general information and introduction to the District Heating and Cooling Feasibility Analysis. William Eskew and William Hanselman of Hanselman-Eskew and Associates represented the Demonstration Team. The program discussed the reasons why the project was initiated, the goals and objectives of the project, and possible impact for the community and Piqua Municipal Power System.

Program #2--The participants of program number two were David Wade of the Georgia Tech Engineering Experiment Station and H.E. Hastings, Piqua Municipal Power Systems Director. With the aid of the Joint Vocational School production classes, the Demonstration Team's slide show was utilized to discuss and analyze cogeneration in general, and specifically, prospects and impacts for the Study Area.

Program #3--Participants in the third program were H.E. Hastings, Piqua Municipal Power Systems Director, and David Wade of the Georgia Tech Engineering Experiment Station. Program number three was the follow-up to program number two and presented a discussion with slides of the distribution system type/size; and potential service areas were previewed. That portion of the slide show which deals with the distribution system again was utilized as a visual aid throughout the program.

Program #4--The participants in program number four were William Hanselman of Hanselman-Eskew and Associates and H.E. Hastings, Piqua Municipal Power Systems Director. The main topic of discussion was end-user retrofits, how this could be accomplished and potential costs. The color slide show was utilized as a visual aid.

In summary, the CATV system has provided and will continue to provide an invaluable asset to this project in that it visually allows the Demonstration Team to reach a much broader consumer market than could be reached in a single public meeting. The availability and useability of such a system is quite beneficial, and will further the understanding and consumer acceptance of the central source thermal system.

THE PROJECT ADVISORY COMMITTEE (PAC)

In order to insure that various agencies, institutions and interest groups which directly and/or indirectly relate to the overall success of the project are identified and involved in the Demonstration Project during all phases, a Project Advisory Committee was formed and participating. The specific purposes of the advisory committee are:

- 1) to provide representation and access to the Demonstration Project by specific community interest groups/agencies which will ultimately contribute to implementation of the project;
- 2) to identify other parties/interest groups which will relate to the success of the project;
- 3) to identify additional issues which should be subject to analysis within the context of the broader community;
- 4) to review and discuss alternative Demonstration Project recommendations; and
- 5) to insure that potential customer needs are addressed.

The Project Advisory Committee meets periodically throughout the project period.

The PAC includes representation of the following groups:

- real estate
- commercial banking
- savings & loans
- local area-wide agency
- Miami County
- Chamber of Commerce
- City Commission
- development/construction
- regional air quality agency
- industry
- merchants
- schools
- hospital

The individual PAC members were selected with special attention to their access within specific sectors of the community. The list below identifies the PAC members.

1) Piqua City Commission
219 W. Water Street
Piqua, Ohio 45356	8) Construction
Thomas Hinger, President
Mid-Con Hinger Associates, Inc.
322 W. Water Street
Piqua, Ohio 45356
2) Piqua Chamber of Commerce
Jerry Easley, Executive Director
400 N. Wayne Street
Piqua, Ohio 45356	9) Regional Air Pollution Control
Agency
William T. Burkhart, Director
Regional Air Pollution Control
Agency
451 West Third Street
Dayton, Ohio 45402
3) Miami County, Ohio
Gary B. Cline,
Planning Director
Miami County Plaza
Troy, Ohio 45373	10) Piqua Downtown Merchants
Association
Robert Shroyer, President
Piqua Furniture Mart
322 N. Main Street
Piqua, Ohio 45356
4) Miami Valley Regional Planning
Commission
Dale Bertsch, Executive Director
Dayco Building
333 W. First Street
Dayton, Ohio 45202	11) Piqua Association
Sam Jackson
Jackson Tube Service, Inc.
8210 Industry Park Drive
Piqua, Ohio 45356
5) Real Estate
Eileen Sharp
226 W. High Street
Piqua, Ohio 45356	12) Piqua City Schools
Wayne Bachman,
School Superintendent
419 Caldwell
Piqua, Ohio 45356
6) Commercial Banking
Robert B. May
Director of Marketing
Piqua National Bank & Trust Co.
Piqua, Ohio 45356	13) Piqua Memorial Hospital
Mr. Sorrell, Director
624 Park
Piqua, Ohio 45356
7) Savings and Loans
Keith Fletcher
Border City Savings
300 W. High Street
Piqua, Ohio 45356	

The Demonstration Team held two meetings with the Project Advisory Committee during the Phase I study process. At the first meeting in October, team members present included H.E. Hastings, PMPS Director, William C. Hanselman, William C. Eskew of Hanselman-Eskew and Associates, and David Wade of the Georgia Tech Engineering Experiment Station. The purpose of the meeting was:

- 1) Introduce the Demonstration Team
- 2) General presentation of "Cogeneration"
- 3) Exploring Piqua's suitability
- 4) Defining and delineating the study process.

The majority of the discussion centered primarily upon cogeneration generally, and specifically the capacity of the PMPS to deliver thermal energy on a broad scale, and the potential problems of retrofitting the end-users.

On April 24, 1979, a second meeting was held with the Project Advisory Committee. Present at the second meeting were David Wade of the Georgia Tech Engineering Experiment Station, William C. Eskew, William C. Hanselman and Alison Zatik of Hanselman-Eskew and Associates, and Frank Patrizio Jr., Piqua City Manager, Elmo Hastings, PMPS Director, Steve Klein, Piqua Law Director, Ray Miller, City Utilities Director, and Donald Van Tyul of the Ohio Department of Energy. The primary purpose of this meeting was to present the results of the survey research and the developed, alternative retrofit schemes. In depth discussion focused on the survey results and how it is applied to the market penetration rates and the retrofitting process.

Questions concerning the initial service area and the ultimate service area were discussed. The in-plant retrofits as well as the consumer retrofits were discussed as well as what was needed to actually retrofit the plant and bring it up to full capacity. Earlier the committee had expressed some concern about expected penetration rates, therefore, we went into a detailed description of the analysis used to arrive at the penetration rates in the various zones. In addition, the legality of cogenerating when under contract with D.P.&L. was raised. Estimated BTU savings with district heating in the ultimate service area were revealed.

The Project Advisory Committee will remain a standing committee throughout the project phasing. During Phase II, members will be added from the initial or early-start service area identified in Section 4.0 of this report.

EXISTING ORGANIZATIONS--The existing organizations provide an existing structured system of resources for consumer/customer involvement and commercialization. These organizations are made up of citizens who are active in the community, and who would be willing to contribute more to the community in the future. Many times, it is from these organizations that the leaders of the community emerge. It is imperative that decision-makers within the Study Area continue to utilize this existing resource to its full potential. The members of these groups are generally characterized as having more leadership potential and being more involved. The existing organizations contained within this section of the study process must not be confused with those that are essentially governmental in nature. These governmental groups, such as the Regional Air Pollution Control Agency, the Ohio Department of Energy, the Public Utilities Commission of Ohio, and Miami Conservancy District, were met with as part of the Phase I effort and the results are presented in other sections of this study.

Given the time and the scope of the Phase I process, it was determined to seek out those existing organizations which could provide the most critical, technical and informational input to the study process. The organizations identified are:

- 1) the Citizens Community Development Task Force
- 2) the Manufacturer's Association
- 3) the Downtown Merchant's Association.

CITIZENS COMMUNITY DEVELOPMENT TASK FORCE--The Citizens Community Development Task Force is an eleven member group whose function is to provide input into Piqua's community development efforts. The Task Force consists of Piqua residents, and business, industrial and institutional leaders. The group's oversight responsibility spans issues from housing rehabilitation and the needs of low and moderate income households, to the overall growth and vitality of the City. Thus, input from the Task Force is deemed quite appropriate in that discussion and debate can occur from a perspective which is broader than specific end-user

concerns and approaches the study process from the top (Study Area impact) down (End-user retrofits).

The Demonstration Team held two meetings with the Task Force. The first meeting centered primarily upon an introduction to the study process, and a discussion of cogeneration and how it would relate to the PMPS and the broader community. The Task Force felt that improving the efficiency and ultimately the capability of the system would be critical for the continued growth and viability of the City. Further, they felt that with rising energy costs, implementation of this process could positively affect not only business and industry, but also the household budgets of City residents--especially the elderly and low/moderate income households.

The second meeting held with the Task Force consisted of the detailed slide show including the statistical analysis and evaluation of the survey results, and how these function to generate the probability of applying district heating to the end-users. The second portion dealt with the technical aspects of the inplant retrofit alternatives and the initial/ultimate distribution system. The Task Force was encouraged by the preliminary results, and felt that if costs were appropriate, that this concept should be further explored and ultimately implemented.

PIQUA AREA MANUFACTURER'S ASSOCIATION--The Piqua Area Manufacturer's Association is a sub-committee of the Chamber of Commerce. This group consists of the leaders of the industrial community, of which many are currently utilizing the PMPS steam capability. Members of the Demonstration Team held two meetings with the Manufacturer's Association.

The purpose of the first meeting was to present the slide show which had been generated from the Demonstration Team's effort to date. Discussion centered more on the technical aspects of the retrofitting process, and how it would specifically relate to the industrial end-users of the thermal system. While there was general encouragement on behalf of the group, many of the questions raised could not be considered specifically at that time. This was due to the fact that the study process had not progressed to the point whereby

conclusionary data was available. As a result, it was determined to have a second meeting within one month where their concerns could be answered. Cost/money is the financial and institutional issue to industry.

The second meeting opened with a slide show in which the results of the questionnaires and the technical end of district heating were discussed followed by questions and discussions thru which the manufacturers agreed that + 250 degree hot water was sufficient for the majority of their needs. The Association was concerned about possible funding alternatives to which the team explained that the feasibility of the District Heating Project would be evaluated under all possible scenarios.

Three different retrofit options of the plant were discussed in detail as well as the BTU's ultimately saved with the different retrofit systems. The Team asked the Manufacturer's Association to briefly give their thoughts about the characteristics of firstly, pollution evaporators, for example, the Dow Corning Evaporators used to recover chemicals, process heat in the industrial park, air conditioning and steam for manufacturing purposes. As far as the steam for manufacturing purposes, most concurred that 250 degree hot water was generally sufficient and that should their needs rise above this, industries themselves or booster stations would provide the processes by which to raise the temperature of the water. The Manufacturer's were also excited about the possibility of bringing new industry into the Piqua area with the hot water available, and suggested marketing toward thermal dependent industries. The meeting concluded with the discussion of air conditioning in the Piqua area and all concurred that district cooling did not seem feasible because of a low demand present for cooling.

In essence, this group has provided invaluable assistance to the Phase I study process, and their role and level of involvement will surely expand in future phases.

DOWNTOWN MERCHANT'S ASSOCIATION--The Downtown Merchant's Association is a sub-committee of the Chamber of Commerce whose members are business owners within the central business district and other commercial area; thereby possessing a number of potentially major end-users of the thermal system. Therefore, a

meeting was held in April 24, 1979 with the Demonstration Team and the Downtown Merchant's Association.

A major portion of the meeting consisted of a detailed slide show in which the entire structure of the questionnaire and interviewing process, statistical analysis and the related results of district heating applied in Piqua. The second portion of the slide show involved actual construction and design of a central source thermal system where it was explained and delineated to the merchants under which conditions the system would be feasible, how it would actually fit into their business, where metering would occur, how it would be implemented, and how it would be operated. Different methods of financing the system were also discussed.

The merchant's did show some concern about the demand for cooling and consequently the feasibility or infeasibility of district cooling was discussed. Further, the current status of the plant was discussed in detail as well as the necessary retrofits. Since this was the merchant's first formal introduction to district heating, the meeting was basically informative.

SUMMARY--the ability to present the findings of the demonstration study to these groups proves a very effective way of dealing face to face with many of the potential end-users of the project. Their concerns, feelings and willingness to connect to the system will depend not only upon the costs, but in many respects their ability to feel comfortable with central source, thermal heating technology. The Task Force itself, while not consisting totally of major end-users, does present a prospective of the community which is not obtainable in other ways. The Manufacturer's Association and the Downtown Merchants all are potentially major end-users of the system; and therefore, their continuing input, understanding and interests in the project will be critical for long term viability. In the future, the roles of these organizations will be continued and reinforced. In addition, other organizations and groups in the community will be approached in the appropriate forum whereby the process of delivering hot water heat through a central source thermal system will be presented, discussed, analyzed and evaluated.

PUBLIC MEETINGS--The purpose of a public meeting is to generate a two-way flow of information between the decision-makers and the citizens. It is a process in which citizen involvement can occur on a less structured basis.

The public meeting process is best described as an opportunity for the citizenry to participate in the discussion of a given issue in a less structured atmosphere. Usually, the meeting is dominated by an outward flow of information from those desiring "citizen input". However, if a series of public meetings are held concerning a given issue, the amount of constructive input generated can be increased as a result of the more intense effort on behalf of the decision-makers to solicit the citizen view.

The product of a public meeting is that of maintaining a communications channel between the decision-makers and the citizenry. The resultant is two-way flow of information that produces discussion and debate. However, the effectiveness of public meetings as a method of obtaining valid input can only be measured in terms of the effectiveness of a county's information dissemination process, and the willingness of officials to freely join in the deliberations.

Therefore, all of the meetings held by the Demonstration Team and the Project Advisory Committee, Citizens Community Development Task Force and the City Commission were public meetings, advertised publically by the local media. Due to the very nature of a Public Meeting and the desired results, they will be utilized throughout the future phases of the study process.

CITY COMMISSION--The Piqua City Commission's role within this project is quite obvious--they are the final authority. They are the policy making body within the city, and as such, will decide the fate of central source thermal heating. Their level of involvement in this study process must in fact be intense not only because they will ultimately decide the fate of the project, but also due to the fact that as representatives and residents of the city, questions will be put to them at all hours of the day with the questioner expecting a knowledgeable response. It is this body and other key city staff who receive telephone calls at 10:00 p.m. wondering what is happening with the project. Thus, as citizens of the city and neighbors of the general population, it is very

important to have the City Commission informed of the continuing study process, and provide them with as much data and results as possible. This is due to the fact that today, cloak-room public decision-making does not occur, but rather within full public view.

Therefore, the City Commission are not only members of the Project Advisory Committee but also are kept constantly informed of the project's process through group meetings with the Demonstration Team and through informal, individual sessions. For a more detailed presentation of the authority of the Commission, see Section 5.

DEMONSTRATION TEAM MEETINGS HELD

Project Advisory Committee
Manufacturer's Association
Chamber of Commerce
Downtown Merchant's Association
Citizens Community Development Task Force
Regional Air Pollution Control Agency
Ohio Department of Energy
Public Utilities Commission of Ohio
Dayton Power and Light Company
Miami Conservancy District
Johns Manville Company
Department of Housing and Urban Development
Columbus Area Office
Piqua City Commission
Bond Council - Squire Sanders & Dempsey
Underwriters - Donaldson, Lufkin & Jenerette
Piqua City Staff
- Finance Director
- Law Director
- Public Utilities Director

2.0 CHARACTERIZATION OF DEMONSTRATION COMMUNITY - PIQUA, OHIO

INTRODUCTION

The City of Piqua, Ohio, was selected as a demonstration community for the District Energy System (DES) feasibility study because it offers several advantages: a city owned electric utility with a variety of power units (in effect a complete power system in miniature), one unit of which presently operates on a form of cogeneration cycle; several industrial firms which are now using process steam supplied by the municipal power plant; an existing, although abandoned, steam distribution system in parts of the downtown area which was used for building heating; a dense residential, commercial, and industrial development pattern which would be conducive to effective distribution of thermal energy; and the qualitative advantage of a community attitude which is receptive to new ideas such as a district energy utility.

The concept of district heating and cooling through the distribution of thermal energy has been power effective through many years of utilization in the primary-fuel-resource-poor Scandinavian countries. Those district heating systems have been developed over the period of many years, beginning as early as the 1920's, as the major metropolitan areas developed. However, in order to adapt district heating technology to cities in the United States, the need for an extensive retrofit approach is obvious.

An attractive source of thermal energy for distribution via the district heating network is cogeneration. Thus, the extensively developed power generation systems in the U.S. can be viewed as a huge and heretofore untapped thermal energy source if the appropriate retrofit approach can be developed. A major technical focus of this study will be to analyze Piqua's existing power plant in order to determine the most efficient way to modify it so that it may serve as the thermal energy source, utilizing the cogeneration concept, for the District Energy System.

The following sections of this chapter are directed at characterizing the configuration and performance of the existing power plant, documenting the energy production/consumption patterns of the community, and identifying sections, or "zones," of the community which may prove attractive to serve

with a District Energy System.

2.1 PIQUA MUNICIPAL POWER SYSTEM

2.1.1 LOCATION

The City of Piqua is located in the midwestern region of the U.S., in southwestern Ohio. It is approximately thirty miles north of Dayton on the adjacent Interstate 75. Piqua lies in the north central area of Miami County, primarily west of I-75 and the Great Miami River (Figure 2-1). It is the largest city in Miami County, and contains the largest amount of industrial acreage. The prime access routes are Interstate 75 and County Road 25-A north and south, and U.S. 36 east and west. Piqua was founded in the early 1800's and continues to serve as a regional center for the upper Miami Valley. In the mid to late 1800's Piqua served an important role as a transportation center and, since the early 1900's, has served as a manufacturing and commercial center in the area.

Piqua owns and operates its own municipal electric power system. The Municipal Power Plant is located in the southeastern corner of the City (see Figure 2-2). It is sited along Main Street, approximately one and one-fourth (1 1/4) miles from the central business district, on a site adjacent to residential and industrial sectors of town. This site offers several advantages. Plant access is very good owing to the fact that it is located within the main north-south corridor of the city. Ample cooling water is available from the Miami River adjacent to the plant site. Because of its proximity to its service area, the main substation on site can also serve as the pivot points for the system's sub-transmission loop. However, there are several disadvantages associated with this "in-town" site. The land plot is quite small, approximately 9 acres, of which only 2 acres is available for coal and ash storage. The on-site coal supply storage is thus limited. The potential for plant expansion is also severely limited. Indeed, it may be safe to say that when the space in the existing building envelope is occupied, no further expansion on this site could be considered.

A principal advantage of this site to the feasibility study is the close proximity of the thermal energy source (the Municipal Power Plant with the

FIG. 2-1
REGIONAL
LOCATION MAP

appropriate retrofitted cogeneration units) to a large potential thermal load in the residential and commercial sections of town. The lower transmission distances that would be involved for a District Heating System in Piqua would impact favorably on the economic viability of the system by lowering the capital costs of the distribution system and the costs of operation associated with pumping losses, heat losses, etc.

2.1.2 HISTORICAL

The city-owned Municipal Power System commenced operation in 1933. Prior to 1933, the City of Piqua was served by Dayton Power & Light Company (DP&L). However, in order to provide reliable electric power in an economical manner and maintain local control of utility operations, the citizens of the City voted to purchase the facilities of DP&L in the Piqua area and establish and operate a municipally-owned electric system.

The original power plant building, one fourth of the present structure, was erected in 1933 as a competitive plant without a single customer. By 1936 it had 4,242 customers. The original building contained two steam generating units, each with a capacity of 50,000 pounds of steam per hour and two 4,000 Kilowatt Turbo-Generators.

In 1939 the first addition to the original plant was constructed. In size it was 50% of the original building and contained an additional 50,000 pounds per hour steam generating unit and 4,000 Kilowatt Turbo-Generator.

In 1944 the Director of Utilities made a detailed load forecast and report to the City Manager and the City Commission for each year up to and including 1950. This report recommended the second plant addition as it now stands. The City Manager and the City Commission, acting on this report, authorized the construction of the second addition, and engineering and planning was begun.

The new addition tripled in size of the original plant, tripled the steam generating capacity of the original plant by the addition of one 150,000 pound per hour Steam Generating Unit, and increased the total capacity of the Turbo-Generators to 20,500 Kilowatts. The new 7500 Kilowatt Turbo-Generator unit was placed in service in January 1948, while the 1000 Kilowatt Turbo-Generator

went into service in February 1948. The 1000 KW unit, a "backpressure turbine", has the added feature of cogenerating electrical and thermal energy by utilizing the steam pressure drop from 400 pounds per square inch to 150 pounds per square inch to produce electricity in the standard manner, then exhausting 150 pound steam into a steam distribution system ultimately to be sold to local industries for process use.

The addition in 1951 of a steam generator (boiler) similar in design to the 1948 unit and a 10,000 Kilowatt Turbo-Generator further expanded the Municipal Power Plant's electrical generating capacity and completed what is now referenced as the second addition to the plant. Total plant capacity at this point stood at 480,000 pounds of steam per hour and 30,500 Kilowatts.

The third and final plant addition was completed in 1961. This addition consisted of a complete power unit, segregated from the existing steam (necessary because of newer, more efficient equipment and system design), comprised of a 215,000 pound per hour steam generator and 20,000 Kilowatt Turbo-Generator. Total plant capacity was raised by this addition to 695,000 pounds of steam per hour and 50,500 Kilowatts per hour. The plant now stands as shown in Figure 2-3 Operating Floor Plan - Municipal Power Plant.

In addition to the steam - electric generating equipment housed in the powerhouse proper, the Municipal Power System owns and operates a 20,000 Kilowatt combustion turbine. This equipment serves mainly to supply peaking load to the system and as a back-up for the steam - electric units.

Until mid - 1975, the Electric System operated as an "isolated system" i.e. completely self-contained with no connections to neighboring utilities. The main disadvantage of an isolated system is that the system must provide for its own back-up capability by installing sufficient generation in excess of its peak demand requirement to provide power in the event that there is an outage on the generation system. The isolated system cannot share in the reserve capacity of other systems. Also, being isolated, a small utility must of necessity have small generation units and cannot benefit from the economies of scale inherent in larger units.

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-78-C-07-4976

TEAM MEMBERS CITY OF PIQUA, OHIO

GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESKEW AND ASSOCIATES

Fig. 2-3

PIQUA MUNICIPAL
POWER PLANT
OPERATING FLOOR PLAN

SHEET OF

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CHKD _____
APPR VD _____

In June 1975, the Electric System completed an interview with DP&L. The interconnection agreement requires both the Electric System and DP&L to maintain a normally operable total generating and purchased capacity of not less than 110% of each system's annual peak demand. Each system may purchase from the other, to the extent that the other party is willing, sufficient capacity to maintain this requirement.

Most large utilities as well as a majority of small utilities are interconnected on a pool basis. These power pools enable the systems to operate on a coordinated basis to achieve economies in supplying their combined loads. The interconnection between the Electric System and DP&L is of sufficient capacity (50 mva) to enable the City to obtain its entire power requirement from DP&L in the event of an emergency shut down of the Electric System's generation plant for a limited period.

CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

2.1.3

MEMORANDUM ON OWNERSHIP RIGHTS IN A MUNICIPAL PUBLIC UTILITY

TO: Hanselman/Eskew & Associates

FROM: Stephen E. Klein

DATE: May 25, 1979

In reply to your request for my opinion on the ownership rights of the City of Piqua and its power plant and the proposed district heating and cooling project, please be advised as follows:

Article XVIII, Section 4 of the Ohio Constitution states unequivocally:

Any municipality may ... own ... within or without its corporate limits, any public utility, the products or service of which is or is to be supplied to the municipality or its inhabitants ...

The above-quoted provision which allows cities like Piqua to own public utilities is self-executing, cannot be limited by statute and does not need statutory enactment to give it life. Cleveland v. Cuyahoga Heights, 81 O. App. 191, 75 N.E. 2d 99. Moreover, this provision constitutes a grant of power which is plenary. Priest v. Wapakoneta, 24 O.L. Abs. 214.

Therefore, it is my opinion and you are so advised, that the City of Piqua is able to possess full rights of ownership in the district heating and cooling system facilities whenever they are brought into existence.

"CITY OF OPPORTUNITY"

Stephen E. Klein
Attorney at Law

2.1.4 MUNICIPAL POWER PLANT

As previously discussed, the installed capacity of the municipal power plant is 695,000 pounds of steam generation per hour with electrical generation capacity of 50,500 Kilowatts per hour of the combustion turbine. Steam generator units 1 through 5 (combined capacity 480,000 lbm/hr) along with turbine-generator units 1 through 6 (combined capacity 30,500 kw) comprise what is referred to as the "low-pressure system." The five steam generators and six turbines were designed to approximately the same specifications to be compatible on a common header steam/condensate/feedwater system. Steam generator unit 6 and turbine-generator unit 7 comprise a power unit segregated from the other units and referred to as the "high-pressure system". All units in the Municipal plant operate on the Rankine thermodynamic cycle, modified with superheat. A brief discussion of the thermodynamic theory behind this cycle is presented in Appendix A along with pertinent comments and explanations concerning the Piqua installation. Further discussions of each system are included in the following sections of this chapter.

LOW-PRESSURE SYSTEM - GENERAL DESCRIPTION

The low-pressure system, so called because it operated at a relatively low main steam pressure - 400 psig, was constructed in stages, starting with the initial plant construction in 1933 and concluding with the plant "second addition" in 1951. As each new steam generator, turbine-generator, or other associated equipment was installed, it was incorporated into the plant's common header steam/condensate/feedwater system design. The low-pressure system as it is now exists is detailed on Drawing-1, Piqua Municipal Power Plant - 400 PSIG System - Flow Diagram.

Several of the system components, having exceeded their efficient operational life spans, have been retired from active service. Steam generator units 1, 2, and 3 and turbine-generator 1 have been completely removed from service. Turbine-generators 2 and 3 are relegated to standby status, with unit 3 being operated most frequently when standby service is required.

Normal day-to-day operation involves steam generators 4 and 5 and turbine-

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-78 C-07-4976

TEAM MEMBERS CITY OF PIQUA, OHIO

GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESHEW AND ASSOCIATES

Drawing 1

**PIQUA MUNICIPAL POWER PLANT
400 PSIG SYSTEM
FLOW DIAGRAM**

SHEET OF

DATE
DRAWN *KAT* *JEH*
CHECKED
APPROVED

generators 4, 5, and 6. The major components in routine operation on the low-pressure system have been assembled onto a simplified flow diagram, Drawing- 2A, entitled Heat Balance Diagram. Normal operating procedure is to fire the two steam generators (boilers) at approximately the same steam output rates to supply steam to the 400 psig header system. Turbines 4, 5, and 6 intake steam at 400 psig and 750°F from the header for power production. Turbines 4 and 6 exhaust at a vacuum to condensers utilizing circulating water from the Miami River in a once-through cooling system. Turbine 5 exhausts steam at approximately 150 psig into a steam distribution system ultimately to be distributed to industries in the community with process steam requirements.

For the purposes of a performance analysis of the low-pressure system and for planning plant modifications and operation strategies, the components represented on Drawing-2A can be regarded as the functional low-pressure system. Descriptions of the major pieces of equipment follow.

STEAM GENERATORS - The two operational steam generators on the low-pressure system, units 4 and 5, are of the Combustion Engineering Company type VU design pictured in Figure 2-6. Unit 4, rated at 150,000 lbm/hr. steam supply @ 400 psig and 750°F, was installed and put into service in 1947. Unit 5, with the same nameplate rating as unit 4, was installed and commenced service in 1951. Both "boilers" are of the Stirling two drum, bent tube, balanced draft (forced draft and induced draft fans) type. (A general description of the Stirling type power boiler is included in Appendix A.) Both are coal fired with coal feed by a traveling grate stoker. Forced draft combustion air enters the furnace through the traveling grate. Radiant and convective superheat is achieved in the upper reaches of the furnace ("fire box"). The first pass of the convection zone provides heat transfer into the riser leg of the natural circulation boiler section. The second pass provides additional heat transfer into the downcomer leg of the boiler. The exit pass of the flue gas provides a final amount of heat transfer into the incoming feedwater via an economizer. Both steam generators, being incorporated into the header system of the low-pressure system, can be operated either separately or in tandem. Thus the combined steam generating capacity of the low-pressure system is 300,000 lbm/hr. A summary of the nameplate information for the operational boilers is presented as Table A-1 in Appendix A.

**PIQUA MUNICIPAL
POWER SYSTEM**

CITY OF PIQUA

WIND COUNTY OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-8-C-22-100

TEAM MEMBERS CITY OF PIQUA OHIO
GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HARSHBARGER-EDSON AND ASSOCIATES

DRAWING 2A

PIQUA MUNICIPAL POWER PLANT
HEAT BALANCE DIAGRAM

BOILERS 4 & 5 - TURBINES 4, 5 & 6

SHEET OF

DATE: 11-16-73

DRAWN: J. H. HARRIS

CHECKED: J. H. HARRIS

APPROVED: J. H. HARRIS

COMBUSTION ENGINEERING CO.
TYPE V.U. STEAM GENERATOR
150,000 (LBM/HR.)
400 PSIG. 750° F.

FIGURE 2-6. BOILER UNITS 4 AND 5
PIQUA MUNICIPAL POWER SYSTEM

TURBINE-GENERATORS - All steam turbine machinery in operation at the Municipal Power Plant was manufactured by the Elliott Company. All turbines are multivalve, single cylinder, multistage machines. Unit 4 (installed in 1947) and unit 6 (installed in 1951) are Elliott type NC and NCX straight-flow condensing units, respectively; each with a single automatic low-pressure extraction for feedwater heating. (See Figures 2-7A and B.) Both units operate on a typical speed-load governor control. Unit 5 (installed in 1947) is an Elliott type QV straight-flow, noncondensing unit operating at a rated backpressure of 150 psig. (Figure 2-7C details the type QV design.) This unit is governed strictly according to the backpressure in the steam exhaust/distribution line. Due to this control feature on the noncondensing unit, operation is usually limited to periods when outside steam demand on the system is 20,000 lbm/hr. or greater. All three units direct drive synchronous (3600 RPM) two pole generators. Generator rotor excitation is provided by integral DC exciters operating at 250 volts. Generator power output is at 4160 volts. A summary of the turbo-machinery is presented as Table A-2 in the Appendix.

CONDENSERS - The condensers in service on turbine-generators 4 and 6 are typical two-pass, divided waterbox, surface condensers of the general configuration shown in Figure 2-8. Circulating water is provided on a once-through basis from a man-made aqueduct directly underneath the powerhouse, originating at the adjacent Great Miami River.

Figure 2-9 is a cut-away drawing of a typical unit on the low-pressure system in the Municipal Power Plant.

FIG. 2-7A

ELLIOTT CO. TYPE NC CONDENSING TURBINE
P.M.P.S. UNIT 4

FIG. 2-7B

ELLIOTT CO. TYPE NCX CONDENSING TURBINE
P.M.P.S. UNIT 6

FIG. 2-7C

ELLIOTT CO. TYPE QV NONCONDENSING TURBINE
P.M.P.S. UNIT 5

FIGURE 2-8. TYPICAL SURFACE
CONDENSER INSTALLATION

FIGURE 2-9

LOW-PRESSURE SYSTEM - PERFORMANCE ANALYSIS

In order to determine a baseline level of performance for the plant from which comparisons of the various cogeneration cycle efficiencies could be drawn, a heat balance analysis was performed. For the purposes of this preliminary feasibility study it was decided that a rigorous heat balance conforming to the ASME Power Test Codes would not be necessary, but that an approximate analysis based upon existing plant records and manufacturers recommendations for equipment operations would be suitable. It should be noted here that the purpose of this heat balance was to develop an estimate of the level of performance of the total low-pressure system rather than to determine the exact level of performance of the major components such as the steam generator (boiler) or the turbine-generator unit. The paragraphs that follow offer a detailed description of the thermal energy flow pattern through the low-pressure system and a discussion of the results of the comprehensive heat balance.

SYSTEM FLOW SCHEME - Under full load operating conditions, Boilers 4 and 5 produce steam at a rate of approximately 220,000 lb/hr. (half from each boiler). The boilers feed a common high pressure steam header where steam pressure and temperature are 400 psig and 750°F, respectively.

The high pressure header supplies steam to turbine-generators 4, 5, and 6 at flow rates of approximately 75,000, 44,000, and 101,000 lb/hr., respectively. The turbine sections of the turbine-generators convert the thermal energy of the steam into kinetic energy and then into mechanical energy. The generator section of each unit then convert the mechanical energy of the turbine rotation into electrical energy. Under full load conditions, turbine-generators 4, 5, and 6 produce 7500, 1000, and 10,000 KW, respectively.

Turbine-generators 4 and 6 utilize condensing turbines and are set-up similarly. Since both can be represented by the same schematic diagram, a single discussion will describe their operation. Turbine-generator 5 utilizes a backpressure turbine and is of a somewhat different configuration. A description of the operation of turbine-generators 4 and 6 is presented below with a description of the operation of unit 5 to follow.

A schematic diagram of turbine-generators 4 and 6 is shown as Figure 2-10.

FIGURE 2-10
SCHEMATIC OF TURBINE GENERATORS
4 AND 6

The bulk (93-95%) of the steam entering these turbines expands through the turbine and exits at a very low pressure (approximately 2 inches of mercury absolute). The steam exhausts into a condenser where it condenses to a saturated liquid. The condenser serves as a heat exchanger where the latent heat of vaporization of the steam from the turbine is transferred to river-source cooling water. Since the latent heat of vaporization of water is high, the heat transferred to the river water represents a large heat rejection from the system. The boiler must replace this heat loss for each cycle through the steam/condensate circuit. As a result, the thermal efficiencies of turbine-generators 4 and 6 are low as will be shown in the following section.

A 20-horsepower condensate pump is used to remove the condensate from the condenser well and to increase the pressure on the condensate to 40 psig.. The condensate is heated by passing it through two heat exchangers (the air-ejector cooler and the low pressure feedwater heater). The condensate then flows into a surge tank.

The surge tank provides capacity for water storage so that the boiler feedwater flow rate can be varied to meet variations in steam demand. In addition to receiving the condensate pumped from the condensers wells of turbine-generators 4 and 6, the surge tank receives feedwater pumped from the condensate reservoir (the "hot well") and treated make-up water as needed.

Condensate then flows from the surge tank into a deaerating feedwater heater. The deaerator is an open-type feedwater heater utilized to remove noncondensable gasses from the feedwater. Steam exhausted from the auxiliary turbines in the plant provides a low pressure steam blanket in the deaerator.

Boiler feedwater pumps remove the condensate from the deaerator and increase the pressure on the liquid from approximately 30 psig to 475 psig. It is at this point that the liquid is now referenced as feedwater. The feedwater is forced through the high pressure feedwater heater (HP/HTR) and into the boiler, which completes the cycle.

A small amount (5 to 7%) of the steam fed to turbine-generators 4 and 6 is extracted at a point in the expansion (338°F and 20 psig) through the turbine and is used in a closed feedwater heater (low pressure feedwater heater) to heat the condensate being pumped from the condenser to the surge

tank. Heating the condensate in this manner results in a higher cycle thermal efficiency because heat is simply transferred from one point in the cycle to another and added at a high temperature to the condensate flowing toward the boiler, rather than utilizing heat from outside the cycle. After the extracted steam condenses in the feedwater heater, it flows through a low pressure trap and into the hot well reservoir for condensate flowing from various locations throughout the plant.

Approximately 330 lb/hr. of the 400 psig, 750°F steam from the main steam header flows through a steam-jet air ejector. The ejector is used to maintain a low vacuum pressure in the condenser. Since only a small amount of the energy of the steam supplied to the ejector is used in compressing the non-condensable gasses, much of the energy is available at the exit of the ejector. To reclaim the available thermal energy, the steam is passed into the air ejector cooler, a closed feedwater heater. There, the latent heat of vaporization of the ejector steam is transferred to condensate pumped from the condenser. After the air ejector steam condenses, it passes through a trap and into the trapped condensate reservoir.

Turbine-generator 5 (Figure 2-11) utilizes a backpressure turbine and is simpler than turbine-generator 4 and 6. Steam flows from the high pressure header (400 psig, 750°F), expands through the turbine, and exits at a pressure of 150 psig. The steam leaving the backpressure turbine is not condensed as is the case for turbine-generators 4 and 6. Instead, the steam is exhausted into a low pressure steam header (where steam pressure is 150 psig and temperature is 570°F) and then utilized at locations throughout the plant. As a result, the thermal efficiency of turbine-generator 5 is quite high.

The low pressure header supplies steam to: 1) the community steam distribution system, 2) the high pressure feedwater heater (HP/HTR in Drawing-2A), and 3) the auxiliary turbines in the plant used to drive various pumps and fans. Although the low pressure header supplies steam to the community steam distribution system, the bulk of the steam leaving turbine-generator 5 supplies the demands of the auxiliary turbines and the high pressure feedwater heater. The community steam demand must be partially met by throttling steam from the high pressure header to the low pressure header. The steam

FIG. 2-11
TURBINE-GENERATOR NO. 5
SCHEMATIC

throughput of unit 5 (and consequently the electrical production) effectively tracks the steam demand on the community distribution system, but only during the periods when total demand (in or out of the plant) for 150 psig steam is above the threshold which allows unit 5 to operate at a steady state (typically when outside steam demand is 30,000 lbm/hr. or over). The analysis discussed in this section is concerned with the electrical generating system and the utilization of the steam flowing to and from the electrical generating equipment. Therefore, the community steam consumption is considered to be zero in this analysis and discussion.

Steam from the low pressure header flows at a rate of 25,878 lb/hr. to the high pressure feedwater heater. The latent heat of vaporization of the steam is transferred to the boiler feedwater just prior to the feedwater entering the boiler. The steam and feedwater are at pressures of 150 and 475 psig, respectively; hence, the exchanger is referred to as a high pressure feedwater heater. After the steam condenses to a saturated liquid in the feedwater heater, the condensate passes through the steam trap and into the trapped condensate reservoir.

Several auxiliary turbines on the low pressure system also utilize steam from the low pressure header. Combined, they consume steam at the rate of 13,544 lb/hr. The auxiliary turbines are used to drive: 1) one 20-horsepower condensate pump for each of the turbine-generators 4 and 6, 2) one 20 and one 200-horsepower boiler feedwater pump, and, 3) four 75-horsepower fans feeding air to the boiler combustion chamber. Steam enters the auxiliary turbines at a pressure of 150 psig and leaves at a pressure of 30 psig. The exhausted steam flows into the deaerator, providing the low pressure steam blanket necessary in a direct contact, open feedwater heater.

SYSTEM HEAT AND MASS BALANCES - Heat and mass balances (Figure 2-12 and 2-13) were made on the low pressure system incorporating boilers 4 and 5, turbine-generator 4, 5, and 6, and auxiliary equipment. The balances shown in Figures 2-12 and 2-13 are for typical full load operating conditions taken from plant operations logs, manufacturers' guaranteed operating specifications, and various design and technical manuals. The system operating conditions used in the analysis are summarized on Drawing-2b. Standard power plant heat

FIGURE 2-12
MASS BALANCE ON LOW PRESSURE SYSTEM
(BOILERS 4 AND 5 AND TURBINE-GENERATORS 4,5, AND, 6)

FIGURE 2-13
HEAT BALANCE ON LOW PRESSURE SYSTEM
(BOILERS 4 AND 5 AND TURBINE-GENERATORS 4,5, AND,6)

balances procedures and assumptions were used in performing these balances. A comprehensive discussion of the analytical and computational tasks of the heat balance is presented in Appendix A.

THERMAL EFFICIENCIES - The thermal efficiencies were calculated for each of the turbine-generators and for the overall low pressure system. The thermal efficiencies of the turbine-generators can be calculated using the relationship:

$$\eta_{T-G} = \frac{\text{Electrical Energy Generation Rate}}{\text{Heat Addition Rate (from outside of cycle)}} \times 100\% \quad (2-1)$$

Utilizing equation (2-1) and the results of the system heat balance (from Figure 2-13), the thermal efficiencies, η_{T-G} , were calculated for turbine-generators 4, 5, and 6 and found to be 27.0%, 96.0%, and 27.3%, respectively.

The thermal efficiency of the overall system, excluding the boiler fuel conversion efficiency, can be calculated using the expression:

$$\eta_{G-S} = \frac{\text{Rate of Electrical Energy Production}}{\text{Rate of Heat Added to Feedwater By Boiler}} \times 100\% \quad (2-2)$$

By summing the electrical outputs of the three turbine-generators, the rate of electrical energy production of the system was found to be 18,500 KW or 63.1 million Btu/hr. The quantity of heat added to the feedwater by the boilers was obtained from Figure 2-13 by subtracting the quantity of energy carried into the boiler by the feedwater from the quantity of energy taken out of the boiler by the steam and was found to be 236.8 million Btu/hr. Using these values and Equation (2-2), η_{G-S} was determined to be 26.7%. This heat balance is represented schematically as Figure 2-14.

The boiler efficiency in converting the chemical energy of the fuel into thermal energy in the steam leaving the boiler is given by the expression

$$\eta_B = \frac{M_f \text{ HHV} (\text{MAh})}{s} \times 100\% \quad (2-3)$$

where

M_f = fuel input rate (lbm/hr.)
HHV = high heating value of fuel (Btu/lb)
 M_s = flow rate of steam leaving boiler (lbm/hr.)
 Δ_h = difference between enthalpy of feedwater entering the boiler and the steam leaving the boiler (Btu/lb)

The boiler efficiency was determined through combustion testing to be 80%.

The overall thermal efficiency of the total generating system including boiler efficiency is given by the relationship

$$\eta_{TS} = \frac{\eta_{GS} \eta_B}{100} \quad (2-4)$$

Using this expression and the values previously determined for η_{GS} and η_B , the overall thermal efficiency of the low pressure system was calculated and found to be 21.3%. This heat balance is represented schematically as Figure 2-15.

HIGH-PRESSURE SYSTEM - GENERAL DESCRIPTION

The high-pressure system, currently consisting of steam generator No. 6, turbine-generator No. 7 and auxiliaries which comprise a separate power unit, is the most recent addition to the Piqua Municipal Power Plant, constructed in 1961. A simplified flow schematic of the steam/condensate/feedwater cycle is detailed on Drawing-3 - "Heat Balance Diagram." System design is more typical of modern power plant design philosophy with four turbine extractions for staged feedwater heating. Descriptions of the major equipment follow.

STEAM GENERATOR - The steam generator for the high-pressure system is an Erie City Iron Works design, pictured in Figure 2-16, rated at 215,000 lbm/hr. steam supply @ 850 psig and 900°F. The boiler is a two drum, bent tube type Stirling Boiler composed of membrane welded watertube walls forming a water cooled furnace, with top-grid supported construction. The boiler is fitted with a two-pass, pendant type superheater with intermediate spray attemperator. Coal feed is by a Combustion Engineering traveling grate stoker, size 27' x 20'.

FIGURE 2-14. HEAT BALANCE ON GENERATING SYSTEM

FIGURE 2-15. HEAT BALANCE ON TOTAL SYSTEM

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO EM-78-C-02-4975

TEAM MEMBERS CITY OF PIQUA, OHIO

GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANGELMAN-ESKEW AND ASSOCIATES

PIQUA MUNICIPAL POWER PLANT
HEAT BALANCE DIAGRAM

NO. 6 BOILER NO. 7 TURBINE

SHEET OF

DRAWN KMI DATE 2/11/78
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APPR'VD _____

Four circular steam atomizing burners are provided for # 2 fuel oil firing. Combustion air is supplied in a balanced draft (FD and ID fans) arrangement. The boiler is also equipped with a 2" O.D. bare tube economizer.

ERIE CITY IRON WORKS
STEAM GENERATOR
215,000 (LBM/HR.)
850 PSIG 900°F.

FIGURE 2-16. BOILER UNIT 6
PIQUA MUNICIPAL POWER SYSTEM

TURBINE-GENERATOR - Turbine-generator No. 7 is an Elliott Company, multi-valve, multistage, single cylinder, straight flow, condensing machine with a nominal rating of 20,000 KW. Four extractions are provided for feedwater heating in a regenerative cycle. The turbine is direct coupled to a synchronous 3600 RPM, 60 cycle generator. Generator rotor excitation is provided by an integral harmonic exciter operating at 250 volts. Generator power output is at 4160 volts. (See Table A-1 in the Appendix.)

CONDENSER - The condenser in service on this system is a typical two-pass, two section, surface condenser of the general design depicted previously as Figure 2-8, manufactured by Elliott Company. Circulating water is provided on a once-through basis from the plant aqueduct connecting to the Great Miami River.

HIGH PRESSURE SYSTEM - PERFORMANCE ANALYSIS

The purpose of this analysis is to develop an approximative heat balance on the total high pressure system in order to determine a baseline level of performance for the Municipal Power Plant system.

Parameters such as the quantities of extraction steam, the turbine heat rate, cycle efficiency, etc., were determined at approximate rated conditions of turbine pressures, temperatures and steam flow rates. The information obtained from this analysis will serve as the basis for comparison when evaluating the alternatives for the retrofitting of the Power Plant for co-generation and district heating. The thermodynamic cycle, shown as Drawing-3, consists of the following components:

- i) Boiler equipped with an economizer and superheater
- ii) Turbine and generator
- iii) Closed feedwater heaters
- iv) Deaerator
- v) Air ejector and ejector condenser
- vi) Auxiliaries

The paragraphs that follow offer a detailed description of the thermal energy flow pattern through the high-pressure system and a discussion of the results of the comprehensive heat balance.

SYSTEM FLOW SCHEME - Under full load operating conditions, boiler 6 supplies steam at 850 psig and 900°F at a rate of approximately 165,000 lbm/hr. to turbine-generation unit 7. The turbine section accepts the steam, converting the potential energy of pressure into kinetic energy and then into mechanical energy in the form of shaft torque. The generator section accepts torque and induces an electrical current in the station windings of the generator. Under full load conditions, unit 7 produces 20,000 KW of electric power.

Turbine No. 7 utilizes a condensing turbine configuration and as such expands the bulk of the steam from main steam pressure down to a near vacuum (approximately 2 inches of mercury absolute). The steam exhausts into a condenser where it releases the latent heat of vaporization and condenses to a saturated liquid. River-source cooling water is also utilized in the No. 7 condenser in a once-through system. The heat transferred to the cooling water represents a large heat rejection from the system and as such significantly lowers the overall cycle efficiency.

Condensate is removed from the condenser well by a condensate pump which increases the pressure on the fluid to approximately 100 psig. The condensate is then heated by passing it through four closed-type heat exchangers in series (air-ejector cooler, feedwater heater drain cooler, and the low and intermediate pressure feedwater heaters, in order). Condensate next flows into an open-type feedwater heater, termed the deaerator. Steam at approximately 50 psig from a turbine extraction provides the low pressure steam blanket necessary in a deaerating heater. Condensate then flows by gravity into a surge tank connected directly to the deaerator. The surge tank provides a nominal storage capacity of 10 to 15 minutes so that instantaneous changes in the feedwater requirements of the condensate/feedwater system.

The boiler feed pumps take their suction directly from the surge tank and increase the pressure on the liquid to approximately 950 psig. At this point in the cycle, the liquid is now referred to as feedwater. The feedwater is forced through another closed-type feedwater heater, the "high pressure heater," and into the boiler, which completes the cycle.

A portion of the steam (15 - 22%) fed to the turbine is extracted at various points in the expansion and utilized in the feedwater heaters to pre-

heat the condensate/feedwater returning to the boiler. The high pressure heater utilizes extraction steam at 140 psig, the deaerator at 55 psig, the intermediate pressure heater at 24 psig, and the low pressure heater at 7 psig. The high pressure condensate from the extraction steam in the high pressure heater is flushed through a steam trap and into the deaerator to augment the steam blanket. The condensate exiting from the intermediate pressure heater is likewise flushed through a trap and into the low pressure heater. The low pressure heater drains are cycled in liquid phase through the drain cooler and dumped into the condenser hot well.

A small portion of the main steam supply is directed through the air ejector apparatus which maintains the low vacuum pressure in the condenser. Very little of the potential energy of the steam is lost as the non-condensable gasses are extracted from the condenser and compressed. The remaining thermal energy is reclaimed by passing the steam through the air ejector (steam) cooler and transferring it(thermal energy) into the condensate. The cooler drain is vented to atmosphere.

SYSTEM HEAT AND MASS BALANCES

The first law of thermodynamics was applied to the components and the processes of the cycle to determine the properties at certain state points, the steam extraction rates, power output of the turbine, the heat rejection in the condenser, and other quantities. The resulting mass and heat balances are presented as Figures 2-17 and 2-18, respectively. Standard power plant heat balance procedures and assumptions were used in performing these balances. A comprehensive discussion of the analytical and computational tasks of the heat balance is presented in Appendix A.

THERMAL EFFICIENCIES - Tables A-4 and A-5 presented in Appendix A list the calculated enthalpy values, mass steam rates, and other data pertinent to the heat balance on this system. Using these values, several thermal efficiencies, indicative of the performance of the system, can be calculated. The thermal efficiency of the turbine is expressed by the following relationship:

$$\eta_{T-G} = \frac{\text{Electrical Energy Generation Rates}}{\text{Heat Addition Rate (from outside of cycle)}} \times 100\%$$

FIG. 2-17
HIGH PRESSURE SYSTEM MASS BALANCE

FIG. 2-18

HIGH PRESSURE SYSTEM HEAT BALANCE

Utilizing this relation and the results of the system heat balance (from Figure 2-18), the turbine thermal efficiency, η_{T-G} , was calculated and found to be 34.97%. This efficiency represents a turbine heat rate of 9756 Btu/KWH.

Finally, a true accounting of overall system efficiency must also reflect the inefficiencies of boiler design and operation. This factor is taken into account, quantitatively, by the following expression:

$$\eta_{TS} = \frac{\eta_{T-G} \times \eta_B}{100}$$

where

η_{TS} = efficiency of total system
 η_{T-G} = generating system efficiency
 η_B = boiler efficiency

The boiler efficiency for the unit serving the high pressure system, boiler No. 6, was estimated to be 85.0%. Using the above expression and values, the overall thermal efficiency of the high pressure system was calculated to be 29.72%. This heat balance is represented schematically as Figure 2-19.

FIG. 2-19

COMBUSTION TURBINE

In addition to the base-load and cyclic-load capacity of the steam turbine plant, the Municipal Power Plant System has peak load capacity in the form of a combustion (or gas) turbine. Unit No. 8 is a General Electric open, simple cycle, single shaft combustion turbine with regenerator rated at 18,460 KW (25,000 HP) nominal capacity. This machine is fired on No. 2 fuel oil and is capable of a fast start from cold to full load within six minutes. Typical efficiencies for machines operating on this cycle (pictured in Figure 2-20 below) range from 19% to 21%.

FIG 2-20
GAS TURBINE WITH REGENERATION

POWER TRANSMISSION AND DISTRIBUTION SYSTEM

Power distribution in the City of Piqua and its contiguous areas is handled by the Electric Department of the Municipal Power System via the main distribution facilities depicted on Figure 2-21. The primary distribution system is a 13.8 KV loop, originating at substation No. 1 at the power plant and interconnecting two additional 13.8/4.16 KV distribution substations (Nos. 2 and 3). The Municipal Power System is also interconnected to Dayton Power and Light Company (DP&L) via a 69 KV tie line. The intertie is achieved at substation No. 1 through a single 30/40/50/ MVA, three-phase 69/13.8 KV transformer. The station was designed to facilitate the installation of a second 69 KV tie to DP&L.

The existing distribution system facilities are predominately overhead horizontal configurations with wood cross arms. Consistent with most urban distribution systems with a high load density, the distribution lines are substantially under built with secondary distribution. The bulk of distributed power is supplied to city customers at 4.16 KV. The distribution feeders are constructed radially from 5 KV metal-clad switchgear located at each of the three distribution substations.

A long-range plan has been formed to improve the power systems 69 KV bulk transmission capability and improve load center developments. A 69 KV sub-transmission system within the City has been planned by the Electric System. A 69 KV loop to and from the existing 69 KV switching station will become the backbone for three new 69/13.8 KV 25 MVA substations designated "East, North, and South". The material acquisition for two of the three planned substations has been completed. When completed, the East and North substations will have load burden capabilities of 25 MVA. If integrated with the existing 13.8 KV sub-transmission system, interruptions to continuous electric service would be prevented should the system experience loss of one substation transformer. This capability would be continued when the third unit station is completed. Intermediate and long term improvements to the system transmission reliability should include considerations for a second bulk-power supply point. This could include constructing a second tap point on the DP&L Covington-Sidney 69 KV circuit, or constructing a 138 KV transmission and substation facility

and a tap on the DP&L Miami-Sidney circuit.

Based upon load projections and the discussions with Electric System staff, it has been determined that the load center approach to distribution substation planning is the most appropriate plan for the urban type load of the City of Piqua. This will be accomplished with the location of 69/13.8 KV compact substations with specific load areas throughout the system. The load center substation will provide needed capacity for developing commercial and residential areas, and provide excellent back-up source for the existing municipal substations when interconnected with the 13.8 KV sub-transmission system.

The load center approach will provide the following advantages:

1. Greater circuit reliability. Statistically, shorter feeders are exposed to fewer feeder outages.
2. Better circuits performance. Fewer voltage problems, and less time involved in voltage complaints and less money invested in costly line regulators.
3. Greater speed in clearing faults.
4. Fewer customers would be affected when circuit outages or station outage occurs.
5. Lower initial investment in substation equipment.

With the completion of the North and East 69 KV/13.8 KV load centers and the interconnecting 69 KV bulk transmission loop, the Piqua system will have adequate distribution and interconnection facilities through the mid 1980's at the anticipated rate of load growth. At that time the third load center located generally in the western section of the service area is planned. Current plans also incorporate the recommendation for a second 69 KV tie between DP&L and Piqua to augment the existing 2.5 mile radial interconnect between the systems.

Additional 69 KV facilities could be accelerated if a very large industrial consumer should locate in the service area not readily served from the existing system.

STEAM SYSTEM

As mentioned in a preceeding section of this chapter, the Municipal Power System, in addition to providing electrical service to the community, also provides steam service to approximately eight industrial customers. The steam supply service developed as a by-product of the operational steam turbine electric generating plant because in the past, this arrangement resulted in a favorable overall heat balance on the low-pressure system with resulting economies in electric power production which could not have been effected by separate electric and steam producing sources.

Eight industrial-type customers in the general vicinity of the power plant are provided steam service (steam @150 psig and (approx) 400°F) via the distribution system depicted on Figure 2-22. The community supply system steam source is a direct piping connection inside the powerhouse with the plant low-pressure (150 psig) steam supply header. The steam system extending from the north end of the powerhouse consists of an 8" steam supply line and 3" condensate return line, feeding a main distribution junction at manhole No. 1, northwest of the powerhouse and west of Main Street. Two customers, ORR FELT COMPANY and MILLER-METEOR, are supplied from the junction at this manhole. One distribution leg of the system, consisting of an 8" steam supply line and a 3" condensate return line, extends in a westerly direction along Clark Avenue and terminates west of the Baltimore & Ohio Railroad at the intersection of Clark and Roosevelt Avenue. Two customers, A. C. MILLER COMPANY and HARTZELL INDUSTRIES, INC. are served from this leg.

A second leg of the distribution system, consisting of a 4" steam supply line, extends north from the No. 1 manhole along Main Street to the intersection of Main and South Street, where it terminates at Bennett Junior High School. One other customer, DUER PLASTICS, is served from this leg of the system.

The third leg of the distribution system, again drawing steam from the plant's low-pressure steam header, extends from the south end of the powerhouse southward along south Main Street. This leg consists of two separate 8" steam lines. This line is currently out of service due to maintenance problems. The second line parallels the first line south along Main Street to

CITY OF PIQUA

MIAMI COUNTY,

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-76-C-02-1976

TEAM MEMBERS CITY OF PIQUA, OHIO
GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSelman-ESKEW AND ASSOCIATES

Fig. 2-22

**PIQUA MUNICIPAL
POWER SYSTEM**

STEAM DISTRIBUTION SYSTEM

SHEET

OF

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Hemm Road, where it crosses Main to connect with a customer, the Joint Hospital Services (Laundry). Also tied into this second line is an 8" steam supply line to the now decommissioned Experimental Nuclear Reactor, across the Miami River. During the Reactor's active service in the early 1960's the Municipal System had a reciprocal supply/receive arrangement with the A.E.C. installation. This section of the line has been dismantled.

Steam distribution during the period 11/1/77 through 10/31/78 totalled 202,285,400 lbm. for an average hourly requirement of 23,100 lbm. Peak demand during this period was 50,000 lbm/hr. The bulk of the steam is sold to the eight industrial customers located along the steam distribution line routes are also served by the system.

Steam service is provided to the steam customers under individual contracts. Several of these contracts are in effect until the early 1980's and in the preliminary opinion of City Counsel, the City is obligated to provide service until that time.

2.1.5 CURRENT PLANT STATUS

As may be apparent from the discussion of the historical aspects of the Municipal Power System, several of the major system components may be approaching, or have already reached, the end of their efficient operational lifespans. Two major factors contribute to this situation. The first obviously is age and the attendant deterioration of equipment. The second is the matter of system economics which influences operating practices to take advantage of the economies of scale inherent to the larger power units. The affect of each of these factors can be seen in the equipment status in the Piqua Plant.

Steam generator (boiler) units 1 and 2, manufactured by Combustion Engineering and placed in service in 1933, have deteriorated to the point that they are no longer serviceable for operation on the low-pressure system. Problems such as extensive boiler tube leakage, outer casing gas leaks, etc. have forced the Municipal Power Plant to decommission this equipment. In the event that extra space is needed inside the building envelope for expansion of the plant electrical generating system or for the installation of District Heating System - related equipment, the Power System Director has expressed a willingness to have this retired equipment removed from the plant and sold for salvage in order to vacate the building sector presently occupied.

Boiler No. 3, on the other hand, was relegated to stand-by status because of its low utilization (capacity) factor once boilers 4 and 5 became operational, and because of the inferior economies of scale as compared with the newer units. This unit (No.3) was fired as recently as 1975 in an operational test at rated conditions (400 psig, 750^oF) for a brief period of time. This unit is today in suitable operating condition (environmental considerations aside) and may, pending a current operational status check and engineering rerate study, quite likely be modified to serve as a source of peak thermal energy to a District Heating System installed at the plant. The feasibility of this option will be discussed in a later section of this chapter.

Boilers 4 and 5 are in routine service on the low pressure system with no significant operational problems. Boiler 4 suffers from a slightly decreased combustion and heat transfer efficiency due to problems with the combustion air control mechanisms (dampers) and from a minor casing breach

which allows excess air intake (due to the slightly negative internal casing pressure of the balanced draft design). It is duly noted, though, that efficiency on this unit suffers only to the extent that excess O_2 (a measured 19.4% excess O_2 versus a 10.0% excess O_2 level recommended by the manufacturer) can effect the fuel combustion efficiency in a unit of this design. Additionally, these above-mentioned problems are presently being investigated and corrected under the Municipal Power System's recently upgraded preventive/remedial maintenance program. Boiler 5 has a similar problem, although to a much lesser extent. A minor damper misalignment for supply air to two of the five combustion air zones in the proximity of the traveling grate stoker precludes precise control of the excess O_2 level in the furnace. The effect upon combustion efficiency is marginal; excess "air" was measured to be around the 13.5% level (versus the recommended 10.0%). It is estimated that an approximate 1% to 1.5% increase in combustion efficiency could be achieved with proper adjustment, and this action is likewise being undertaken under the improved maintenance program. Both boilers have been equipped with bare tube economizers which aid in recuperating energy otherwise wasted as stack losses. However, at this time both economizers have been bypassed (in the water circuit) because of significant feedwater leakage problems likely caused by fly ash erosion of the tube surfaces. The System Director has put out for and received several bids for re-tubing the internals of both economizers. Acceptance of the low-bid is pending an analysis of the projected payback period.

Turbine-generators 1, 2, and 3 on the low pressure system have been retired from active service. Unit 1 has been partially dismantled and is utilized only as a spare parts source. Units 2 and 3 are still serviceable, however, and see occasional stand-by service. This pair of units has been relegated to stand-by status chiefly due to their low utilization factors once the larger units were put in service.

Turbine-generators 4, 5, and 6 have been in routine operation since they commenced operation with no extraordinary maintenance having been required. The new preventive maintenance program has included provisions for regular service intervals on these machines. It is anticipated that the routine inspection and maintenance intervals can be scheduled for periods of low demand on the system (notably during the spring and fall seasons with their

attendant moderate weather) and can be accomplished with no deleterious effects on the Municipal System load/operation strategy.

The segregated high pressure system has been out of service since mid - 1976 due partly to the lack of support from the equipment manufacturer, Elliott Co., in resolving an operations problems, and partly to the inattention of the plant maintenance department. A sporadic problem in the mechanical turbine load control system (specifically the main steam admission valves) was causing sudden variations in generator output. Preliminary inspections revealed the need for new turbine control parts and the unit was shut down pending receipt of replacement parts and technical support from the manufacturer. The problem was compounded by the lack of a comprehensive maintenance policy/procedure for the plant. The problem continued unresolved and finally the equipment was left to deteriorate. The first goal of the upgraded maintenance program, instituted by the new Power System Director upon his appointment in September 1977, was to re-commission this unit for service in the Municipal System. An extensive rebuild on the turbine-generator, the boiler, and auxiliaries is nearing completion with the system tentatively scheduled to return to service by the end of June 1979.

The three boilers which will be in routine operation (4, 5, and 6) have been evaluated to determine modifications necessary to bring them under compliance with recently enacted Ohio Environmental Protection Agency standards. These standards provide mainly for the regulation of the area-wide concentrations of sulphur dioxide and total suspended particulates. The plant currently meets the emission standards for sulphur dioxide by burning "low-sulphur" coal (approximately 0.6% by weight); however, particulate emission standards are exceeded. The City has signed a Consent and Abatement Order with OEPA committing the Power System to meeting the particulate emission standards by whatever means necessary. The design/bid/construction process is now underway to retrofit each of the three operational boilers with bag-type dust collectors. This retrofit, upon completion, should bring the P.M.P.S. plant within compliance. A more thorough discussion of the OEPA regulations and their effect on the Piqua Power Plant is presented in Chapter 5.0.

The City administration and the citizenry of Piqua has heartily supported

the operation of "their" power system since its inception and has recently renewed its commitment to its continued ownership and operation. In response to an obvious decline in the condition of the plant and system and to the incompetence of and the lack of policy direction from the previous Power System Director, the City hired in September 1977 a new Director with many years experience in Municipal Power System technical and administrative management. The City Council has pledged Piqua's resources to the acquisition and installation of the appropriate environmental protection equipment and to the support of an increased and improved maintenance program within the plant itself. Plans are going forward for the expansion and improvement of the System's transmission and distribution facilities and for the upgrade of the intertie facilities with the neighboring DP&L utility. In sum, all indications are that the City of Piqua intends to maintain and operate its Power System through the foreseeable future.

One final note of observation is necessary concerning the City's favorable decision on the continued operation of their Power System. In the earlier years of slow to moderate power system growth, the planning strategy for most electric utilities provided for the construction of small to moderate capacity power units (size effectively limited by what the then - current technology could produce) which would serve during a planned plant lifespan and then be retired from active service as new capacity was brought on line. However, in light of the rapid growth patterns in electrical load demand in recent years (particularly during the period 1960-73 when the yearly growth averaged 4.35%), electric utilities have revised their planning strategies for supplying electric power demand.

Rapid demand growth, coupled with longer plant lead times and the entirely revised economic outlook of current times, has brought the utilities to the realization that it may be more cost effective to retain the capacity of the older plants, which would have been decommissioned, through extensive rebuild/renovate programs than to construct an entirely new plant. Admittedly, the system economics of a Municipal system like Piqua's are reduced by several orders of magnitude from those of a large, multi-plant, investor owned utility, but the basis for the decision is the same and appears sound.

2.1.6 LOAD DISPATCH

In any community's overall pattern of energy consumption (particularly electric power), several characteristic usage patterns, depending on such diverse factors as community composition and degree and type of industrial development, combine to produce an overall consumption curve. These distinguishable but interrelated patterns were perceived in the Piqua community as being: hourly levels of power usage during a 24-hour period (illustrating the daily power demand cycle); daily patterns of total kilowatthour production (which, when delineated for a 365-day period, reveal the weekly and seasonal load demand pattern); and the standard load level (percent of peak demand) versus duration patterns. In order to discern and comprehend the energy consumption patterns on a community-wide scale, a methodology to reduce the various forms of operational data into a concise, readable, and standardized form was necessary. In the sections that follow, the methodology for deriving these curves is discussed and the results are presented.

METHODOLOGY

Energy is produced and delivered in two forms from the Piqua Municipal Power Plant: industrial quality steam (150 psig), and electric power. In addition, purchased electric power (from Dayton Power & Light Company) is received and metered at the Power Station's main switchyard before being distributed to the community through the Municipal transmission and distribution system. Thus, the power plant operational log sheets serve as a readily accessible source of energy production/consumption information. Producing the curves which depict the first two energy consumption patterns - hourly KW demand and daily KWH production - involved only reproducing in graphical form the operational data from plant log sheets. Plant procedures dictate that various operational data be documented once each hour, on the hour. Such readings include entries on the DAILY SWITCHBOARD LOG for "Total Indicated K.W." (which denotes the total instantaneous demand on the Municipal System) and "69 K.V. Incoming Power" (which represents power purchased from DP&L - registered in megawatts - MW). Community power consumption - i.e. outgoing power from the plant is totalized via a kilowatt hour meter on the main power distribution electrical bus; power production/distribution during each 24-hour period is

tallied from these meter readings. For the graph of hourly KW demand, the hourly total demand readings from the switchboard log sheets were plotted as the graph ordinate versus time (hourly divisions) as the graph abscissa. Purchased power was plotted in the same manner. Lacking more detailed data on the path of the demand curve, demand was assumed to be constant throughout each hourly period. The result is a histogram-type plot, rather than a smooth curve, for hourly electrical demand. The area under the curve, easily integrated by the graphical method, thus represents total kilowatt hour production during the specified period. Seven 24-hour periods from the winter of 1978 were selected and graphed to represent a typical hour-by-hour electric demand profile for a one week period.

The graph of daily total kilowatt hour production was produced in much the same manner as the first graph. The totalized daily KWH production reading was taken directly from the DAILY SWITCHBOARD LOG and plotted as the graph ordinate versus time (daily divisions) as the graph abscissa. A histogram-type plot was produced to facilitate distinguishing each daily level of KWH production from the next. Daily production was graphed for the period 11/1/77 through 10/31/78.

Derivation of the Load-Duration curves for community power consumption was somewhat more involved, in spite of the ready availability of appropriate data from the plant operational log sheets. To produce curves with a degree of accuracy suitable to this analysis necessitated an hour-by-hour tally of the levels of electrical demand. Again, the DAILY SWITCHBOARD LOGS for the period 11/1/77 through 10/31/78 were utilized as the data source. In order to facilitate the recording of the log sheet data, the bin method of data reduction was employed. A preliminary survey of hourly demand throughout the one year base period revealed a nominal annual peak demand of 40,000 KW. 80 data storage bins, in lots of 500 KW each (1-500 KW, 501-1000 KW, etc.), were structured. Plant operational log sheets containing entries for hourly community KW demand were then inspected. For each hourly reading from the log sheets, a mark was made in the appropriate data bin on the tally sheet, representing one hour of community KW demand at that particular level. Separate tally sheets were completed for each of the twelve months in the one-year base period. In addition, an overall tally sheet for the yearly period was totalled from the monthly

sheets.

It should be noted that, at this point, there are two options for producing a graphical representation of the Load-Duration curve. Computer programs are available to produce the desired curve from the appropriate data. However, some amount of data interpretation and coding are required. The second option is, of course, manual graph construction. Due to the fact that extra effort is required to interpret and code the data for input into the computer program, it is likely that, if only a limited number of graphs are required, the manual graphing method will be the more expedient.

In the classic Load-Duration curve, (an example is shown as Figure 2-23) time is represented as the graph abscissa versus load (usually represented in percent of peak demand) as the graph ordinate. For the monthly graphs, an appropriate scale was selected for the axis of the abscissa to represent time from zero (0) to (up to) 744 hours - 31 days. For the axis of the ordinate, an appropriate scale was selected to represent load from zero to 100 percent with 100% equivalent to a peak demand of 40,000 KW. In order to transpose the accumulated data from the bin form in KW to a percent of peak demand, the mid-point value (representative of the average value of that bin range) was selected and calculated as a percent of the nominal peak load (40,000 KW). Each mark in that bin then represented one hour of demand at that percentage level. With the data in each bin thus defined, graph construction was routine. The point represented in the highest level of demand, necessarily at the shortest duration, was first plotted. A point representing each bin, in decreasing order and predictably at longer and longer periods of duration, was then plotted, with time in each monthly period illustrated cumulatively. Finally, a curve was plotted, with the appropriate amount of detail, to connect each of the actual data points. This procedure was followed to produce twelve monthly Load-Duration curves for November 1977 through October 1978 (inclusive) and one overall, or annual, Load-Duration curve for the base period.

FIG. 2-23
LOAD DURATION CURVE

As previously noted, a significant quantity of thermal energy in the form of industrial quality steam is also distributed from the Municipal Power Plant. A complete analysis of the community's energy consumption patterns must necessarily include usage of this form of energy. For this reason, a similar documentation for steam distribution/consumption was performed. Load-Duration graphs for each of the twelve months in the base period, plus an annual graph of steam consumption, were constructed using much the same procedures as for developing the electrical Load-Duration graphs. Plant operational logs document the rate of steam distribution (in pounds-mass per hour) each hour. These readings were extracted from the plant BOILER ROOM LOGS and reduced to the appropriate data points using the bin method previously discussed. The ordinate axis of the steam distribution graphs was scaled from zero (0) to 100 percent with 100% of annual peak steam demand being equivalent to 50,000 pounds-mass per hour steam flow. Graphs were constructed manually following the same method as for the electric energy consumption graphs.

With the overall community energy consumption patterns thus characterized,

it was necessary to formulate a methodology to segment the various portions of the load pattern between the particular power producing turbo-generator units within the Municipal Power Plant. In general, power system accounting practice utilizes two factors as indices of individual unit performance: operational availability and capacity factor. The operational availability factor is an indicator of the percentage portion of time in any specified period that a particular unit is in service and capable of producing power. It accounts for time out of service for scheduled maintenance, emergency shutdowns, or any number of other reasons. Capacity factor is an indicator of the average level of actual power production or output (expressed as a percent of peak capacity) from any particular power generation unit, while it is in service. Capacity factor reflects the effects on each power unit of the cyclic nature of power system energy supply and demand. (As an example, a typical 24-hour electrical demand cycle demonstrates a significant decrease in demand throughout the night-time hours. The power unit supplying this decreased demand, even though in service and capable of supplying more power than is consumed, is operating at far below its rated capacity, thus resulting in a decreased capacity factor for the period it is in service.) These two indices are defined as follows:

$$\text{CAPACITY FACTOR} = \frac{\text{TOTAL KWH GENERATED}}{\text{NAMEPLATE CAPACITY (KW)} \times \text{HOURS ON LINE}} \times 100\%$$

$$\text{OPERATIONAL AVAILABILITY} = \frac{\text{TOTAL HOURS ON LINE}}{\text{HOURS IN PERIOD}} \times 100\%$$

From the definitions it is apparent that only two sets of operating parameters, total KWH generated and hours on line, are necessary to define these factors for any particular unit. Again, the plant operational log sheets served as the data source. For each individual turbine-generator in service at the Municipal Power Plant, the actual power generated and time in service was tabulated from the DAILY TURBINE LOG on each unit. The appropriate data was fed into the above equations to generate operational availability and capacity factors for each of the twelve months and an annual figure for the one-year base period.

For the base period of November 1977 through October 1978, actual power production figures are available for turbine-generator units 4, 5, and 6. However, due to the fact that the Municipal system's base-load unit, the 20,000 KW unit 7, was out of service during this period, a radical alteration in system operating procedures was in effect. The most noticeable affect on the system was that approximately 56% of the power consumed in the Piqua community during the base period was purchased from DP&L. In light of this situation, a different approach was utilized to estimate the production capacities of the various turbine-generator units. In effect, a scenario for normal operating procedures was constructed, based on power plant operating experience, maintenance requirements, and the seasonal nature of the community energy demand profile.

Typical capacity factors and operational availabilities are as follows for the various ranges of the load-duration pattern:

BASE LOAD UNITS

- Capacity factor - 70-85%
(Piqua's unit 7 when
reactivated, will assume
this duty)
- Operational Availability - 90-100%
(scheduled outages from
maintenance)

CYCLIC LOAD UNITS

- Capacity factor - 40-65%
- Operational Availability - 40-60%
is typical for the
Piqua System

PEAK LOAD UNITS

- Capacity factors - As necessary to
supply peak in
- Operational Availability - demand curve

In addition, the P.M.P.S. has another unit which must be considered in a unique category, the backpressure turbine-generator unit 5.

BACKPRESSURE UNIT

Capacity factor - level of output is again dependent on steam demand. Therefore, historical trends from the base period are to be assumed.

Operational availability - Due to system design, Piqua's unit 5 backpressure turbine can be operated only when steam demand for plant or community usage exceeds 30,000 LBM/HR. Therefore, historical trends from November 1977 - October 1978 base period can be assumed.

With the above discussed "rules of thumb" for power system operating practices in mind, the monthly Load-Duration curves were segmented into blocks of kilowatt hour production commensurate with the estimated performance of each turbine-generator unit. The results of this analysis of the community energy consumption pattern are presented and discussed in the following sections.

RESULTS

The results of the reduction of the plant operational data are presented graphically in the various load versus time plots shown on the following pages. The first pair of plots, Kilowatt Demand vs. Time (by hours) and Kilowatt-Hour Production vs. Time (by days), is presented primarily to illustrate qualitatively the dynamics of community energy demand. The second series of plots, Monthly and Annual Load vs. Duration graphs - details quantitatively the cumulative levels of demand for the various forms of energy supplied by the Municipal Power Plant and will be used in estimating and assessing the costs of energy production (or more correctly conversion) at Piqua's conventional cycle power plant. These plots will also form the basis for comparison with the various alternatives for cogeneration energy production (which will be discussed in later chapters). Each particular graph is discussed briefly in the paragraphs which follow.

Kilowatt Demand vs. Time - This graph, presented as Figure 2-24, illustrates the hourly variations in the level of electrical demand on the Municipal Power System. As is typical, the lowest demand level occurs in the early

FIGURES 2-24 A & B
KILOWATT DEMAND vs. TIME
(by hour)

morning hours (2:00 - 4:00am) with the highest demand level occurring in the late morning hours (9:00 - 11:00am). Demand then drops off steadily until approximately 6:00pm, when a second characteristic peak (although proportionately lower than the mid-morning peak) occurs. Weekend peaks are noticeably lower than the weekday peaks. A secondary plot on this same set of axes reveals that, during this subject period, the Piqua system was base loaded at approximately 15,000 KW with the remainder of demand made up with power purchased from DP&L. This operating strategy is not typical but was necessitated by the loss of the base load capacity of the unit 7 turbine-generator.

Kilowatt Hour Production vs. Time - This graph, presented as Figure 2-25 a-c, illustrates the daily and seasonal variations in the level of electrical demand on the Municipal Power System. As would be expected, weekend production/consumption is significantly lower than during the weekdays. Midwestern utilities are generally considered to be winter-peaking systems (with uniformly low levels of KWH production during the summer months); indeed, the overall peak during the base period occurs on 10 January 1977 at 725,000 KW consumption. However, recent trends in the Piqua load pattern have been to exhibit significant summer peaks also. During the base period, there occur two significant summer peaks: 21 July 1977 and 19 September 1977, both at 715,000 KW consumption. Further examination of the load pattern reveals that it more closely resembles that of a twin-peaking system (winter and summer). Electrical production generally is high during the periods of December through February and mid-July through September. The Spring and Fall months exhibit a generally lower demand profile due to the moderate weather. It is recommended, based on the above observations, that the Piqua Municipal Power System be considered a twin-peaking system.

PRODUCTION SUMMARIES AND LOAD-DURATION CURVES - The most generalized statement which can be made regarding the data presented in the production summaries is that it confirms the radical change in the P.M.P.S. operating procedures influenced by the loss of its base-load unit 7. Table 2-1 presents a month by month and annual tally of the energy distribution from the plant. Of the total 191,859,350 KWH distributed from the plant during the base period 56% (107,563,000) was purchased power. If the base load unit were returned to service, it is estimated that the purchased power could be reduced to an

CITY OF PIQUA, OHIO
MUNICIPAL POWER SYSTEM
DAILY ELECTRIC LOAD
11-1-77 — 10-31-78

FIG. 2-25A

CITY OF PIQUA, OHIO
MUNICIPAL POWER SYSTEM
DAILY ELECTRIC LOAD
11-1-77 — 10-31-78

FIG. 2-25B

CITY OF PIQUA, OHIO
MUNICIPAL POWER SYSTEM
DAILY ELECTRIC LOAD
11-1-77 — 10-31-78

FIG. 2-25C

approximate 14.5% of the total system demand. (Note: this condition will be reflected in the operations scenario developed for the base case vs. cogeneration comparison.)

TABLE 2-1
PIQUA MUNICIPAL POWER PLANT
PRODUCTION SUMMARY (11/1/77 - 10/31/78)

MONTH	P.M.P.S. PRODUCTION KWH	PURCHASED POWER KWH	STEAM DISTRIBUTION LBS.
NOV.	6,858,140	8,563,000	12,811,800
DEC.	9,714,200	6,912,000	19,322,400
JAN.	10,074,080	7,901,000	21,601,900
FEB.	9,342,380	7,594,000	23,811,150
MARCH	9,036,460	7,528,000	36,305,250
APRIL	5,511,660	8,612,000	19,435,900
MAY	2,392,980	12,401,000	19,045,800
JUNE	5,710,400	9,737,000	6,816,000
JULY	7,733,060	8,314,000	8,438,400
AUG.	4,463,440	12,248,000	9,768,600
SEPT.	4,258,940	11,571,000	12,003,600
OCT.	9,200,610	6,182,000	12,924,600
TOTALS	84,296,350	107,563,000	202,285,400

Table 2-2 presents a month by month and unit by unit breakdown of the power plants performance during the base period. On a more specific unit by unit examination:

- Unit 3 - variable O.A. and high capacity factor confirms this units status as a stand-by unit.
- Unit 4 - wide range of O.A. factors is not typical of a cyclic load unit and is also not representative of normal P.M.P.S. operating procedures. However, the capacity factor ranging from 52.36% to 74.12% confirms the suitability of the unit to cyclic load range.
- Unit 5 - High O.A. during the winter months, lower during the spring and fall months, and off line during summer months and variable capacity factor indicates that the backpressure unit, supplying steam into the community steam distribution line, will effectively track the climate variations during the heating season.
- Unit 6 - O.A. and capacity factors are most representative of cyclic load unit operation on the Municipal Power System.
- Unit 7 - off-line for extended maintenance.
- Gas Turbine - Operation was typical of Peak Unit operation which depends strictly upon specific system dynamics.

As explained in the section detailing the methodology, operation of the plant during the base period was not representative of plant operating strategy when all units are available for service. Therefore, the average operational availability and capacity factor statistics from the base period are instructional but not particularly useful in constructing and documenting a scenario for the operation of the plant under typical conditions. Such a scenario is necessary, however, in order to make credible estimates of the primary fuel consumption of the Piqua Power Plant when meeting the energy needs of the community. It should be noted here that the task of estimating primary fuel consumption in the plant is compounded by the agglomeration of units in the plant and by the diversity of their attendant heat rates. It was necessary then to develop, through the methodology previously discussed, an operating schedule which

TABLE 2-2
PRODUCTION SUMMARY

MONTHLY OPERATIONAL AVAILABILITY AND
CAPACITY FACTOR

MONTH	#3		#4		#5		UNIT #6		#7		GAS TURBINE	
	O.A.	CAP	O.A.	CAP	O.A.	CAP	O.A.	CAP	O.A.	CAP	O.A.	CAP
NOV. 77	-----	-----	31.45	67.11	65.23	52.97	100.0	64.72	-----	-----	-----	-----
DEC. 77	-----	-----	73.61	56.14	97.57	51.08	100.0	64.52	-----	-----	17.12	50.61
JAN. 78	-----	-----	24.42	57.96	100.0	63.23	100.0	80.38	-----	-----	27.40	5.79
FEB. 78	65.24	92.55	.56	35.56	100.0	67.68	100.0	64.58	-----	-----	32.06	49.62
MARCH 78	30.02	83.96	14.27	56.51	100.0	48.06	83.57	57.27	-----	-----	40.49	57.02
APRIL 78	13.96	86.57	-----	-----	100.0	31.58	100.0	49.03	-----	-----	-----	-----
MAY 78	-----	-----	-----	-----	64.21	25.12	100.0	65.05	-----	-----	.75	54.55
JUNE 78	-----	-----	35.73	74.12	-----	-----	65.10	64.64	-----	-----	2.53	43.93
JULY 78	54.53	97.73	100.0	73.66	-----	-----	-----	-----	-----	-----	4.36	62.85
AUG. 78	8.85	95.70	95.86	47.48	-----	-----	95.59	42.89	-----	-----	1.81	100.0
SEPT. 78	-----	-----	59.06	52.36	-----	-----	100.0	60.83	-----	-----	.04	35.71
OCT. 78	10.45	47.65	58.75	57.96	-----	-----	90.86	78.25	-----	-----	.08	32.26

reflected the utilization of the full operational capacity of the plant in meeting the load-duration conditions during the base year. The monthly load duration curves were used to great advantage in performing this sub-task. The curves were first examined for their characteristic peak, cyclic and base load segments, then segmented according to the individual capacities and load characteristics of the full complement of power generation units. The result, an example of which is Figure 2-26, is a load duration curve for each month during the base period which illustrates graphically the total community electric demand during the period and the plant load strategy which was followed to meet that demand, and contains data concerning the specific performance of each power generation unit as it was utilized to meet the demand. In the example, the curve shows that power was purchased from DP&L at a constant rate of 3000 KW from the full period. Unit 7, operating to supply the base load for the system, was in service for the full period, operating at roughly three-quarters capacity (15,000 KW average). Unit 5 was placed in service in response to mounting steam demand and operated for approximately 470 hours ($.6523 \times 720$ hrs). Unit 4 was in service for less than half the period (41.67%) and operated at an average capacity of 4688 KW output. The gas turbine peak unit was operational for approximately 25 hours total as system peaks occurred. Each of the twelve monthly load-duration curves, illustrating the community demand profile and the plant operation to meet that demand, is reproduced in Appendix A.

The annual load-duration curve, presented as Figure 2-27, illustrates the overall community power demand pattern during the base period. While the annual pattern cannot be segmented by the same methodology applied to the monthly curves, the data from the monthly curves can be tallied to produce a statistical profile of each power unit's operation in meeting the annual demand. The results of that analysis are presented as Table 2-3.

TABLE 2-3
PRODUCTION SUMMARY

<u>UNIT</u>	<u>HOL*</u>	<u>KWH GENERATED</u>	<u>CAPACITY FACTOR</u>	<u>OPERATIONAL AVAILABILITY</u>
3	-	-	STANDBY	-
4	1460	7,450,000	67.12%	16.67%
5	4464	2,249,764	50.40%	50.96%
6	3291	20,580,279	62.54%	37.57%
7	8016	124,936,327	77.93%	91.51%
GAS TURBINE	735	1,965,430	13.37%	8.39%

An important factor in the operation of the Municipal Power Plant is the ability to purchase power from the neighboring Dayton Power and Light Company (DP&L), subject to the terms of the Interconnection Agreement, reproduced in Appendix A. This agreement provides for the purchase of power classed in four categories: firm power, short term power, emergency energy, and economy energy. P.M.P.S. currently purchases significant amounts of energy under the firm power arrangement. This arrangement calls for the purchasing entity to specify the level of firm power desired and, if DP&L agrees to the terms, sign a contractual commitment for that amount for a one year period. The supplying utility agrees to "stand ready at all times to deliver to the [purchaser] firm power and associated energy in any amount desired by the [purchaser] up to the firm contract demand,..." The purchaser agrees to compensation on the following terms:

- Demand charges - \$4.24 per kilowatt per month for the privilege of keeping the ready reserve in firm power
- Energy charge - \$0.01156 per KWH for energy actually consumed
- Fuel Adjustment - 0.01032 per KWH, subject to fluctuating adjustment

P.M.P.S. currently has contracted for 10 MW of firm power due mainly to the fact that the 20 MW unit 7 has been out of commission. Once this unit resumes service, it is likely that the System will reduce its commitment for purchasing

firm power to perhaps 5 MW, subject to the next contract renewal data.

The agreement also technically provides for the scale of power by P.M.P.S. to DP&L through the interconnection point, subject to the terms of the short term power, emergency power, or economy energy arrangements. However, the terms of these arrangements are not particularly conducive, economically, for the Municipal Power System to output power into DP&L's power grid. Thus, under the current terms of the agreement, the P.M.P.S. would be effectively prohibited from outputting significant power to outside the boundaries of their own system should a Total Integrated Energy System (TIES) approach be considered for the cogeneration plant. This situation can be considered an institutional obstacle and will be dealt with more fully in Chapter 5.0.

A portion of the community thermal energy demand is also supplied from the Municipal Power Plant in the form of high quality steam (150 psig) via the previously discussed steam distribution system. A set of load duration curves for the community steam demand was constructed in a manner similar to the electric energy demand pattern analysis. The result in each monthly case is the classic load duration shape, with a proportionately higher level of demand during the heating season. This characteristic reinforces the estimation that the bulk of the steam load is utilized as heating energy at the connected industrial installations. An annual load duration curve, Figure 2-28, was arrived at by tallying monthly statistics from the 12 month base period. Total demand for the base period was 202,285,400 lbm; peak demand was 50,000 lbm/hr with a minimum of 3,000 lbm/hr and an average demand of 23,092 lbm/hr throughout the 8760 hour period.

The overall result of the foregoing analysis of the community energy demand and the Piqua Municipal Power Plant load dispatch to meet that demand is a month by month detailed model of the energy demand profile which documents the community demand profile for the 12 month cycle of the base period, November 1977 to October 1978. It should be emphasized that this model is a dynamic model which reflects the fluctuations in energy demand from month to month and season to season. The model also reflects the month to month changes in operating strategy to meet the varying loads of the community. The model will be utilized in developing estimates of primary fuel consumption of the plant in meeting the load, as well as in predicting future plant operations and

primary fuel consumption in meeting the continually growing loads of the study period.

2.1.7 FUEL UTILIZATION

The consumption of significant quantities of primary fuel resources is implicit in the production, or more properly conversion, and distribution of energy for consumption in the community. The previous sections of this chapter have developed the methodology to document the profile of the community energy demand pattern, have predicted an appropriate operating strategy to meet these energy demands had the full complement of power generating units at the Municipal Power Plant been available and in service, and finally, have developed estimates of the operating efficiencies of the various systems in the plant. All three of the preceeding study components are necessarily utilized in making estimates of the consumption of primary fuel resources at the Municipal Power Plant.

As presented in the Load-Duration discussion, the community energy demand pattern was documented for each of the twelve months of the base period and segmented according to the various operational capacities and load range characteristics of each of the units in the Power System. The appropriate operational statistics (Hours on line, KWH generated, Capacity Factor, Operational Availability) were then calculated. With the individual performance of each unit during the base period thus characterized, the efficiencies of each of the units, estimated through the foregoing heat balance analyses, could be applied to arrive to an estimate of the primary fuel consumption at the plant site which could be allocated to the energy production from each particular unit. In order to facilitate the calculational procedure, a worksheet was constructed to present all necessary performance data for a specified period. An example of a completed worksheet from the November 1977 period, corresponding to the completed load-duration curve for the same period presented as Figure 2-26, is shown as Figure 2-29. Capacity Factors and Availabilities were taken from the load-duration curves and a corresponding KWH production was calculated (and verified with the load-duration curve totals). Net Heat Rates for the individual units were developed by first adjusting the turbine-generator efficiency (η_{T-G} from the heat balance analyses) with the boiler efficiency (η_B) to obtain an overall efficiency ($\eta_{OVERALL}$). The efficiency figures (in percent) were then converted to heat rate form through the following expression:

$$\text{Heat Rate} = \frac{3413 \frac{\text{Btu}}{\text{KWH}}}{\eta_{OVERALL}}$$

MONTH NOVEMBER 1977

UNIT	NAMEPLATE RATING	HRS. IN PERIOD	CAP	O. A.	KWH	NET HEAT RATE	BTU X 10 ⁶ CONSUMED	P.M.P.S. Fuel Costs Purchased Power Costs
#4	7,500 KW	720	62.5	41.67	1,406,250	16,749	2.355 x 10 ⁴	
#5	1,000 KW	720	52.97	65.23	248,777	4,711	1.172 x 10 ³	
#6	10,000 KW	720	S.B.	----	-----	16,565	-----	
#7	20,000 KW	720	76.04	100%	10,949,273	12,930	1.4157 x 10 ⁵	
Gas Turbine	20,000 KW	720	7.5	3.47	37,500	16,252	6.095 x 10 ²	
Purchased Power	3,000 KW	720	100%	100%	2,160,000	11,010	2.378 x 10 ⁴	Purchased Power Costs
TOTALS					14,801,800		1.907 x 10 ⁵	

FIG. 2-29

Finally, the gross heat rate figure was adjusted to reflect a 6% electric power requirement for the station service on each unit, yielding the net heat rate figure. The results are shown as Table 2-4.

TABLE 2-4
PIQUA MUNICIPAL POWER PLANT
POWER UNIT HEAT RATES

UNIT	η_{TG}	η_{BOILER}	$\eta_{OVERALL}$	GROSS HEAT RATE	NET HEAT RATE*
4	27.0%	80.0%	21.6%	15,800 $\frac{Btu}{KWH}$	16,749 $\frac{Btu}{KWH}$
5	96.0%	80.0%	76.8%	4444 $\frac{Btu}{KWH}$	4,711 $\frac{Btu}{KWH}$
6	27.3%	80.0%	21.84%	15,627 $\frac{Btu}{KWH}$	16,565 $\frac{Btu}{KWH}$
7	34.98%	80.0%	27.98%	12,198 $\frac{Btu}{KWH}$	12,930 $\frac{Btu}{KWH}$
GAS TURBINE			21.0%		16,252 $\frac{Btu}{KWH}$

*NET HEAT RATE IS ADJUSTED TO REFLECT A 6% ELECTRIC POWER REQUIREMENT FOR STATION SERVICE FOR EACH UNIT.

Primary fuel resource consumption was then easily calculated by multiplying directly the KWH production of each unit by its attendant heat rate. The result of each calculation is displayed on the worksheet as million BTU's consumed. This set of calculations was followed routinely for each of the twelve monthly periods. Each of the twelve worksheets, corresponding to the monthly load-duration curves previously presented, are reproduced in Appendix A. Upon completion of the monthly calculations, a tabulation of all pertinent data was made for the twelve month period and is presented in worksheet form as Figure 2-30. The worksheet shows that, for the 157,081,800 KWH produced by the Municipal Power Plant under the predicted operations scenario, 2.122×10^{12} Btu's of primary fuel resources were consumed.

MONTH 12 MONTH BASE PERIOD

11/1/77 - 10/31/78

UNIT	NAMEPLATE RATING	HRS. IN PERIOD	CAP	O. A.	KWH	NET HEAT RATE	BTU X 10 ⁶ CONSUMED	
#4	7,500 KW	8760	67.12%	16.67% (1460 hrs)	7,450,000	16,749	1.231 x 10 ⁵	P.M.P.S. Fuel Costs
#5	1,000 KW	8760	50.40%	50.96% (4464 hrs)	2,249,764	4,711	1.060 x 10 ⁴	
#6	10,000 KW	8760	62.54%	37.57% (3291 hrs)	20,580,279	16,565	3.409 x 10 ⁵	
#7	20,000 KW	8760	77.93%	91.51% (8016 hrs)	124,936,327	12,930	1.615 x 10 ⁶	
Gas Turbine	20,000 KW	8760	13.37%	8.39% (735 hrs)	1,965,430	16,252	3.194 x 10 ⁴	
Purchased Power	3,170 KW (AVG.)	8760	100.0%	100%	27,768,000	11,010	3.057 x 10 ⁵	Purchased Power Costs
TOTALS					184,849,800		24.279 x 10 ⁵	

FIG. 2-30

Also to be considered is the primary fuel consumption which may be attributed to the community steam demand. The heat balance analysis revealed that, at full loads, if all steam turbine drive auxiliaries were in operation, the total 150 psig steam output of the backpressure unit could be consumed within the system. The unit and system efficiency figures derived in the analysis account for this characteristic. It was therefore assumed, for the purposes of estimating the primary fuel consumption attributable to steam demand, that boilers 4 and 5, indirectly connected to the steam distribution system through the plant's header system, supply steam to the community at their 80% coal combustion efficiency. Primary fuel consumption attributable to steam was then calculated for each of the twelve months in the base period. The results, presented as Table 2-5 below, show that the 202,285,400 pounds of steam supplied from the plant during the base period represent a primary fuel consumption of 2.862×10^{11} BTU's.

Obviously, a distinction must be made in the form in which the total BTU's of primary energy were consumed. Steam turbine units 4 through 7 utilize sub-bituminous coal as their primary resource for energy conversion. In addition, boilers 4 and 5, which supply steam to the low pressure system, also utilize the same coal source in supplying steam to the community distribution system. The gas turbine utilizes No. 2 fuel oil. Purchased power, which could ultimately be broken down to primary resource consumption according to the mix and average heat rate of the supplier utility, will not be considered as on-site primary resource consumption for this analysis.

The following assumptions were made in order to determine the quantities (in standard measures) of on-site primary fuel consumption:

HHV of Coal - 11,800 Btu per lbm. A typical coal analysis covering a three month period in summer 1978 yielded an HHV of 11,797 Btu/lbm. (Analysis summary is presented in Appendix A.)

HHV of No. 2 Fuel Oil - 139,000 Btu/gallon

The results of the analysis, presented in tabular form as Table 2-6, reveal that, for the twelve month base period, primary fuel consumption was 100,700 tons of sub-bituminous coal and 229,800 gallons of No. 2 fuel oil in meeting full steam demand and approximately 85% of the total electrical demand of the community.

TABLE 2-5
STEAM CONSUMPTION (CONT'D)

SUPPLEMENTAL STEAM FROM P.M.P.P. BOILERS

MONTH	STEAM DISTRIBUTED (LBM)	EFFICIENCY**	PRIMARY FUEL CONSUMED BTU x 10 ⁶
NOV. '77	12,811,800	80.0%	18.129 x 10 ³
DEC. '77	19,322,400	80.0%	27.343 x 10 ³
JAN. '78	21,601,900	80.0%	30.568 x 10 ³
FEB. '78	23,811,150	80.0%	33.694 x 10 ³
MARCH '78	36,305,250	80.0%	51.324 x 10 ³
APRIL '78	19,435,900	80.0%	27.503 x 10 ³
MAY '78	19,045,800	80.0%	26.951 x 10 ³
JUNE '78	6,816,000	80.0%	9.645 x 10 ³
JULY '78	8,438,400	80.0%	11.940 x 10 ³
AUG. '78	9,768,600	80.0%	13.823 x 10 ³
SEPT. '78	12,003,600	80.0%	16.985 x 10 ³
OCT. '78	12,924,600	80.0%	18.288 x 10 ³
Totals	202,285,400(LBM)		286.244 x 10 ³

(Million Btu's)

** Heat Utilization on the following basis:

$h_{\text{STEAM DELIVERED}} = 1312 \text{ Btu/lbm (150 PSIG)}$

$h_{\text{WATER RETURNED}} = 180 \text{ Btu/lbm (212}^{\circ}\text{F)}$

TABLE 2-6
PRIMARY FUEL CONSUMPTION

MONTH	COAL		OIL
	P.M.P.S. POWER (BTU X 10 ⁶)	STEAM (BTU X 10 ⁶)	GAS TURBINE POWER (BTU X 10 ⁶)
NOV. '77	1.663 x 10 ⁵	18.129 x 10 ³	6.095 x 10 ²
DEC. '77	1.865 x 10 ⁵	27.343 x 10 ³	2.439 x 10 ²
JAN. '78	1.962 x 10 ⁵	30.568 x 10 ³	9.130 x 10 ²
FEB. '78	1.825 x 10 ⁵	33.694 x 10 ³	1.706 x 10 ²
MARCH '78	1.797 x 10 ⁵	51.374 x 10 ³	
APRIL '78	1.507 x 10 ⁵	27.503 x 10 ³	
MAY '78	1.592 x 10 ⁵	26.951 x 10 ³	6.501 x 10 ²
JUNE '78	1.691 x 10 ⁵	9.645 x 10 ³	19.50 x 10 ²
JULY '78	1.757 x 10 ⁵	11.941 x 10 ³	14.63 x 10 ²
AUG. '78	1.922 x 10 ⁵	13.823 x 10 ³	21.33 x 10 ²
SEPT. '78	1.730 x 10 ⁵	16.985 x 10 ³	20.32 x 10 ²
OCT. '78	1.592 x 10 ⁵	18.288 x 10 ³	217.80 x 10 ²
Totals	20.903 x 10 ⁵	286.244 x 10 ³	319.45 x 10 ²

TOTALS - COAL = 2.3765 x 10⁶ (Million Btu's)

= 2.3765 x 10¹² Btu

≈ 1.007 x 10⁵ Tons

(HHV of Coal - 11,800 Btu/lbm)

- OIL = 31.945 x 10³ (Million Btu's)

= 31.945 x 10⁹ Btu

≈ 2.298 x 10⁵ Gallons

(HHV of Fuel Oil - 139,000 Btu/Gal)

2.1.8 SYSTEM GROWTH

ELECTRICAL SYSTEM

Since its construction, the Piqua Municipal Power System has supplied all of the electrical energy demands of the city's residents. These requirements were met solely with the generating resources of the power plant until June 1975, at which time an interconnection with the Dayton Power & Light Company electrical distribution grid was made.

The interconnection with Dayton Power and Light coupled with the base load coal-fueled generating capacity and oil peaking capacity of the power plant provide excellent reliability for meeting any short term electrical load growth requirements placed on the Piqua system.

Long range electrical load projections are somewhat uncertain for the Piqua system due to relatively low population growth projections and unstable growth patterns in the last 5 years. This poses an especially difficult situation to the power systems planners since large growth rates could exceed the power plant's generating capacity in a relatively short time. This would, of course, necessitate plant expansion or incurring the higher costs of contracting with DP&L to supply the needed capacity.

The situation is given even greater significance since the most likely plant expansion would stepwise increase the generating capacity by 35 percent. If load projections prove overly optimistic, the power system could be faced with a large amount of debt service for unused generating capacity.

LOAD FORECASTS for the system's peak electrical demands and total Kilowatt-hour delivery were made by independent consulting engineering firms in 1974 and 1976. As part of the forecasts the electric system annual peak loads, net KW, energy requirements and net KWH, for the years 1952 through 1975 were analyzed. These system loads were exclusive of sales to Pioneer Rural Electric Cooperative and the Piqua Nuclear Power Facility in order to establish trends for the Piqua system alone. Table 2-6 summarizes the KW & KWH requirements in the 1952-1975 era. The trend toward annual system peak loads occurring summer months established in the latter years of the study period has prevailed. The forecasting studies concluded from electric industry

TABLE 2-6
PIQUA MUNICIPAL POWER SYSTEM
ANNUAL SYSTEM REQUIREMENTS
1952 - 1976 INCLUSIVE

<u>YEAR</u>	<u>ENERGY NET KWH</u>	<u>PEAK LOAD NET KW</u>	<u>ANNUAL LOAD FACTOR PERCENT</u>
1952	46,723,180	10,981	48.7
1953	51,059,000	11,669	50.0
1954	42,047,540	12,099	49.3
1955	58,665,600	13,084	51.3
1956	63,757,600	14,180	51.4
1957	63,032,800	14,857	48.8
1958	65,586,400	15,111	49.6
1959	73,989,800	16,055	52.6
1960	75,640,900	17,166	50.3
1961	76,889,200	17,767	49.0
1962	79,605,292	17,048	53.2
1963	80,059,736	18,212	50.2
1964	86,824,352	19,344	50.6
1965	93,287,341	20,444	52.1
1966	102,679,785	21,388	54.6
1967	105,101,029	21,366	56.2
1968	113,469,484	24,736	52.4
1969	126,615,369	25,550	56.5
1970	134,778,200	27,700	55.5
1971	144,803,100	30,650	53.9
1972	154,586,800	33,420	52.8
1973	164,889,611	36,570	51.5
1974	167,341,000	37,200	-
1975	160,522,000	41,400	-

trends and past data that the Piqua System would experience an annual growth rate of approximately 6.5 percent through the 1980's.

Due to a reduced electric energy consumption pattern such as that shown in Figure 2-31, and recent trends in 1977 and 1978, the study team elected to choose a more conservative 3 percent growth rate for the base case of the study. Figure 2-32, is a graph of the projected electrical load and demands which were used in the analysis and felt to be representative of what will be experienced in Piqua over the next twenty years.

FIG 2-31 HISTORICAL ENERGY CONSUMPTION

STEAM SYSTEM

The steam supplied by the steam utility annually for the 1963-1973 period is presented in Table 2-7.

Steam sales showed declining trends from 1968; however, substantial sales to a laundry connected to the system in 1973 have raised sales to approximately

PIQUA MUNICIPAL POWER SYSTEM
HISTORICAL AND PROJECTED
SYSTEM KWH PRODUCTION

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TABLE 2-7
PIQUA MUNICIPAL POWER SYSTEM
STEAM UTILITY REQUIREMENTS
1963-1973 INCLUSIVE

<u>YEAR</u>	<u>STEAM TO SYSTEM M LBS.</u>	<u>STEAM SOLD M LBS.</u>	<u>LINE LOSS M LBS.</u>	<u>LINE LOSS, PERCENT</u>	<u>NUMBER OF CUSTOMERS</u>
1963	213,656	117,832	35,824	16.8	8
1964	213,014	195,375	17,639	8.3	8
1965	212,316	195,131	17,185	8.1	8
1966	232,623	199,178	33,445	14.3	8
1967	233,127	201,500	31,627	13.5	8
1968	233,954	203,345	30,609	13.1	8
1969	224,602	201,678	22,924	10.2	8
1970	209,033	189,098	19,935	9.5	8
1971	169,385	168,281	1,104	0.7	8
1972	180,609	186,394	--	-	8 - 9
1973	182,975	168,073	14,902	8.1	5 - 9

202 million pounds per year. For the study period it was assumed these sales would remain constant, although some variation due to fluctuations in degree days will occur. It is anticipated the number of customers and/or use of steam by customers will not increase due to the availability of thermal energy from the district heating system and a decreased emphasis on steam sales by the steam utility management.

2.1.9 ALTERNATE RETROFIT SCHEMES

Examination of the plant and systems layout suggests several opportunities for retrofitting the Municipal Power Plant to serve in a cogeneration cycle as a source of thermal energy to a District Heating System.

The first and most obvious option is to increase the utilization of the high quality steam output by the backpressure turbine (No. 5). This option would involve redirecting the steam output from this turbine through a series of shell and tube heat exchangers for the purposes of generating hot water to distribute throughout the community. It is anticipated that the most effective and most flexible way to achieve this configuration would be not to connect the exhaust piping of this unit directly to the steam supply header for the heat exchangers, but to fabricate a cross-connection between the existing 150 psig steam header (which currently accepts the 150 psig steam exhaust of unit 5) and a steam supply header for the heat exchangers. This system configuration will allow several means of dispatching the thermal energy from the backpressure unit:

- 1.) supplying steam to the 150 psig header and ultimately to the turbine drive auxiliaries in the plant which draw steam from the existing header;
- 2.) supplying steam to the 150 psig header and ultimately to the community steam distribution system (as is the present case); or
- 3.) supplying steam, via the 150 psig header, to the District Heating System heat exchangers for hot water generation and distribution. This option would supply enough thermal energy to support a small distribution system and service area and could function as an excellent short-term energy supply for an initial system installation. This option would have the added attraction of the capability to accept steam indirectly from boiler 4 and 5 through the plant's steam header system as a supply to the heat exchangers in the event that the backpressure turbine was out of service.

Only nominal difficulty would be encountered in connecting the steam supply from the high pressure system (through a pressure reducing valve) to the district heating steam header in order to have it available as a back-up thermal source.

Finally, unit 5 could serve as an excellent thermal energy charging source for a thermal storage accumulator, should it be included in the system, because it would not be functionally limited by a low coincident electrical demand (the system could likely tolerate the full load output - 1000 KW - of the turbine generator at any time that charging the thermal storage would be required).

Options two and three are functionally the same but are accomplished through different approaches. Each option would involve reconfiguring one of the remaining operational units on the low pressure system. Option two would provide a steam source for the district heating system by modifying the existing condensing turbine No. 6 to exhaust steam at approximately 10 psig. Turbine modifications are of course contingent upon the recommendations of an engineering re-rate study performed by the manufacturer, but indications are that it is a feasible approach. Hot water generation for this option would again be achieved with shell and tube heat exchangers.

Option three would provide a steam source for the district heating system by replacing the existing condensing turbine No. 4 with a new backpressure unit specified explicitly for service in this type application. Steam supply to shell and tube heat exchangers would be at approximately 15 psig.

Option four would involve specifying, designing, and constructing a new 30 MW cogeneration unit in the empty bay in the south end of the Piqua Plant. This turbine unit would be specified with three uncontrolled extractions for feedwater heating and two automatic, variable extractions provided specifically for the cogeneration of thermal energy for the district heating system. This unit would have the advantage of being able to vary the electrical load on the unit and steam flow to the district heating system heat exchangers semi-independently. Also, portions of the capital expenditure for the construction of such a unit could be allocated to improvement of the electrical plant, an expansion in capacity that would no doubt be required at some point in the study period even if no cogeneration capacity were specified.

It is obvious from a cursory examination that the many "hardware options" available at the Municipal Power Plant would make Piqua a flexible and attractive site of application for a cogeneration-district heating system. The detailed feasibility of these options will be examined in Chapter 4.0. Further sections

of this chapter characterize the Piqua community with respect to determining viable service areas for a district heating system serving the City.

2.2 THERMAL MAPS AND SURVEY RESEARCH

2.2.1 DEFINITION OF STUDY AREA BOUNDARIES

The current service area of the Piqua Municipal Power System is generally outlined by the corporate limits of the City of Piqua. The power system does, however, supply kwh hours to customers outside of the present city limits. Further, it is anticipated that the PMPS will expand its electric service area during the study period. This becomes important in view of the recently enacted State of Ohio Energy Act which provides for definitively and permanently dividing the service areas among the States power systems. This issue is discussed in more detail in section 5.0, Institutional Analysis.

Findings of Fact and reasonable assumptions regarding the following issues are used to delineate the Study Area boundaries, these include:

- 1) existing city corporate limits
- 2) the present and planned service area of the PMPS within the City of Piqua and beyond its present limits
- 3) realistic limitations on the extension of the PMPS electric service area
- 4) existing development patterns outside the City of Piqua including locations of residential, commercial and industrial development
- 5) the growth allocations resulting from the housing, industrial, and commercial analysis *
- 6) topographical barriers and soil limitations
- 7) planned extensions of municipally owned and operated infrastructure
- 8) interstate-75 and the two nearby interchanges
- 9) location of prime agricultural farm land

Given the size, density and configuration of development in the City of Piqua and its immediate environs limits on the distance which centrally cogenerated thermal energy can be transported is not an issue. Generally, all areas within the Study Area, and some outside the Study Area, are well within the reach of current piping technology. The Thermal Zone Map outlines the total Study Area boundary.

* Please refer to Appendix 2.2 for current and projected densities.

2.2.2 THERMAL MAP AND SURVEY RESEARCH

The process of inventorying the potential service area centered upon an interlocking 3-fold process:

- 1) the thermal map
- 2) growth projections and housing market analysis
- 3) field inventory/survey research

This process facilitates the quantitative and qualitative understudy of end-users, their ability/willingness to utilize thermal energy and identifies problem areas.

In order to evaluate the feasibility and design of distributing and selling thermal energy, a comprehensive thermal density map must be generated. The objective is to identify homogeneous areas which could employ district heating and cooling through end-user retrofit. Thus, the type and concentration of thermal energy loads must be identified. County Auditor's records, landuse patterns and a structure inventory are used to identify residential, commercial and industrial users and divide the Study Area into thermal zones. These zones reflect, to the extent possible, areas of homogeneous building types and energy service requirements; taking into account size and geophysical constraints. As a result, 52 zones in the City of Piqua and 18 zones outside the City were identified as reasonably homogeneous areas. Hospitals and the larger schools within the City are identified as separate zones due to their unique energy requirements and prevailing heating/cooling systems. Parks and large areas of vacant land were likewise considered as separate zones to allow for a more realistic measurement of density in all other zones. Areas outside the City are included in the zone system as they display present or future potential concentrations of energy usage that ultimately could be serviced with central source thermal energy.

The Thermal Map on the following page shows the division of the Study Area into zones. With the exception of several industrial and institutional cases the zone is the smallest level at which data is assembled and analysis carried out.

A Thermal Map Code Sheet is then generated to quantitatively summarize the building inventory data by zone and building type. The twelve categories are based upon type of end-user (residential, commercial, or industrial) and type of structure. Number of structures, number of units total floor area by category, size of the zone in acres, prevailing heating/cooling system(s) and main industries in each zone are all quantified.

Miami County Auditor's records are used to calculate total square footage of commercial and industrial buildings within each zone. Each building in all zones is located in the files and the data entered on tally sheets. (Nonheated barns, warehouses or yard structures, were not considered in these computations.) In addition, the existing heating/cooling systems in these structures were identified and recorded. Mixed-use structures, those containing commercial concerns and residences within the same building, are included in the commercial categories with a tabulation made of number of residential units in each category.

A field survey was conducted throughout the study area to identify all lots in each zone as to use (single-family, two-family, multi-family, commercial/mixed use, and industrial) and number of stories. This was necessary to obtain a total count of structures by type and size and was also instrumental in reinforcing/complementing the counts and computations generated from the Auditor's records.

A 10% sample of each residential category by zone was drawn from the Auditor's records to arrive at a mean building square footage and prevailing heating/cooling system per zone, per category. These mean building square footages are multiplied by the field survey residential counts to obtain total residential square footage in each category.

Study Area wide building inventory data is then tabulated by zone and entered on Thermal Map Code Sheets. In addition to collecting and assembling data for input to the zone specific load curves, the inventory also provides a detailed land use map of the area. A generalized version of this map may be found on the following page.

CITY OF PIQUA

MADE IN U.S.A.

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-78-C-02-4978

TEAM MEMBERS CITY OF PIQUA OHIO

GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESHEW AND ASSOCIATES

THERMAL ZONES CITY OF PIQUA & SURROUNDING COMMUNITY

SHEET OF

DRAWN	DATE
CHECKED	
APPROVED

CITY OF PIQUA

MIAMI COUNTY,

OHIO

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

PREPARED FOR: DEPARTMENT OF ENERGY - CONTRACT NO. EM-75-C-52-4976

TEAM MEMBERS: CITY OF PIQUA, OHIO
 GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
 HANSELMAN-ESHEW AND ASSOCIATES

THERMAL ZONES
 CITY OF PIQUA & SURROUNDING
 COMMUNITY

SHEET

OF

DRAWN: AS DATE: 11-22
 CH'D: BT 11-22
 APPROV: _____

City of Piqua/U.S. Dept. of Energy

Thermal Map Code Sheet

Zone No. _____

Structure Type	# Structures	# Units	Floor Area
1) <u>Single Family 1 Story</u> A1, A2, A9			
2) <u>Single Family 2 Story</u> A3 thru A8, A10			
3) <u>Two Family 1 Story</u> B1, B2, B8			
4) <u>Two Family 2 Story</u> B3 thru B7, B10			
5) <u>Multi-family 1 Story</u> C1, C2			
6) <u>Multi-family 2 Story</u> C3 thru C7			
7) <u>Commerical/Mixed Use</u> <u>Single Story</u> D1, D2, D9 thru D13, F1, F2			
8) <u>Commercial/Mixed Use</u> <u>2 Story</u> D3 thru D5, D14, F3 thru F5			
9) <u>Commerical/Mixed Use</u> <u>3 Story</u> D6, D7, D8, F6 thru F10			
10) <u>Commerical/Mixed Use</u> <u>4 Story</u> D6, D7, D8, F6 thru F10			
11) <u>Commerical/Mixed Use</u> <u>5 Story</u> D6, D7, D8, F6 thru F10			
12) <u>Industrial</u> E1 thru E14			

TOTAL

2.2.3. GROWTH PROJECTIONS--RESIDENTIAL, INDUSTRIAL AND COMMERCIAL

2.2.4

The second step in the process involves the development of residential, commercial and industrial growth projections that will occur in the Study Area over the next 20 years, with zone specific allocations of this growth. The development of accurate growth projections is critical for this feasibility study in that it provides the base for calculating future energy demand, and establishes the parameters for future plant capacity. In Piqua's case this is especially important in that the power plant under study is the power system.

These growth projections account for an increase in the population over the life of the project, and are related to the accompanying residential, commercial and industrial growth. The projections are a result of extensive analytical and statistical analysis not only of the Study Area, but also of the broader regional economy.

The City of Piqua functions within the broader housing market area of the Dayton SMSA, and as such, will experience growth within this larger context. A recently completed Housing Market Analysis (prepared by Hanselman-Eskew and Associates for the City of Kettering, Ohio) provides the basis for the Study Area assessment. This market analysis divides the housing market area into five sectors:

City of Dayton - Incorporated Area

North Sector - Butler Twp., Harrison Twp, Mad River Twp.,
Wayne Twp., and Miami County

West & Northwest Sector - Madison Twp., Jefferson Twp,
Randolph Twp., and West including Preble County

South Sector - Kettering, Moraine, Oakwood, Miami Twp.,
and Washington Twp.

East & Southeast Sector - Bath Twp., Beaver creek Twp.,
Sugar creek Twp., and remainder of Green County

Population within the housing market area increased significantly between 1950 and 1976. Not coincidentally, this significant population increase occurred during the period of rapid employment expansion in this area. Since population growth/decline is directly related to employment, (especially in

the northeast/midwest) employment trends not only for this area, but also the state economy must be assessed.

Ohio's economy can be characterized as primarily concentrated in the manufacturing sector. This sector has historically represented the "driving force" (as far as its export base) in the Ohio economy. This sector is now declining in Ohio (especially as it relates to employment opportunity) at a greater-than-national rate and will not regain the relative importance it held in Ohio in 1960, or even in 1970; in fact, it will continue to drop in relative importance. There has been a trend over the last two decades for large corporations to relocate operations outside the older Northeast and Midwestern regions. The moves have occurred for a variety of reasons, including the availability of cheaper, nonunion labor; proximity to natural resources, such as natural gas, and nearness to new population centers. Although Ohio firms are not necessarily less efficient than firms elsewhere, the fact remains that new plant additions and new industries tend to be located outside the Midwest including Ohio.

Disaggregating manufacturing into durable and nondurable industries shows that the specialization is loaded overwhelmingly toward the durable goods sector, (which accounts for 74 percent of total Ohio manufacturing employment). Thus, Ohio is predominantly an exporter in the "heavy" industry segment of manufacturing. The State is losing some of this relative concentration in durable manufacturing over time although such industries still represent the "driving force" in the state's economy. The decline in relative importance of durable goods manufacturing in the Ohio economy is in part a continuation of the relatively greater rate of growth of nonmanufacturing activities in both Ohio and the U.S.; a relatively lower national growth rate (or decline) projected by the Bureau of Labor statistics for some of the durable industry classifications most important in Ohio employment--primary metals, transportation equipment, especially autos, and electrical machinery and equipment; and a less-than-historical growth rate in Ohio for fabricated metals and machinery. Caution must be exercised, however, in viewing these results. Here, the "declining sector" means that the amount of employment has

not grown with increases in the value of its output. Productivity gains and intensive capital investment in the durable goods sector have led to employment declines in these industries even though output in durable goods manufacturing has not declined.

In nondurable manufacturing, Ohio is gaining concentration relative to the U.S. but it is still not as specialized in these industries as is the rest of the nation. Some decline in the relative importance of Ohio non-durables might be expected; however, due to the continued lower-than-U.S. growth rate in Rubber and Plastics products, Ohio firms in this industrial sector continue to decentralize.

Ohio seems to be experiencing a greater percentage shift in its total employment to nonmanufacturing than is the nation, although not large enough a shift to offset the greater percentage decrease in manufacturing. The nonmanufacturing sectors which are gaining larger percentages of total employment in Ohio, but are losing or are not changing their relative position in the U.S. economy; are mining and quarrying, contract construction, and transportation and public utilities. The wholesale and retail trade sector is gaining in percentage share in the nation but in Ohio it is gaining at a faster rate. In the finance, insurance, and real estate subsector of the service sector, and in the state and local government section, Ohio is not keeping up with the national rate of increase although it is registering increases.

At the national level, the service sector is experiencing the greatest increase in employment as a percentage of total employment for the nation, followed by the state/local government sector and the wholesale and retail sector. The contract construction sector is experiencing the greatest percentage decline as an internal share nationally. Ohio, however, is not exactly mirroring these structural changes. Its greatest increase in this category is in the wholesale and retail sector, followed by services and then by the state and local government sector but this is the only nonmanufacturing sector experiencing such a loss of internal share.

What we observe, in summary, is a convergence, a growing similarity between Ohio and the rest of the nation. Ohio is losing its specialization in durable industries and is becoming more like the rest of the country in its degree of industrialization. On the other hand, we observe an increasing specialization in nondurables, wholesale and retail trade, transportation and public utilities, mining and quarrying, contract construction, and a regaining of specialization in finance, insurance, and real estate. These sectors (except wholesale and retail trade) are still registering deficits (in terms of meeting state demand) but the convergence to national levels of specialization can clearly be seen from 1964 through 1976. In the service and state and local government sector, Ohio is registering increases but not as great as the sectoral increases experienced by the balance of the nation. The federal government sector is the only nonmanufacturing sector registering declines in specialization at faster-than-national rates.

The loss in durable industries is at least temporarily damaging to the Ohio economy. A region which has been as narrowly specialized as Ohio runs such a risk. If Ohio can increase its diversity, it is unlikely that it will suffer such declines in total employment in the future and suffer such difficulty in recovering its losses thru developing new activities to take the place of those lost. Resilience is extremely important to a region's economic health--and diversity is the important aspect of resilience. Signs of convergence and increasing diversity as seen in this analysis are signs of increasing economic health. Perhaps such movements can keep Ohio's unemployment from surpassing the national level. However, it is evident that Ohio needs to increase its specialization in nonmanufacturing industries, particularly in the service and government sectors.

DAYTON SMSA INDUSTRIAL SETTING

While it is necessary to evaluate Piqua's industrial direction through the larger state framework, it is also necessary to evaluate the immediate area to arrive at an accurate overview of the city's position and development potential. The main difficulty here is that the bulk of sources providing economic data report figures on the SMSA level. Therefore, the remainder

of this overview relies on data reported from the Dayton SMSA, of which Piqua is a part.

Manufacturing in Dayton, which comprises a little less than a third of the total employment, has been declining steadily since 1970. However, this loss has been counteracted by considerable gains in nonmanufacturing. Consequently, the area is experiencing an essentially stable level of total employment. While national figures, too, have reflected this trend, growth in nonmanufacturing in the Dayton area had not approximated proportions experienced nationally until the last few years. In addition, 1976/77 period displayed declining labor costs with respect to U.S. figures. Allowing for considerable time lag, this should theoretically result in an increase in investment, employment, population and the size of the labor force. While the 1977 figures do reflect these increases--leaving us optimistic about the future, the time period of the increase is insufficient to verify the occurrence of a trend.

Disaggregating the data into manufacturing and nonmanufacturing sectors is much more interesting because it not only helps us understand the behavior of the aggregate, but it also provides more detailed information which can be used for specific cases. Because relative unit labor costs in manufacturing continue to increase, we can expect a continuation of the trend toward investment of capital to areas where cheap, non-unionized labor exists. On the other hand, in all of the nonmanufacturing sectors (the largest employer in our economy) unit labor costs have been declining for the last three years. Furthermore, by 1977 these sectors became quite competitive with the South, however, when sectors are analyzed individually, we find that a continuation of this trend is a necessity. For example, the communication, gas and electric sector, relative labor cost, although declining for the last three years, are still about 15% above that of the South. Conversely, both the construction and retail trade sectors have displayed labor costs lower than those in the Southeast for the first time. These facets, as well as the fact that nonmanufacturing is not as sensitive to business cycle fluctuations as is manufacturing could be employed to the advantage of the Dayton SMSA.

However, consideration must also be given to the fact that nonmanufacturing wages are generally lower than those in manufacturing which would imply a decline in real income should the trend continue.

Although this analysis draws a picture of a reasonably health economy, it does imply that the economy has reached a plateau. There are no current implications that economic growth will start again in this area, other than the continuing decline of nonmanufacturing unit labor cost. The policy implication of this would be to direct efforts towards expanding nonmanufacturing fast enough to absorb the continuing decline in manufacturing. Industrial growth projections for the Study Area are based on historical and current trends in Piqua compiled with an analysis of changing economic conditions in the nation relative to the State of Ohio, and the number of square footage of available acres for industrial usage.

Piqua currently displays a specialization in durable goods manufacturing. Nationally the trend in these industries is negative. This trend does not mean that productivity in this sector is decreasing. On the contrary, more output is now being produced. The problem, in terms of declining employment in these industries, is due to increasing capital investments and technological advances in this sector which allows for more output produced with less labor inputs. Thus, nationally we see a movement out of this Sector in terms of levels of employment. As indicated above, Ohio is experiencing this trend but to an even greater extent than is the nation. Ohio's industries are usually old and established ones. Its capital stock is also old and often obsolete. Soaring energy costs, the presence of strong unions in the North (making per unit labor costs higher in the North relative to the South), amenity considerations, and an increasing trend in mobility are a few important factors manufacturing firms consider when making reinvestment decisions. The greater-than-the-nation loss of employment in this sector would support the conclusion that rates of return on investments are more attractive outside of Ohio and that the obsolete capital stock in Ohio is not being replaced here but moved elsewhere.

PIQUA MUNICIPAL POWER SYSTEM -- STUDY AREA

Population and Dwelling Unit Projections

1980 - 2000

	<u>Population</u>	<u>Dwelling Units</u>
1) 1970, Piqua (census)	20,741	6,914
2) 1978, Piqua	22,248	7,416
1978, Townships	+ 1,977	+ 659
1978, T. Study Area (Inventory)	24,225	8,075
3) 1980, Study Area (Projection)	24,729	8,243
4) 2000, Study Area (Projection)	30,267	10,089

Note: 1980-2000 growth rate = $PV = (FV) \frac{1}{1 + I^n}$
 $I = 1.11\%$

COMMERCIAL GROWTH

Commercial growth projections are made considering commercial services now available, services that will be needed to support the additional population projected, historical trends, changes in consumer habits, and Piqua's role in Miami County. Piqua is the largest City in Miami County and, as such, services a larger region than the City itself. The most obvious example of such a service center function is the Piqua East Mall, which is supported by a market area larger than the City of Piqua. It is assumed theoretically sound to project commercial growth in the mall zone as a result of the expansion of the mall and its environment. The City of Piqua already has a well-established central business district with very little vacant, developable land. New commercial development will essentially replace obsolete facilities.

Thus, the growth of industry in Piqua will primarily be in the lighter, supportive industries not displaying this negative trend; with one or two new durable goods manufacturing industries being projected as well. Such growth was allocated among zones based on existing growth patterns in these zones and on available number of acres. Furthermore, this type of employment will produce a lower per job supported household size. Where previously, a typical manufacturing job may support 3.5 to 4 people, the typical employment ratio in this different economy will be approximately 1 to 2.75 persons. Therefore, rapid expansion of the housing stock will simply not occur.

Returning to the housing market analysis, it can be clearly understood that while growth will continue, it will be at a much slower pace than during the previous two decades. Additionally, household size will continue to decline in the housing market area from 3.05 pph to 2.94 pph in 1995. Further, while new household formation and related housing starts will continue, there will be a shift in the housing market area. The direction of housing development between 1976 and 1995 will show some deviation from the trends established between 1960 and 1974. The North Corridor including Butler, Harrison, Mad River and Wayne Townships and Miami County will capture approximately 25% of new housing starts. As Wayne Township builds out, significant portions of this activity will occur in the southern part of Miami County. Butler Township will be another area of substantial housing activity within the north corridor.

The South Corridor, which includes Kettering, Moraine, Oakwood and Miami and Washington Townships will capture fewer of the housing market area new starts. Land availability/price, water supply access to metropolitan activity centers and commuting times will affect different areas within this corridor to varying degrees. The South Corridor will continue, however, to capture approximately 22% of the market area new housing starts. Primary development activity in this corridor will occur in Miami and Washington Townships.

The East/South Corridor which includes Bath, Sugarcreek, Beavercreek Townships, and the remainder of Greene County will begin to capture an

increasing share of the SMSA's new housing starts--approximately 24%. This fast track will certainly be facilitated if the sewer and water problems are solved in Beavercreek and Sugarcreek Townships and by the completion of I-675. The West/Northwest Corridor which includes Madison, Jefferson and Randolph Townships and the area west including Preble County will likely capture approximately 20 to 22% of the SMSA's new housing starts.

Between 1960 and 1974, the City of Dayton's share of new housing starts dropped from 17.5 to 7.1%. A significant increase above 7% is certainly not anticipated during the next decade.

During the twenty-year period, approximately 25% of the demand will be for households whose income is below \$10,000 per year. Over the period, this percentage should decline slightly. Applying commonly accepted home-ownership cost/rent indices, this segment of the market will require housing in a price range under \$20,000 or a monthly contract rent of \$208 per unit per month. On the other end of the scale, approximately 7% of the demand will be for housing with the cost in excess of \$70,000 and/or a contract rent in excess of \$729 per unit per month. This percentage over the twenty-year period will rise modestly. In summation, the distribution of housing demand is:

- 1) 25% for households with income under \$9,999;
- 2) 19% for households between \$10,000 and \$14,999;
- 3) 32% for incomes between \$15,000 and 24,999;
- 4) 17% for incomes between \$25,000 and \$34,999; and
- 5) 7% for incomes above \$35,000.

RESIDENTIAL PROJECTIONS

Residential projections are made for the Study Area using an existing and the housing market analysis supplying new household formation and projections for the next 20 years. These projections are made for the entire north corridor. Analyzing the market for Miami County, it is assumed that Miami County will capture an approximate 25% of this growth. Of this 24%, it is also assumed reasonable that the City of Piqua and its surrounding environ-

ments will capture 20% of the County growth (or 5% of the growth in the North Corridor).

These new households are allocated among the thermal zones based on development patterns reflected in zoning, public policy, access to existing and planned infrastructure, geophysical restraints, and available/developable/saleable acres of land. Densities throughout the project life were then computed applying the residential projections to zone acreages assessed in the field inventory.

The mix of residential structures (single family versus multi-family) is determined by using historical trends coupled with an analysis of current family-formation and housing development trends. The analysis concludes that there will be a moderate increase in the rate of multi-family structures over the historical trend due to the increase in the cost of housing relative to rising disposable incomes, the trend toward decreasing family size, and other cultural realignments. These economic and behavioral factors will lead to even higher increase in multi-family structures if not for strong resistance in the housing market due to single-family structure preferences (displayed in the higher percentage of disposable income now being spent for single-family housing). In summary, the residential growth in the Study Area over the life of the project will be 2,014 dwelling units, or a 19.9% increase.

POPULATION PROJECTIONS

Continuing the above analysis provides an indication that the Study Area has not experienced significant changes in the number of persons per household in previous decades while maintaining a growth rate of approximately 1% per year. Utilizing these trends, the following table presents the population projections to the year 2000. The household characteristic data is applied to the residential dwelling unit projections to arrive at the population projections for the year 2000, which results in a growth rate of 1.11% per year during the project life.

The bulk of the growth projection is then allocated based on the aforementioned considerations around the Piqua East Mall, around the Sunset Shopping Area extending out Covington Road, and along County Road 25-A due toward the future I-75 improvements and the positive economic implications of such access improvements.

Structure Type	# Structures	# Units	Floor Area
1) <u>Single Family 1 Story</u> A1, A2, A9	3238 + 686 <u>3924</u>	3238 + 686 <u>3924</u>	3,776,811 + 835,949 <u>4,612,760</u>
2) <u>Single Family 2 Story</u> A3 thru A8, A10	3365 + 730 <u>4095</u>	3365 + 730 <u>4095</u>	5,862,210 + 1,224,598 <u>7,086,808</u>
3) <u>Two Family 1 Story</u> B1, B2, B8	41	82	66,187
4) <u>Two Family 2 Story</u> B3 thru B7, B10	389	778	860,901
5) <u>Multi-family 1 Story</u> C1, C2	15 + 24 <u>39</u>	89 + 242 <u>331</u>	49,856 + 200,350 <u>250,206</u>
6) <u>Multi-family 2 Story</u> C3 thru C7	87 + 11 <u>98</u>	448 + 242 <u>690</u>	442,567 + 200,350 <u>642,917</u>
7) <u>Commerical/Mixed Use</u> <u>Single Story</u> D1, D2, D9 thru D13, F1, F2	322 + 33 <u>355</u>	395 + 36 <u>431</u>	1,960,078 + 619,780 <u>2,579,858</u>
8) <u>Commercial/Mixed Use</u> <u>2 Story</u> D3 thru D5, D14, F3 thru F5	193	427	1,195,733
9) <u>Commerical/Mixed Use</u> <u>3 Story</u> D6, D7, D8, F6 thru F10	41	70	559,465
10) <u>Commerical/Mixed Use</u> <u>4 Story</u> D6, D7, D8, F6 thru F10	5	99	285,350
11) <u>Commerical/Mixed Use</u> <u>5 Story</u> D6, D7, D8, F6 thru F10	1	5	31,780
12) <u>Industrial</u> E1 thru E14	342 + 28 <u>370</u>	344 + 28 <u>372</u>	4,048,962 + 1,100,000 <u>5,148,962</u>

TOTAL 9551 11,304 23,320,927
(Script equals growth projections)

2.2.5 THERMAL ENERGY USE PROJECTIONS

Three types of thermal energy demands were considered in the study. These demands are the current steam distribution system loads servicing the nine customers now connected to the system, the space heating load of those buildings connected to the district heating system and the domestic water heating loads associated with connected buildings. Two other types will also be incurred by the system; the first will be some industrial process loads which may be added for certain industrial customers, and the second will be thermal losses from the distribution system.

EXISTING STEAM LOADS

The Piqua Municipal Power System currently supplies nine customers with 150 lb steam for use primarily in space heating applications. These steam sales amount to an approximate total of 202.4 million pounds per year of which approximately 100,000 are supplied from backpressure operation of turbine generator No. 5. The remainder is supplied from Boilers 4 and 5.

In order to completely characterize steam demands and flows over a typical annual cycle, it was necessary to analyze log sheets compiled by the power plant operating personnel. Monthly load duration curves were developed and a single annual load duration curve was developed. The annual duration curve is presented in Chapter 2.0 of the report.

The loads serviced by the existing steam distribution system are predominantly of a temperature dependent nature as can be seen by the shape of the annual load duration curve. For the most part, industrial process loads are not allowed by the steam system supplier due to the extreme fluctuation in industrial process energy demand. Table 2-3 is an analysis of the sources of steam for the existing steam load, the actual sales experienced in a typical year, and the estimated losses from the distribution system. Most condensate is returned from the system to the plant and reused as boiler feedwater. As can be seen from the table, the system is penalized by heavy distribution system losses and less than desirable use of the backpressure turbine unit.

The appendix includes a sample steam rate agreement for a typical industrial customer. As can be imagined, the industrial users are quite satisfied with steam purchases due to their extremely low price. This price typically averages less than \$2.25 per million Btu's.

For the purpose of the district heating system study, it is anticipated that all existing steam contracts will be honored, but that no additional steam customers will be connected to the system to increase the system load. All new industrial customers would be connected to the district hot water system in lieu of purchases from the steam distribution system.

A map of the existing steam distribution system now in service in the proximity of the Piqua power plant is presented in Chapter 2.0 of the report.

To estimate temperature dependent space heating loads, a computerized zone energy consumption program was utilized. Input to the program included thermal integrity factors developed from the Rand Corporation's "ENERGY USE AND CONSERVATION IN THE RESIDENTIAL SECTOR: A REGIONAL ANALYSIS". Unitized energy consumption data was estimated on an annual basis. The categories of buildings considered are presented in Table I, with their corresponding average floor areas.

Monthly thermal integrity factors were developed by apportioning the annual thermal energy use factors on a monthly basis according to pro-rated heating degree days. Table II is a typical "printout" of consumption figures.

To arrive at total thermal load per zone, the computer program was set up, which then input with the number of building units of a particular category per zone to multiply the average floor area per unit by the monthly thermal integrity factor by the number of units of the specified type to obtain a total monthly Btu requirement. This process was carried out for every thermal zone and summarized to obtain a total system load.

A provision was made in the program to simulate market penetration into an area with a variable called "penetration factor". This variable allowed the design team to estimate how much load would be generated within a zone when the distribution network is first installed and how loads will grow over time.

A complete discussion of this parameter is discussed under the section "Market Analysis".

Weather data from the national climatological center was utilized to obtain average heating and cooling degree days. Heating and cooling loads were assumed to be at peak load when the outside air temperature reached 0° F.

One useful statistic in determining overall desirability of providing central heating or cooling media for use by a community, is to determine the total number of hours per year when some heating or cooling is required by most residences. In order to do this, cumulative hours were developed from hourly temperature distribution data to indicate the number of hours per year when heating or cooling is required in Piqua. Heating was assumed to be needed when the outside air temperature was 65° F and below. This resulted in approximately 5,860 hours per year when some form of heating energy was required by most buildings. Likewise, cooling was assumed to be required when the outside air temperature was above 75° F. For the Piqua area, this resulted in less than 1,290 total hours per year which required some form of cooling. On the basis of this observation, it would generally be concluded that simultaneous use of cooling and heating media would be utilized only slightly during the annual period and would not justify the large capital expense required to provide a year-round cooling media to normal residential areas.

Domestic water heating requirements were developed on a unit basis, assuming a subscriber was the lowest increment for analysis. Water heating energy consumption was projected as constant year round, however, in actuality there will be some increase in energy required during winter months when entering water temperatures are lower than the yearly average. This fluctuation is considered unimportant for the preliminary analysis.

TABLE I

<u>UNIT TYPE</u>	<u>NO IN. STUDY AREA</u>	<u>TOTAL SQ. FT.</u>	<u>AVG. UNIT SQ. FT.</u>
A-1	3,264	4,399,981	1,350
A-2	3,141	5,507,081	1,753
B-3	78	62,598	802
C-5	278	234,970	845
C-6	628	574,786	915
D-7	338	2,186,132	6,467
D-8	276	1,172,170	4,250
D-9	65	559,417	8,606
D-10	99	1,579,281	15,952
D-11	5	31,780	6,356
E-12	315	4,102,774	13,025

 TYPE DEFINITIONS

HEATING DATA (MBTU/SQ. FT.)

TYPE ***	JAN ***	FEB ***	MAR ***	APR ***	MAY ***	JUN ***	JUL ***	AUG ***	SEP ***	OCT ***	NOV ***	DEC ***
A-1	13.610	11.530	9.590	4.910	1.970	0.000	0.000	0.000	.750	3.650	7.800	12.580
A-2	12.250	10.380	8.630	4.420	1.770	0.000	0.000	0.000	.680	3.290	7.020	11.320
B-3	12.930	10.950	9.110	4.660	1.870	0.000	0.000	0.000	.710	3.470	7.410	11.950
B-4	12.250	10.380	8.630	4.420	1.770	0.000	0.000	0.000	.680	3.290	7.020	11.320
C-5	12.930	10.950	9.110	4.660	1.870	0.000	0.000	0.000	.710	3.470	7.410	11.950
C-6	12.250	10.380	8.630	4.420	1.770	0.000	0.000	0.000	.680	3.290	7.020	11.320
D-7	17.160	14.540	12.090	6.190	2.490	0.000	0.000	0.000	.945	4.610	10.440	15.860
D-8	16.300	13.810	11.490	5.880	2.370	0.000	0.000	0.000	.898	4.380	9.920	15.070
D-9	15.440	13.090	10.880	5.570	2.240	0.000	0.000	0.000	.851	4.150	9.400	14.270
C-10	14.590	12.360	10.280	5.260	2.120	0.000	0.000	0.000	.803	3.920	8.870	13.480
C-11	13.730	11.630	9.670	4.950	1.990	0.000	0.000	0.000	.756	3.690	8.350	12.690
E-12	22.880	19.380	16.120	8.260	3.320	0.000	0.000	0.000	1.260	6.140	13.920	21.140

COOLING DATA (MBTU/SQ. FT.)

TYPE ***	JAN ***	FEB ***	MAR ***	APR ***	MAY ***	JUN ***	JUL ***	AUG ***	SEP ***	OCT ***	NOV ***	DEC ***
A-1	0.000	0.000	0.000	0.000	.715	2.380	3.500	2.990	1.200	0.000	0.000	0.000
A-2	0.000	0.000	0.000	0.000	.644	2.140	3.150	2.690	1.080	0.000	0.000	0.000
B-3	0.000	0.000	0.000	0.000	.679	2.260	3.330	2.840	1.140	0.000	0.000	0.000
B-4	0.000	0.000	0.000	0.000	.644	2.140	3.150	2.690	1.080	0.000	0.000	0.000
C-5	0.000	0.000	0.000	0.000	.679	2.260	3.330	2.840	1.140	0.000	0.000	0.000
C-6	0.000	0.000	0.000	0.000	.644	2.140	3.150	2.690	1.080	0.000	0.000	0.000
D-7	0.000	0.000	0.000	0.000	1.170	3.890	5.720	4.900	1.960	0.000	0.000	0.000
D-8	0.000	0.000	0.000	0.000	1.050	3.500	5.150	4.410	1.760	0.000	0.000	0.000
D-9	0.000	0.000	0.000	0.000	1.050	3.500	5.150	4.410	1.760	0.000	0.000	0.000
D-10	0.000	0.000	0.000	0.000	1.050	3.500	5.150	4.410	1.760	0.000	0.000	0.000
D-11	0.000	0.000	0.000	0.000	1.050	3.500	5.150	4.410	1.760	0.000	0.000	0.000
E-12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

ZONE 2-P

HEATING DATA (°E09)

TYPE	NO. UNITS	MEAN SQ FT/UNIT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
A-1	3	805.0	.033	.028	.023	.012	.005	0.000	0.000	0.000	.002	.009	.019	.030	.160
A-2	1	2350.0	.029	.024	.020	.010	.004	0.000	0.000	0.000	.002	.006	.016	.027	.140
B-3	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B-4	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C-5	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C-6	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D-7	5	2188.0	.188	.159	.132	.068	.027	0.000	0.000	0.000	.010	.050	.114	.174	.923
D-8	1	1584.0	.026	.022	.018	.009	.004	0.000	0.000	0.000	.001	.007	.016	.024	.127
D-9	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D-10	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D-11	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E-12	113	9533.0	24.647	20.877	17.365	8.898	3.576	0.000	0.000	0.000	1.357	6.614	14.995	22.773	121.102
TOTAL			.25E+02	.21E+02	.18E+02	.90E+01	.36E+01	.0	.0	.0	.14E+01	.67E+01	.15E+02	.23E+02	
TOTAL HEAT BT (480) P. F.			11.9627	10.1327	8.4282	4.3187	1.7358	0.0000	0.0000	0.0000	.6588	3.2103	7.2769	11.6530	

ZCNE 2-P

HEATING DATA (°E09)

TYPE	NO. UNITS	MEAN SQ FT/UNIT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
A-1	3	805.0	.033	.028	.023	.012	.005	0.000	0.000	0.000	.002	.009	.019	.030	.160
A-2	1	2350.0	.029	.024	.020	.010	.004	0.000	0.000	0.000	.002	.008	.016	.027	.140
B-3	7	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
B-4	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C-5	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C-6	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D-7	5	2188.0	.188	.159	.132	.068	.027	0.000	0.000	0.000	.010	.050	.114	.174	.923
D-8	1	1584.0	.026	.022	.018	.009	.004	0.000	0.000	0.000	.001	.007	.016	.024	.127
D-9	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D-10	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
D-11	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
E-12	113	9533.0	24.647	20.877	17.365	8.898	3.576	0.000	0.000	0.000	1.357	6.614	14.995	22.773	121.102
TOTAL			.25E+02	.21E+02	.18E+02	.96E+01	.36E+01	.0	.0	.0	.14E+01	.67E+01	.15E+02	.23E+02	
TOTAL HEAT. @ (480) P. F.			11.9627	10.1327	8.4282	4.3187	1.7358	0.0000	0.0000	0.0000	.6588	3.2103	7.2769	11.0530	

ZONE 2-P

SUMMARY SHEET

TYPE ****	MEAN UNIT AREA *****	NO. OF UNITS *****	TOTAL AREA *****	TOTAL HEATING (BTU) *****	TOTAL COOLING (BTU) *****	ADJUSTED TOTAL HEATING *****	ADJUSTED TOTAL COOLING *****
A-1	805.0	3	2415.0	.160E+09	.260E+08	.770E+08	.125E+08
A-2	2350.0	1	2350.0	.140E+09	.228E+08	.674E+08	.109E+08
B-3	0.0	0	0.0	0.	0.	0.	0.
B-4	0.0	0	0.0	0.	0.	0.	0.
C-5	0.0	0	0.0	0.	0.	0.	0.
C-6	0.0	0	0.0	0.	0.	0.	0.
D-7	2188.0	5	10940.0	.923E+09	.193E+09	.443E+09	.926E+08
D-8	1584.0	1	1584.0	.127E+09	.251E+08	.609E+08	.121E+08
D-9	0.0	0	0.0	0.	0.	0.	0.
D-10	0.0	0	0.0	0.	0.	0.	0.
D-11	0.0	0	0.0	0.	0.	0.	0.
E-12	9533.0	113	107722.0	.121E+12	0.	.581E+11	0.

TOTAL ZONE HEATING IS12E+09 MBTU
TOTAL ZONE COOLING IS27E+06 MBTU
ZONE LAND AREA IS 80.40 ACRES
TOTAL ZONE HEATING PER ACRE IS152304E+07 MBTU/ACRE
TOTAL ZONE COOLING PER ACRE IS332652E+04 MBTU/ACRE
TOTAL BUILDING AREA IS 1094518.00 SQUARE FEET
TOTAL NUMBER OF UNITS IS 123
HEATING PENETRATION FACTOR IS 0 .480
COOLING PENETRATION FACTOR IS 0 .480

ADJUSTED ZONE HEATING IS59E+08 MBTU
ADJUSTED ZONE COOLING IS13E+06 MBTU
ADJUSTED NO. OF UNITS IS 59.0400
ADJUSTED BUILDING AREA IS 525368.6400 SQUARE FEET
ADJUSTED HEATING PER ACRE IS 731058.35 MBTU/ACRE
ADJUSTED COOLING PER ACRE IS 1593.85 MBTU/ACRE

ZONE	LAND AREA (ACRES)	HEATING LOAD FOR THE MONTH JANUARY (BTU)	DESIGN HEATING LOAD (BTU/HR)	(DESIGN) THERMAL DENSITY (BTU/HR ACRE)	ASSUMING 100% (PENETRATION) REMARKS (SEE EXPLANATION OF SYMBOLS)
1	52.8	0.24×10^9	0.6837×10^6	0.0129×10^6	E
2	80.4	0.25×10^{11}	7.22×10^6	0.886×10^6	B
3	100.4	0.53×10^{10}	15.098×10^6	0.15×10^6	E
4	15.50	0	0	0	-
5	207.3	0.19×10^{11}	54.125×10^6	0.261×10^6	D
6	1.40	0.44×10^9	1.253×10^6	0.895×10^6	B
7	12.90	0.36×10^{10}	10.26×10^6	0.795×10^6	B
8	43.8	0.39×10^{11}	111.1×10^6	2.536×10^6	A
9	101.1	0.55×10^{10}	15.668×10^6	0.155×10^6	E
10	30.9	0.92×10^{10}	26.21×10^6	0.848×10^6	B
11	45.8	0.47×10^{10}	13.39×10^6	0.2923×10^6	C
12	96.4	0.12×10^{11}	34.18×10^6	0.354×10^6	C
13	257.1	0.22×10^{11}	62.67×10^6	0.244×10^6	D
14	4.0	0.13×10^{10}	3.7033×10^6	0.926×10^6	B
15	3.90	0.36×10^9	1.0255×10^6	0.263×10^6	D
16	2.80	0.12×10^{10}	3.4184×10^6	1.221×10^6	A
17	3.60	0.68×10^9	1.937×10^6	0.538×10^6	C
18	5.40	0.40×10^{10}	11.395×10^6	2.110×10^6	A
19	25.50	0.22×10^8	0.0628×10^6	0.0025×10^6	E
20	89.00	0.37×10^8	0.1054×10^6	0.0012×10^6	E
21	65.40	0.13×10^{10}	3.703×10^6	0.057×10^6	E
22	123.10	0.31×10^{10}	8.831×10^6	0.0717×10^6	E
23	89.70	0.86×10^{10}	24.5×10^6	0.273×10^6	D
24	1.70	0.18×10^9	0.513×10^6	0.302×10^6	C
25	2.30	0.21×10^{10}	5.982×10^6	0.260×10^6	A
26	30.20	0.68×10^{10}	19.37×10^6	0.641×10^6	C
27	12.7	0	0	0	
28	2.62	0.10×10^{11}	28.487×10^6	0.109×10^6	E
29	6.5	0.57×10^9	1.624×10^6	0.25×10^6	D
30	156.8	0.13×10^{11}	37.03×10^6	0.236×10^6	D
31	5.10	0.66×10^9	1.88×10^6	0.369×10^6	C
32	106.4	0.59×10^9	16.807×10^6	0.158×10^6	E
33	9.0	0.80×10^9	2.279×10^6	0.253×10^6	D
34	179.90	0.83×10^{10}	23.64×10^6	0.131×10^6	E
35	58.50	0.99×10^8	0.282×10^6	0.005×10^6	E
36	100.20	0.59×10^{10}	16.807×10^6	0.168×10^6	D
37	31.6	0	0	0	
38	53.7	0.39×10^{10}	11.11×10^6	0.207×10^6	D
39	25.6	0.13×10^{10}	3.703×10^6	0.144×10^6	E
40	39.50	0.29×10^{10}	8.261×10^6	0.209×10^6	D
41	192	0.16×10^{11}	45.58×10^6	0.2374×10^8	D
42	369.5	0.63×10^8	0.1795×10^6	0.0005×10^6	E
43	125.8	0.51×10^{10}	14.53×10^6	0.1155×10^6	E
44	6.9	0.64×10^{10}	18.232×10^6	2.642×10^6	A
45	75.4	0.63×10^8	9.6695×10^6	0.0023×10^6	E
46	172.4	0.27×10^{11}	76.915×10^6	0.446×10^6	C
47	130.6	0.37×10^{10}	10.54×10^6	0.081×10^6	E
48	7.9	0.48×10^{10}	13.674×10^6	1.731×10^6	A
49	173.9	0.12×10^{10}	3.418×10^6	0.0197×10^6	E
50	163.5	0.72×10^{10}	20.51×10^6	0.125×10^6	E

ZONE	LAND AREA (ACRES)	HEATING LOAD FOR THE MONTH JANUARY (BTU)	DESIGN HEATING LOAD (BTU/HR)	(DESIGN) THERMAL DENSITY (BTU/HR ACRE)	ASSUMING 100% (PENETRATION)
					REMARKS (SEE EXPLANATION OF SYMBOLS)
51	1.30	0.16×10^9	0.456×10^6	0.351×10^6	C
52	1.20	0.73×10^9	2.08×10^6	1.733×10^6	A
100	293.9	0.19×10^{10}	5.413×10^6	0.0184×10^6	E
101	259.0	0.26×10^{10}	7.407×10^6	0.0286×10^6	E
102	429.8	0.37×10^{10}	10.54×10^6	0.0245×10^6	E
103	362.3	0.47×10^9	1.35×10^6	0.0037×10^6	E
104	349.2	0.50×10^9	1.424×10^6	0.0041×10^6	E
105	707.50	0.44×10^9	1.253×10^6	0.0018×10^6	E
106	814.50	0.74×10^9	2.108×10^6	0.0026×10^6	E
107	134.00	0	0	0	-
108	49.60	0.71×10^9	2.022×10^6	0.041×10^6	E
109	949.8	0.19×10^{10}	5.412×10^6	0.0057×10^6	E
110	668.3	0.98×10^{10}	27.917×10^6	0.042×10^6	E
111	111.60	0.11×10^{11}	31.34×10^6	0.28×10^6	C
112	219.5	0.14×10^{10}	3.988×10^6	0.018×10^6	E
113	237.60	$.40 \times 10^{10}$	11.395×10^6	0.048×10^6	E
114	42.90	0	0	0	
115	433.70	$.16 \times 10^9$	0.456×10^6	0.0011×10^6	E
116	1409.30	$.19 \times 10^{10}$	5.412×10^6	0.0038×10^6	E
117	834.50	$.14 \times 10^{10}$	3.988×10^6	0.0048×10^6	E

SYMBOLS:

A → VERY FAVORABLE
B →

Design
Thermal Density
 10^6 Btuh/Acre

Category

Symbol Used
in Table

Over 0.97

Very Favorable

A

0.97 - 0.70

Favorable

B

0.70 - 0.28

Possible

C

0.20 - 0.17

Questionable

D

Less than 0.17

Not Possible

E

2.2.6 THE PUBLIC OPINION SURVEYS

METHODOLOGY--

To obtain the best and most accurate end-user data base, it was determined to use primary source data collected from field survey research. This method of collection, when completed on a statistical significant sampling basis, provides the user with an in-depth, picture of the community. The data collected establishes not only the base for various frequency distributions relative to existing heating and cooling facilities, usage and demographics, it also provides the input variables for the multivariate analyses, ie., factor analysis and discriminant analysis.

The thermal zones establish the physical boundaries for the survey research. As mentioned previously, the zones were established according to use and type of structure. A total of 70 thermal zones were delineated. This provides the base for the residential, commercial, industrial and institutional data collection. The results of the surveys allows analysis and evaluation of the 4 sectors of the Study Area relative to attitudes/problems/perceptions of retrofitting for thermal energy. Furthermore, economics concerning the cost of end-user retrofitting can be more adequately assessed and analyzed; thereby defining certain financial/institutional barriers that exist in the community.

While the objective of sampling among the residential/commercial, industrial and institutional community remains constant, the method of collection and data assemblage varies relative to the type of information desired, the anticipated problems of retrofitting, and the need to assess various schemes. Therefore, different methods were employed in each sector.

Within the residential community, the purpose of the research is to obtain responses from heads of households who are representative of all heads of households in the Study Area. In order to insure representativeness of the sample, a combination of sampling techniques is employed--stratified, area random, quota-control, fixed start, designated interval sampling methodology is used.

PIQUA DISTRICT HEATING & COOLING DEMONSTRATION PROJECT

THERMAL INVENTORY/SURVEY RESEARCH PROCESS

TABLE

<u>Sampling Stage</u>	<u>Unit of Sampling</u>	<u>Procedure Employed</u>
1	Zone	Stratification
2	Block	Random
3	Dwelling Unit	Fixed Start, Designated Interval
4	Respondent	Quota-Control Selection

An expression for determining the sample size when the sample is taken without replacement from a finite population was determined as the appropriate statistical technique. This expression relates the required sample size to the level of risk, population size, tolerable error and an initial assumption of the value of π . The formula utilized is:

$$n = \frac{\frac{N}{2} - N \times Z^2 \times \pi (1 - \pi)}{(N - 1) \times e^2 \times Z^2 \times \pi (1 - \pi)}$$

n = Sample Size

N = Population Size

Z = Normal Deviate

π = Proportion of elementary units
in the population having a particular
attribute

e = Tolerable Error

The population size, determined from field survey counts of dwelling units, is 8,075 units. The e statistic, or tolerable error, is defined as the maximum amount by which the estimate ought to be above or below the parameter. The level of tolerable error, or confidence level, for this calculation is .05. Therefore, in solving the equation, a sample size for the residential universe is established at 367 units. (For a detailed explanation of the residential survey methodology, interview process and completed questionnaire, see Appendix 2).

The survey process for the commercial, industrial and institutional sectors differs from the residential in that the universe is much smaller, with much of the information being of a more technical nature. Therefore, random

sampling is not employed, rather a systematic approach is employed to interview essentially all units. Within the commercial sector, nine zones show heavy commercial loadings. These zones contain 709 commercial units, with 499 (70.4%) participating in the survey process. (See Appendix 2 for the detailed methodology survey process and completed questionnaire).

The survey process for the industrial and institutional sectors differs from the residential and commercial given the smaller number of units. Here, an attempt was made to interview all users within these sectors instead of the random sampling technique. For these sectors, a two part survey is utilized, with the first part being technical in nature, and the second concerning attitudes and perceptions of the respondent. A total of 41 industrial respondents and all institutional (schools) respondents participated in the survey process. (See Appendix 2 for the methodology, survey process and completed questionnaire).

The surveying process was accomplished during the month of January, 1979. Due to the exorbitant amount of data compiled from each of the surveys, it was necessary to mechanize the data in a form compatible with computer tabulation. Employing appropriate subprograms, frequency and cross-tabulation are obtained from the Statistical Package For The Social Sciences for both absolute and percentage distributions. The quantity and specificity of data permits analysis and evaluation for both Study Area wide results, and zone specific analysis relative to the marketing approach. Therefore, generalized data results are presented in this chapter, while zone specific analysis and evaluation occurs in Chapter 3. In addition, frequency of response cross-tabulations and related statistics for each zone in the Study Area are available at the offices of Hanselman-Eskew and Associates.

2.2.7 DATA SUMMARY

RESIDENTIAL-- The residential survey provides insight into the types of energy use within this sector, respondent's energy consciousness, willingness/ability to make improvements, and other attitudes and perceptions regarding energy in

general. The Study Area community is a typical one that displays major similarities in the distribution and use of energy. As shown by the following illustration, 62.8% of the heating systems are gas-fired warm and forced air. In addition, 11.6% are either gas-fired boilers or gas space heaters.

DISTRIBUTION OF HEATING SYSTEM TYPES (Study Area) *

This is extremely important for the retrofitting process in that the majority of heating units in the Study Area (74.4%) are of the type which are the easiest to convert to hot water heating. On the following page see the further delineation of these parameters. As shown, 82.6% of the residents use natural gas as the primary heating fuel, with only 9% utilizing electricity.

The prevailing hot water heating systems within the area are natural gas - 74%; with another 23.5% being electric. Obviously the thermal system can perform this function; thereby displacing the present fuel usage. The demand for air conditioning in the community does not appear to be of the magnitude

* Please refer to Appendix for detailed Residential and Commercial Heating System Characteristics at the Zone level.

DISTRIBUTION OF HEATING FUELS (Study Area)

DISTRIBUTION OF HOT WATER HEATING SYSTEM TYPES
(Study Area)

where district cooling will be useful, or cost effective. More than 50% of the community does not have any form of air conditioning; and as shown by the following illustration, those that have air conditioning, 73.6% have window units with 1.45 the mean number of window units per household.

The location of the main heating system is very important, particularly as it applies to the ease and cost of retrofitting. As shown by the following graph, 59.7% of the units are located in the basement, with an additional 34.1% located on the first floor. Thus, 93.8% of the systems are in areas of the structures where physical retrofitting problems will be minimized.

LOCATION OF MAIN HEATING SYSTEM

(Study Area)

The age of the heating system is very important specifically as it relates to the end-user's desire to convert to the thermal system. If all of the units were less than 5 years old, very few would retrofit; if though, the majority were greater than 16 years old, the design of the first phase may become too large and too expensive. Fortunately though, neither are the case. As expressed by the following pie graph, the ages of the heating systems in the Study Area are evenly stratified by 5 year increments. This provides the proper format for end-user phasing assuming a life expectancy of heating systems at 20 years. Furthermore, given this stratification, only a small percentage of the systems are in fair or poor condition--as perceived by the residents.

HEATING SYSTEM AGE (Study Area)

HEATING SYSTEM CONDITION (Study Area)

The residential community within the Study Area is both knowledgeable and concerned about the energy situation. Most agree that there is an energy crisis, and feel they have taken actions to try and mitigate energy use and price increases. More than 50% believe that there is, in actuality, an energy crisis, with such reasoning being distributed among the responses listed below.

Do you agree strongly, agree, disagree or disagree strongly that there is an energy crisis?

Why do you feel that way?

26.0%	RESOURCE DEPLETION/EXCESS CONSUMPTION/POPULATION GROWTH
25.5%	OIL COMPANY MANEUVER FOR INCREASED PROFITS/POLITICAL MANEUVER/GOVT. REGULATIONS
19.2%	INFLATION/PRICE INCREASE/GAS HIKES/FOREIGN DEPENDENCE
18.0%	PASSIVE COMPLIANCE/HEAR SO MANY DIFFERENT STORIES YOU DON'T KNOW WHAT TO BELIEVE
5.0%	NEED TO DEVELOP ALTERNATIVE FUEL SOURCES
11.3%	OTHER/DK

As a result, energy consciousness on their behalf results in the following distribution relative to energy saving actions:

- 86.2% have storm windows
- 88.5% have storm doors
- 78.2% have attic insulation

while these responses would be expected in a newer development, one must remember that more than 70% of the residences in the Study Area were built prior to 1950; and as such, these types of improvements would not have been part of the original structures.

Concerning energy improvements, the majority would be willing to make significant improvements if it provided a 10 year pay back of the investment. Obviously the percentage increases if the pay back period is reduced to 5 years.

HEATING SYSTEM IMPROVEMENTS (Study Area - Homeowners Only)

Willingness to improve heating system with 10 year payback period.

Willingness to improve heating system with 5 year payback period.

The financing of energy improvements on behalf of the residential community provides insight into certain institutional obstacles that may arise as a result of end-user retrofits. If energy improvements (retrofitting) would cost \$500 or more, the following breakdown is how the residences would pay for such improvement:

- 28.6% Cash on Hand
- 17.0% Money from Savings
- 10.9% Time Payments
- 24.6% Borrow from Bank
- 1.6% Other
- 7.1% Would not make any such improvements
- 10.0% Don't know

Significantly, only 7.1% indicated that they would not make any such improvement. (See Appendix 2 for zone specific responses to this question).

In summary, the Study Area's residential sector appears to:

- 1) be energy conscious
- 2) be concerned about fuel usage
- 3) consist of retrofittable structures
- 4) be willing to make energy saving improvements
- 5) have made, some, energy saving improvements
- 6) realize that energy will continue to increase in price
- 7) be willing to accept thermal energy as a replacement for scarce fuels--natural gas
- 8) will likely retrofit where possible over time

COMMERCIAL

The distribution of heating-system types in the commercial sector of the Study Area is indicated on the following page. As shown, the overwhelming majority of the units are the type that could be retrofitted for thermal energy - 89.7%. Further, the field survey revealed that in the Central Business District, there are presently 38 boilers in operation currently fired either by natural gas or oil. The predominant heating fuel employed is natural gas; and when combined with the remaining types of fuel usage, provide a retrofitting situation that could be adequately dealt with in a central thermal system.

DISTRIBUTION OF HEATING SYSTEM TYPES (Study Area)

DISTRIBUTION OF HEATING FUELS (Study Area)

The majority of heating plants are either in the basement or on the first floor.

These locations not only enable easier retrofits, but also reduce end-user costs of retrofit.

The age of existing heating systems is presented by the following illustration.

As with the residential sector, the ages are stratified by the increments rather than being grouped into one or two categories. While age is not as important in the commercial sector given that much of the existing equipment can be used, it does indicate when major investments could occur over the life of the project.

The majority of the systems are either in good or excellent condition - 81.6%, with only 16.1% in fair or poor condition. Most of the systems have not required any major repairs in the past 5 years - 67.6%. While these facts may present some obstacles for commercial retrofitting, it must be pointed out that for some, the retrofitting will only entail connecting to the district system and minor in-structure changes.

The commercial sector does display a higher degree of air conditioning than the residential sector, with 70.2% having either window units or central air conditioning. While this sector represents a higher demand for central cooling, it does not appear to be sufficient enough to justify a central source cooling supply. Many of the structures though may have sufficient demand where an on-site absorption unit could be cost-effective. These site-specific requirements will be analyzed at a later date.

The commercial sector is not as energy conscious with respect to energy saving improvements as illustrated below:

- 36.4% have storm windows or thermal break windows
- 27.3% have storm doors
- 44.5% have attic insulation

However, further investigation reveals that many of these structures are not suited for storm windows or storm doors via design. Secondly, many are owned by persons other than the occupant whereby energy costs are consistantly passed back and forth between the owner and the tenant via the lease agreement with the owner passing on to the tenant, and the tenant on to the consumer. The survey indicates that 58.1% of the commercial units are not owner-occupied. And of those, 45.3% indicated they would not pay higher rent if more efficient heating equipment was installed that would lower utility costs.

As shown by the following illustration, building owners are not as likely to make energy saving improvements if the return on the investment is 10 years or 5 years.. However, 58.9% would if the investment cost could be recovered, and 74.1% if the return could be 3 years. Obviously the pay back here is tied more closely to capitalization of the debt involved coupled with the equipment's depreciation schedule and an acceptable rate of return. The owners of the commercial structures would finance energy-saving improvements of \$500 or more via the following distribution:

- 48.7% Normal cash flow
- 6.2% Capital contribution
- 15.0% Bank loan
- 3.5% Time payments
- .9% Other
- 23.9% Undecided

HEATING SYSTEM IMPROVEMENTS (Study Area - Building Owners Only)

Willingness to improve heating system with 10 year payback period.

Willingness to improve heating system with 5 year payback period.

The commercial sector of the Study Area does feel that there is an energy crisis; however, there is disagreement as to why. Interestingly though, the percentage distributions display a great deal of similarity with the residential sector.

DO YOU AGREE STRONGLY, AGREE, DISAGREE, OR DISAGREE STRONGLY
THAT THERE IS AN ENERGY CRISIS?

WHY DO YOU FEEL THAT WAY?

- 27.5% RESOURCE DEPLETION/EXCESS CONSUMPTION/POPULATION GROWTH
- 29.1% OIL COMPANY MANEUVER/POLITICAL MANEUVER/GOVT. REGULATIONS
- 17.3% "CRISIS UNTIL PRICES GO UP"/ RESOURCE ABUNDANCE
- 13.8% INFLATION/PRICE INCREASE/GAS HIKE/FOREIGN DEPENDENCE
- 7.8% OTHER/DK
- 5.1% NEED TO DEVELOP ALTERNATIVE FUEL SOURCES

Furthermore, when questioned on the best method of addressing this problem, only .7% responded "Do Nothing". The following distribution represents the range of responses.

- .7% Do Nothing
- 15.0% Higher prices of heating fuel
- 7.7% Higher taxes on heating fuel
- 74.3% Tax deductions or other such incentives offered by the government to encourage heating fuel conservation (For example: Tax deductions for installing insulation in your home)

- 43.4% Elimination of pollution controls so that more forms of fuel (such as high sulfur content coal) could be used.
- 26.1% Charging those who use more heating fuel more per unit (The more a household or business uses, the higher rate they are charged)
- 11.1% Regulation or rationing of heating fuel only (Not automobile gasoline) by the government.
- 11.5% None of the above

And, when asked to identify the singularly best method of dealing with the problem, 58.6% felt that tax deductions or other such incentives that would encourage conservation was the most appropriate, while 20.3% felt that the relaxing of pollution constraints to allow for more forms of fuel to be utilized would stimulate energy conservation.

The commercial community is quite informed, with only 25% never hearing of the District Heating and Cooling Project. In addition, more than 70% indicated a positive feeling concerning the Piqua Municipal Power System's attempt to provide central source thermal energy to the community.

INDUSTRIAL

The industrialists in the Study Area responded to the survey only as the questions related to the Study Area. Any of their plants with facilities located outside the Study Area were omitted from the appropriate calculations.

The first part of the questionnaire dealt primarily with the energy requirements of their plants, the product produced, the type of existing HVAC system including a breakdown by production usage and heating requirements and an analysis of the existing boilers. The analysis and evaluation of this material is contained in other sections of this study.

Concerning applicable portions herein, the industrial sector of the Study Area is not only energy conscious, but also willing to make improvements if energy efficiency is improved. The following illustration indicates that the majority (71.4%) feel there is an energy crisis. There is though, stated differences as to why this crisis exists.

DO YOU AGREE STRONGLY, AGREE, DISAGREE, OR DISAGREE STRONGLY
THAT THERE IS AN ENERGY CRISIS?

WHY DO YOU FEEL THAT WAY?

- 40.5% OIL COMPANY MANIPULATION/GOVT. REGULATIONS (PRICE CONTROLS)
- 33.3% RESOURCES AVAILABLE/EXAGGERATED RESPONSE TO ENERGY CRISIS
- 19.0% MEDIA AND PEOPLE TALK ABOUT IT/MUST BE TRUE
- 11.9% FOREIGN DEPENDENCE
- 9.5% RESOURCE DEPLETION/EXCESS CONSUMPTION
- 8.5% NEED TO DEVELOP ALTERNATIVE FUEL SOURCES

The industrial sector is involved in energy conservation programs with 54.8% currently pursuing these programs. The following indicates the various types of conservation programs ongoing, and the programs' accomplishments.

Conservation Programs

- 26.7% Lower temperature/set thermostat at 68°, 62°, etc.
- 19.0% Seal windows/doors/caulking, bricking
- 9.5% Heat recovery systems/heat ducts installed which pipes production air to warehouse for heating/recovery from furnace to heat water
- 7.1% Add insulation
- 7.1% Redesign lighting/lights kept down or off during off hours

- 7.1% Installation of heat exchangers, capacitors
- 4.8% Changes in method of production
- 4.8% Boiler temperature reduction at night
- 4.8% Employee education on conservation issue
- 2.4% Timer circuits installed

Program Results

- 21.1% Lower heating costs
- 10.5% Reduced electrical costs
- 21.4% Reduction in natural gas usage
- 5.3% Reduction in propane gas usage
- 5.3% More comfort for employees
- 26.4% Unknown/in developmental stages
- 5.3% None

When questioned concerning investing in energy improvements with a given pay back period, the following illustrations present the results. As shown, the majority will make such an investment if the return is 2 years, with less than 50% if the pay back is 5 years. Undoubtedly, this response is closely tied with in-plant planning and development cycles.

As indicated by the accompanying table, this sector is very informed about the District Heating and Cooling Feasibility Study, and is a reflection of their involvement/commitment to the area.

- 28.6% Know a little about it
- 28.6% Heard of it, but don't really know anything about it
- 23.8% Know quite a bit about it
- 16.7% Never heard of it
- 2.4% DK/No opinion

WILLINGNESS TO INVEST IN ENERGY CONSERVATION IMPROVEMENTS WITH 2 YEAR PAYBACK PERIOD.

WILLINGNESS TO INVEST IN ENERGY CONSERVATION IMPROVEMENTS WITH 2 YEAR PAYBACK PERIOD.

A Piqua Area Manufacturers Association has been and continues to be quite active in the community, and the Demonstration Team has held two meetings with this group, and some are members of the Project Advisory Committee.

Furthermore, most feel good about the possibility of utilizing the Piqua Municipal Power System to provide thermal energy to Piqua area residents, businesses and industries.

- 26.2% Good if cost is feasible/less expensive/cheaper than buying from outside source/if able to use same plant
- 7.1% Good, if efficient for manufacturing/industry
- 7.1% Good, because sound steam system attracts industry/keeps Piqua competitive with surrounding area
- 7.1% Good, because steam is good source of heat/more consistent
- 7.1% Good, because steam helps alleviate natural gas depletion/economical

- 7.1% Good, because steam is source of energy conservation which makes use of flow pressure steam that is being dumped into condensers
- 2.4% Balance is problem/demand too fluctuating in Piqua for system to be practical
- 7.1% Limitations to system/have to be within certain radius of plant to benefit
- 4.8% Capital outlay is great and end would have to justify means
- 4.8% Need to study other areas where system has been in use
- 9.5% System just not practical
- 4.8% Do not know enough to comment
- 16.7% No opinion
- 2.4% Government should not operate power system
- 21.4% Good idea

In essence, it is apparent that the industrial sector within the Study Area is very much concerned not only about their operation, but also that of areawide viability. It is a group that is well-informed, participates in community affairs, and has the demonstrated ability to react to situations which would be detrimental to their facilities and that of the broader community.

INSTITUTIONAL

The institutional sector centers primarily upon the Piqua City School System. As part of the thermal zoning, each school is defined as a separate and distinct zone. The purpose of this assignment is that the load demand for each school appears to be sufficient to permit this type of classification.

The primary heating system within the system is gas fired boilers. There is one school, Bennet, which is currently a PMPS steam customer.

The school system is energy conscious, and has instituted a number of energy conservation measures. Measures taken include thermostat control, added insulation, weather stripping and plastic insulating window covers.

In summary, it is apparent that where possible, the school system will connect to the central source thermal system providing efficiencies are increased and cost stabilized.

DISTRIBUTION OF HEATING SYSTEM TYPES (STUDY AREA)

SERVICE AREA EVALUATION

In order to identify areas that could be favorably served by the District heating system, the same zone system used in the Hanselman-Eskew survey was employed. These zones were termed "Thermal Zones" and are shown on the map on page 165.

In the identification of the most attractive thermal zones, the following factors were considered.

- 1.) Type of energy use, such as gas, electric, oil, etc.
- 2.) Type of end-users - residential, commercial, industrial
- 3.) Density of Structures

Data obtained from the survey included the type of structure, floor area, total land area of the thermal zone, type of heating system, and other relevant information.

Based on information collected from this survey, the heat loads of the thermal zones for each month were calculated as the computer program previously explained.

For the purposes of identifying prospective areas for district heating, the design heat loads and the design thermal density of each zone (Btuh/Acre) was calculated (see Appendix). Ideally, to be served by the District heating system, the thermal density of a zone should be as high as possible. For our preliminary study, the threshold thermal densities based on Swedish and U.S. experience (Ref.) have been used to identify areas that have the most promise for District heating. They are classified as follows:

<u>Design Thermal Density 10⁶ Btuh/Acre</u>	<u>Category</u>	<u>Symbol Used in Table</u>
Over 0.97	Very Favorable	A
0.97 - 0.70	Favorable	B
0.70 - 0.28	Possible	C
0.20 - 0.17	Questionable	D
Less than 0.17	Not Possible	E

Based on the information gathered, the most attractive thermal zones were grouped and categorized with respect to their potential for District heating. These are presented in Table 2-8.

The map on page 350 is a representation of the initial service zone based on the most favorable heat loads, an ultimate service area by the year 2000.

Note that some zones were excluded from the ultimate service area. This is due to low load density and little projected growth.

TABLE 2-8

<u>ZONE</u>	<u>DESCRIPTION OF BUILDINGS</u>	<u>PROSPECT FOR DISTRICT HEATING</u>
8	Commercial, Mixed and Multi-Family Structures	<p>Very Favorable For 100% Penetration Favorable to very Favorable for 50% Penetration</p>
16	Commercial and Mixed Use (1 Structure)	
18	Industrial (9 Structures)	
25	School	
44	School	
48	Commercial and Mixed Use	
52	School	
2	Commercial and Mixed Use and Industrial	<p>Favorable For 100% Penetration for 50% Penetration "Possible" to Favorable</p>
6	School	
7	Commercial and Mixed Use and Industrial	
10	Commercial and Mixed Use and Industrial	
14	Hospital-Health Care	
11	Commercial, Mixed Use, Multi-Family and Single 2-Story Structures (40), Single Family (13)	<p>"Possible" For 100% Penetration For 50% Penetration "Questionable" To "Possible"</p>
12	Commercial, Mixed Use (3+8) Single Family 2-Story, 2-Family-2-Story (51), Multi-Family 2-Story (15)	
17	School	
26	Commercial and Mixed Use	
31	School	
46	Single Family 1-Story(297), 2-Story(63), Multi Family(1) 2 Family 1-Story (3)	
51	School	
111	Commercial and Mixed Use Residential	

3.0. ENERGY MARKET ANALYSIS

The objective of the analysis is to arrive at an estimate of the market share/penetration that thermal energy may achieve on the study-wide level over time, while simultaneously providing a profile of the characteristics of those who would be willing to use the system. Marketing problems of this type are inherently multidimensional. Multivariate-techniques were therefore determined to be the appropriate approach to analyze the complex survey data.

Separate analyses were performed on both the residential and commercial populations. Each analysis relied on data from respective questionnaires; (see sections 2.2, 2.3) conducted over statistically appropriate samples (residential-n= 390; commercial-n=272) of Piqua merchants and residents.

Since the problem was too unmanageable to be solved manually, all necessary computations were carried out on an IBM 360 computer with sub-programs from the "Statistical Package for the Social Sciences".

Determining the market structure involved the identification of the perceptual dimensions of the market and how thermal energy consumption decisions are perceived by various market segments with respect to these dimensions. From this information, insights can be obtained into the nature of penetration and when coupled with segment preference information, it can lead to product strategy development. The first step then was to determine some meaningful variables upon which to measure the characteristics/perceptions of the potential end-user. 390 residents and 272 merchants in the City of Piqua were exposed to public opinion questionnaires designed specifically as inputs to the market analysis. (See sections 2.2, 2.3 and Appendix). While the two questionnaires were treated as separate markets - each analysis employed the same methodologies and decision criteria--for this reason the following strategy summary will detail the residential market analysis and results. However, summary commercial statistics are presented at the end of this chapter.

Primarily, the residential questionnaire was designed to inventory present heating/cooling system types and conditions, demographics, and a variety of other attributes - resulting in a total of 104 questions.

Factor analysis, a descriptive statistical technique, was used in the analysis to summarize the large number of questionnaire items into a smaller, more concise body of information, (set of variables) which could subsequently be used as input into the discriminant analysis. Many of the questionnaire items are different dimensions of the same characteristic, and factor analysis can identify the smaller number of valid measurements in the larger set of questionnaire items; thus, condensing the data into a series of new, mutually exclusive variables. The specific objectives of factor analysis as applied in the district heating market analysis are:

- (a) To establish functional relations between variables; factor analysis can be employed to isolate variables which it may not be possible to measure directly, but can be computed from a set of observable and directly measurable, but otherwise unsatisfactory measures.
- (b) To produce a more parsimonious description within the study domain. For example, five questions related to permanency were reduced to one variable which measures the same thing.
- (c) To test theories about interrelationships between variables. For example--is heating system maintenance related to willingness to invest in energy saving improvements?
- (d) To categorize people or businesses into groups ie.- innovators, status conscious, energy conscious.
- (e) Finally, as a preliminary to discriminant analysis, to identify those variables which are most likely to be usefully included in a discriminant classification function.

A factor loading matrix was generated and subsequently analyzed. All questionnaire items chosen for the analysis had a loading of some magnitude on every factor. However, for any one factor, the loadings of a few items are large while the loadings of the other items are very small. These factor loadings portray the degree to which the individual items (questions from the

public opinion surveys) represent a factor characteristic as a whole. For example--factor one shows very high positive loadings on attributes like number of years living in Piqua, number of years in this house, number of times resident has moved in the last five years, age of resident and length of current employment. If the high loaded items on the factor are thought of as a group, the highest loaded items are the best instances of whatever it is that holds that group together. Thus, each factor can be labeled by grouping those variables which load heavily on the factor and then interpreting the characteristics which these grouped items define. In this instance, the factor can be interpreted as a measurement of permanency. Reader should note examples on following page.

EXAMPLE OF FACTOR ITEMS EMPLOYED IN DISCRIMINANT

Characteristic

Privilegedness	Financial Capability relative to other community members Perpensity to consume	What is the head of household's annual income? (Q99) Which of the following items do you own? (Q56)
Permanency	Locational permanency	How many years have you lived in Piqua? (Q85) How long have you lived in this house? (Q86) How many times have you moved in the last five years? (Q87) What is your age? (Q90) How long have you held this job? (Q96)
Cosmopolitanism	Geographical mobility	If you could live any place in the world you choose, where would you live? (Q61) How often do you travel outside the Piqua area? (Q62) How often do you travel outside the State of Ohio? (Q63) Have you ever had a passport to visit a foreign country? (Q64)
Product Innovativeness	Attitude toward innovative behavior Self perception on represented innovator characteristics	How do you feel about buying a new product for your home? (Q55) In regards to new products on the market, I am: (first-last)

These labelled characteristics are subsequently used as inputs into the discriminant analysis. The individual questionnaire items corresponding to the labelled factor characteristic will range on a scale from highly representative of the characteristic to highly nonrepresentative. Then, the mean of these items comprising the characteristic is calculated for each of the questionnaire respondents. This can perhaps be better exemplified by returning back to our permanency example. For each case in the population, the individual's answers on each of the questionnaire items composing the factor are extracted, and the arithmetic mean of these values is calculated. It is this overall mean score on a factor characteristic that is employed as raw data in the discriminant analysis. The questionnaire items which do not have a high loading on any of the factors and thus were not a member of any labelled characteristic group were used as separate inputs in the discriminant analysis if determined to represent interpretable constructs important to the DH market--all other variables were deleted from the analysis.

Once all the data is reduced to its simplest form, multiple discriminant analysis is applied to determine the extent to which it might be possible to distinguish between "willing, unwilling, and unsure" connectors to the proposed district heating-cooling system. Discriminant analysis is a predictive technique which attempts to classify an observation on one of several a-priori groupings--"willing, unwilling, or unsure", dependent upon the observations individual characterizations. The primary use of discriminant analysis is to make predictions in problems where qualitative information "willingness to connect" is determined by quantitative data "demographic decisions, etc.".

By maximizing the ratio of intergroup to intragroup difference, discriminant analysis pinpoints those factors that account for the largest amount of difference between groups. Thus, the groups are forced to be as statistically distinct as possible. Therefore, all Piqua concerns are a member of one of the three groups and some way of assigning them to the proper population is desired for marketing purposes. Although this cannot be done with absolute accuracy, discriminant analysis minimizes the probability of misclassification.

The problem of predicting consumer behavior within the private market place as it relates to a specific good or service is not new. Every firm throughout the nation which markets goods on a national or regional or local scale faces this exact question. Simply installing a thermal distribution network and observing whether or not consumers actually hook up is obviously an unacceptable approach. Similarly, test marketing is equally out of the question in that the cost involved and producing even the first hook up is substantial. Therefore, an empirical approach to estimating the market is necessary--the application of multivariate analysis to forecast in advance the consumer response to thermal service for space heating and cooling and other energy needs.

The discriminant analysis classification matrices for the residential market (initial and post operational) and the commercial market (initial and post operational) are on the following page. These four matrices divide the Study Area-wide market for thermal service into groups--"willing to hook up", "unwilling to hook up", and "unsure about hooking up". The Actual Group column at the left represents the distribution of Study Area-wide consumers according to their response to the dependent variable question (Question 34). This distribution is based upon the sample populations' response to the inquiry about spending substantial amounts of money in their home for energy conservation measures which would result in relative savings. The community's response to this question is similar to asking a group of potential consumers whether they would buy a particular good, e.g. a new Coleman camping stove, a new model car, or a new fluoride toothpaste. The Actual Group column is the categories in which sample population "groups themselves".

The Predicted Group Membership column (1,2,&3) correspond to the Actual Group rows 1,2,&3,:

- * Predicted Group Membership column 1 = "willing to hook up"
- * Predicted Group Membership column 2 = "unwilling to hook up" and
- * Predicted Group Member column 3 = "unsure about hooking up".

The Predicted Group Membership distributions are the forecasts or predictions of the multivariate analysis.

INITIAL RESIDENTIAL DISCRIMINANT ANALYSIS

CLASSIFICATION RESULTS

ACTUAL GROUP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP		
			1	2	3
GROUP	1	216	129	36	51
"willing"			59.7%	16.7%	23.6%
GROUP	2	77	16	42	19
"unwilling"			20.8%	54.5%	24.7%
GROUP	3	95	26	13	56
"unsure"			27.4%	13.7%	58.9%
UNGROUPE CASES		2	2	0	0
			<u>100.0%</u>	<u>0.0%</u>	<u>0.0%</u>
TOTAL		390	173	91	126

INITIAL COMMERCIAL DISCRIMINANT ANALYSIS

CLASSIFICATION RESULTS

ACTUAL GROUP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP		
			1	2	3
GROUP	1	62	33	11	18
"willing"			53.2%	17.7%	29.0%
GROUP	2	82	21	32	29
"unwilling:"			25.6%	39.0%	35.4%
GROUP	3	108	28	21	59
"unsure"			25.9%	19.4%	54.6%
UNGROUPE CASES		20	11	1	8
			<u>55.0%</u>	<u>5.0%</u>	<u>40.0%</u>
TOTAL		272	93	65	114

The residential case indicates that based on the dependent variable response (Q 34), 216 of the sample respondents considered themselves willing to hook up initially, while 77 would not, and 95 are undecided. However, the discriminant analysis of influencing variables indicates that initially 173 will hook up to the distribution system, while 91 are unwilling and, 126 are really unsure. The Predicted Group Membership columns are the predicted market reaction prior to construction and operation (in anticipation of) the district heating system. The initial commercial predicted group membership columns are interpreted in the same manner.

The initial residential and initial commercial results represent market predictions prior to the installation of the district heating system. The important question is how and to what extent will the willingness to hook-up groupings change upon the installation and operation of the system, i.e. when the thermal distribution lines run past the customers front door (post-operational). In order to predict the post-operational market response to thermal service the respondents are subjected to a second discriminant analysis. Based upon the original discriminant functions the respondents are re-categorized into only two groups--Group 1 = willing to hook-up and Group 2 = unwilling to hook-up. The following Predicted Group Membership columns illustrate the results of the second discriminant analysis.

POST-OPERATIONAL RESIDENTIAL DISCRIMINANT ANALYSIS
CLASSIFICATION RESULTS

<u>ACTUAL GROUP</u>		<u>NO. OF CASES</u>	<u>PREDICTED GROUP MEMBERSHIP</u>	
			<u>1</u>	<u>2</u>
GROUP	1	202	149	53
"willing"			73.8%	26.2%
GROUP	2	42	14	28
"unwilling"			33.3%	66.7%
UNGROUPE CASES		146	74	72
			50.7%	49.3%
TOTAL		390	237	153

POST-OPERATIONAL COMMERCIAL DISCRIMINANT ANALYSIS

CLASSIFICATION RESULTS

ACTUAL GROUP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP	
			1	2
GROUP	1	35	26	9
"willing"			74.3%	25.7%
GROUP	2	27	10	17
"unwilling"			37.0%	63.0%
UNGROUPEd CASES		210	122	88
			<u>58.1%</u>	<u>41.9%</u>
TOTAL		272	158	114

In the residential market the number sample willing to hook-up increases to 237 upon construction and operation of the system with 153 remaining unwilling. Again, the Post-Operational results are interpreted in the same fashion.

These forecasts are based upon the variance of the sample's response to the entire set of independent variables contained in the residential and commercial surveys. The independent variables are assembled from specific questions directed at a complete set of issues which directly and indirectly influence individual consumers and generally the market's willingness/ability to use thermal energy:

- * characteristics of community energy use
- * community heating system characteristics
- * current energy conservation measures
- * building inventory characteristics
- * community attitudes toward energy conservation and energy problems
- * financing
- * acceptable payout periods for energy conservation efforts
- * community information/education instruments
- * innovativeness/psychological characteristics of consumers

- * consumer preference patterns
- * attitudes towards community improvement and community issues
- * viability of community business districts
- * community leadership
- * community socio-economic characteristics

Multivariate analysis of these variables then reveals a pattern or distribution relative to the market's willingness to consume thermal energy through district heating and cooling. The forecasted or Predicted Group Membership columns (willing, unwilling, and unsure) represent the way the market will actually respond to implementation of district heating and cooling. These predicted percentages are based upon the discriminant functions and more accurately predict market response. In summary, the Actual Group columns reflect the way consumers within the market place presently think they will respond to district heating and cooling, while the Predicted Group Membership columns forecast the market's actual response.

Three discriminant functions were produced, one for each group. Of greatest interest is the overall strength of discriminant functions and, within any function, the identification of the discriminant coefficients which account for most of the between group variance. These coefficients serve to identify the variables which contribute most to the differentiation along the respective function. Thus, those characteristics which most influence the decision to connect could be identified and statistically tested as to their discriminating power.

CLASSIFICATION FUNCTION COEFFICIENTS

(FISHER'S LINEAR DISCRIMINANT FUNCTIONS)

G	= <u>Most Willing</u>	<u>Least Willing</u>	<u>Unsure</u>
SOCSTAT	0.8756714	1.039522	0.9863990
PERMANT	0.2839999	0.3046683	0.3556742
HOUSCOMP	2.131407	1.746294	1.999079
PRODINN	1.511706	1.816320	1.874132
INTEGRO	5.298535	5.441417	5.112364
Q8	0.1378422	-0.1303783D-02	0.1149266
Q9	2.388195	2.497009	2.175014
Q25	0.4241123	0.5017707D-01	0.3663369
Q26	2.685568	3.207716	2.398611
Q47	2.326762	2.654183	2.494265
Q88	4.109959	3.696184	3.848806
(CONSTANT)	-31.18677	-33.49051	-31.92993

The score of each respondent on these characteristics is substituted into each discriminant function separately and each respondent is assigned to the group for which the discriminant value is highest. Once each respondent has been assigned to a group, a cross tabulation of zones by group is performed to arrive at the percent penetration of those willing, unwilling and unsure per group. Please refer to table on the following page titled Residential-Initial Penetration by Zone.

RESIDENTIAL

INITIAL PENETRATION BY ZONE

<u>Zone #</u>	<u>Most Willing</u>	<u>Least Willing</u>	<u>Unsure</u>
3	26.7%	26.7%	46.7%
5	27.5%	42.5%	30.0%
8	50.0%	50.0%	0.0%
9	40.0%	40.0%	20.0%
11	40.0%	20.0%	40.0%
12	40.0%	36.0%	24.0%
13	28.0%	30.0%	42.0%
21	20.0%	20.0%	60.0%
22	60.0%	40.0%	0.0%
23	45.0%	10.0%	45.0%
26	0.0%	33.3%	66.7%
28	45.0%	0.0%	55.0%
30	50.0%	16.7%	33.3%
32	35.0%	50.0%	40.0%
33	0.0%	33.3%	66.7%
34	85.0%	10.0%	5.0%
36	55.0%	20.0%	25.0%
38	50.0%	40.0%	10.0%
39	0.0%	80.0%	20.0%
43	90.0%	0.0%	10.0%
46	60.0%	15.0%	25.0%
49	80.0%	0.0%	20.0%
50	100.0%	0.0%	0.0%
101	80.0%	0.0%	20.0%
103	60.0%	0.0%	40.0%
109	20.0%	40.0%	40.0%
110	0.0%	0.0%	100.0%
111	80.0%	0.0%	20.0%
112	60.0%	0.0%	40.0%
116	<u>40.0%</u>	<u>20.0%</u>	<u>40.0%</u>
TOTAL	44.4% (173)	23.3% (91)	32.3% (126)

These figures, baring unforeseen technical abatement, are employed as initial penetration rates on the zone and study-wide level. However, some bias is introduced because the respondents within each zone are also part of the study-wide area and thus, the discriminant function is applied to the same sample used to estimate the function.

A second objective of the market analysis was to arrive at an appropriate methodology by which potential customers with unknown group membership can be identified as to their willingness to connect once the system is in operation. Discriminant analysis can derive such a classification function which permits classification of cases with unknown memberships.

The methodology for predictive application of this nature involves reducing the number of discriminant functions from three to two (willing, unwilling). Thus, respondents are once again evaluated; however, this time their scores on the independent discriminant variables are multiplied by the revised discriminant coefficient, resulting in the post-operative penetration rates.

RESIDENTIAL

POST-OPERATIONAL PENETRATION BY ZONE

<u>Zone #</u>	<u>Most Willing</u>	<u>Least Willing</u>
3	53.3%	46.7%
5	52.5%	47.5%
8	70.0%	30.0%
9	50.0%	50.0%
11	60.0%	40.0%
12	68.0%	32.0%
13	46.0%	54.0%
21	20.0%	80.0%
22	60.0%	40.0%
23	75.0%	25.0%
26	66.7%	33.3%
28	45.0%	55.0%
30	60.0%	40.0%
32	60.0%	40.0%
33	0.0%	100.0%
34	80.0%	20.0%
36	65.0%	35.0%
38	40.0%	20.0%
39	80.0%	20.0%
43	90.0%	10.0%
46	85.0%	15.0%
49	40.0%	60.0%
50	100.0%	0.0%
101	20.0%	80.0%
103	80.0%	20.0%
109	60.0%	40.0%
110	0.0%	100.0%
111	100.0%	0.0%
112	100.0%	0.0%
116	100.0%	0.0%

Study Area
Wide

60.5 (236)

39.5% (154)

The following illustrates the application/implication of the discriminant coefficients to both the residential market and the commercial market for thermal energy within the total Study Area.

RESIDENTIAL--INITIAL MARKET

I. STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

	<u>Most Willing</u>	<u>Least Willing</u>
SOCSTAT	-0.30767	0.15433
PERMANT	-0.15436	0.57172
HOUSCOMP	0.44445	-0.00079
PRODINN	-0.32077	0.38968
INTEGRO	-0.08169	-0.25014
Q8	0.49088	0.13816
Q9	-0.07282	-0.33843
Q25	0.26541	0.07906
Q26	-0.32001	-0.48733
Q47	-0.33691	0.08713
Q88	0.29992	-0.13087

II. INTERPRETATION

a) SOCSTAT

As social status rises --so does willingness to connect to the proposed district heating system. SOCSTAT is a measure of respondents' propensity to consume (Q56), financial capability (Q99), employment status and occupation change/mobility (Q94, OCCUCH) and attempts at intellectual growth (Q83).

b) PERMANT

The more permanent in Piqua that resident is--more willing to connect. PERMANT is an indicator of locational permanency as measured by number of years living in Piqua (Q85), number of years in same house (Q86), number of times respondent has moved in the last 5 years (Q87), age (Q90) and length of current employment.

c) HOUSCOMP

The more persons per household as well as more persons under age of 18--more willing. HOUSCOMP inventories both total number of persons per household (Q92) and indicates relative age of family (Q93).

d) PRODINN

The more product innovative respondent is--more willing.
PRODINN indicates consumers attitude toward innovative
behavior (Q55) and self perception on represented innovator
characteristics.

e) INTEGRO

COEFFICIENT NOT SIGNIFICANT

f) Q8

As age of present heating system increase--more willing
to connect.

g) Q9

COEFFICIENT NOT SIGNIFICANT

h) Q25

If respondent has no storm windows--more willing.

i) Q47

More knowledge respondent has of district heating--more
willing.

j) Q88

If respondent does not intend to move in near future--
more willing.

RESIDENTIAL--POST OPERATIONAL MARKET

I. STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS*

	FUNC 1
SOCSTAT	-0.37148
PERMANT	-0.32801
HOUSCOMP	0.35694
PRODINN	-0.28552
INTEGRO	-0.21953
RISKTAKE	-0.23041
Q26	-0.45754
Q28	-0.34645
Q47	-0.26326
STATCONC	-0.16998
Q88	0.20477
Q103	-0.59154
Q104	0.48690

II. INTERPRETATION

a) SOCSTAT

As social status increases--so does willingness to connect.

b) PERMANT

The more permanent resident is--more willing to connect.
(This variable, although displaying the same direction as in the initial market function, shows a marked increase in importance for the post-op period.)

c) HOUSCOMP

The more persons per household, as well as more persons under age of 18--more willing (slight decrease in strength of coefficient from initial marketing period).

d) PRODINN

The more product innovative respondent is--more willing (slight decrease in strength of coefficient from initial marketing period).

e) INTEGRO

The greater capacity respondent displays for intellectual growth--more willing.

* indicates relative contribution of the variables to the respective function. Standardized coefficients may be compared to each other like weights.

INTEGRO is a measure of educational attainment (Q91), involvement in community administration (Q78), number of times respondent reads a book annually (Q54).
- Note that INTEGRO was not significant in the initial market function - yet contributes relatively strongly to the retrofit decision in the post-op period.

f) RISKTAKE

The more of a "RISKTAKER" respondent is--more willingness exhibited to connect to the demonstrated system. RISKTAKE is measured by perceptions of heating bill (ie. too high? too low?) (Q46), willingness of respondent to purchase experimental economy car (Q57), venturesomeness (Q61), cosmopolitanism (Q62), independence (Q89). This variable had not entered in the initial market function.

g) Q26

If respondent has storm door--more willing.

h) Q28

If respondent has added insulation to his home--more willing.

i) Q47

More knowledge respondent has of district heating--more willing.

j) STATCONC

The higher degree of status concern exhibited by respondent--more willing to connect once system has been demonstrated. STATCONC is an indicator of conspicuous consumption as measured by Q60 and Q58.

k) Q88

If respondent does not intend to move in near future--more willing.

l) Q103

If respondent was a male rather than a female--more willing to connect once system has been demonstrated.

m) Q104

As number of units per structure increase--so does willingness to connect.

COMMERCIAL

INITIAL PENETRATION BY ZONE

<u>Zone #</u>	<u>Most Willing</u>	<u>Least Willing</u>	<u>Unsure</u>
5	22.9%	33.3%	40.7%
8	36.5%	24.8%	38.7%
11	33.3%	12.5%	54.2%
33	42.9%	24.3%	42.9%
40	18.8%	37.5%	43.8%
41	45.0%	20.0%	35.0%
49	100.0%	0.0%	0.0%
50	20.0%	24.0%	56.0%
110	42.9%	14.3%	42.9%
Study Area Wide	34.2% (93)	23.9% (65)	41.9% (114)

POST-OPERATIONAL PENETRATION BY ZONE

<u>Zone #</u>	<u>Most Willing</u>	<u>Least Willing</u>
5	37.0%	63.0%
8	53.3%	46.7%
11	62.5%	37.5%
33	71.4%	28.6%
40	56.3%	43.8%
41	80.0%	20.0%
49	50.0%	50.0%
50	60.0%	40.0%
110	35.7%	64.3%
Study Area Wide	54.8% (149)	45.2% (123)

COMMERCIAL

% PENETRATION
OVER
PROJECT LIFE

COMMERCIAL--INITIAL MARKET

I. STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS*

	FUNC 1	FUNC 2
ROOMS	0.42439	-0.27018
SYSTEM	0.03442	-0.61164
INFORM	-0.27672	0.23898
ECONSC	-0.31534	0.06592
TRAVEL	0.06242	0.45711
Q44	-0.50037	-0.14209
Q65	-0.22442	0.27326
Q70	0.43534	0.53332

II. INTERPRETATION

a) ROOMS

The greater the number of rooms requiring heat in business--the more willing to connect.
ROOMS is a size indicator as measure by number of rooms in business (Q27) and number of these rooms requiring heat (Q28).

b) SYSTEM

COEFFICIENT NOT SIGNIFICANT

c) INFORM

The more informed respondent is--more willing to connect.
INFORM as a factor variable measures knowledge of district heating (Q49), civic involvement (Q60, Q61) and financial support of the community (Q69).

d) ECONSC

The higher degree of energy consciousness displayed--more willing to connect.
ECONSE is a measure of energy conservation attempts (Q31, Q35, Q69).

e) TRAVEL

COEFFICIENT NOT SIGNIFICANT

* indicates relative contribution of the variables to the respective function. Standardized coefficients may be compared to each other like weights.

f) Q44

The more strongly the merchant disagrees with energy crisis--
more willing to connect.

g) Q65

The more content the merchant is with viability of business
in Piqua--the more willing to connect.

h) Q70

The greater number of permanent employees--more willing to
connect.

COMMERCIAL--POST OPERATIONAL MARKET

I. STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS*

ROOMS	-0.41456
SYSTEM	0.32238
TRAVEL	-0.80410
Q65	-0.61487
Q70	0.37650

II. INTERPRETATION

a) ROOMS

The greater the number of rooms requiring heat in business--the more willing to connect.

b) SYSTEM

The more depleted the heating system--the more willing to connect.

SYSTEM is an indicator of age (Q8), condition (Q9) and maintenance (Q10) of heating system.

NOTE that this variable was not a significant dimension of the decision to retrofit in the initial market--this can probably be attributed to a high incidence of new systems in business as shown on the Commercial Questionnaire frequencies (SEE APPENDIX).

c) TRAVEL

The more respondent travels--the more willing to connect to the demonstrated system.

TRAVEL Indicates frequency of travel outside Piqua area (Q57) and outside State of Ohio (Q58).

d) Q65

The more content the merchant is with the viability of business in Piqua--the more willing to connect.

e) Q70

The greater number of employees--more willing to connect.

* indicates relative contribution of the variables to the respective function. Standardized coefficients may be compared to each other like weights.

The issue of industrial market penetration is influenced by technical and economic facets, which, with the exception of cost per BTU, are not consistent decision criteria across the industrial community. This, coupled with an insufficient number of cases (52) for multivariate application at the zone level, necessitated viewing the industrial market for thermal energy in Piqua as a heterogenous population lacking parsimony in energy loads and service requirements, product mix and business nature as illustrated below.

<u>Employer</u>	<u>Nature of Activity or Business</u>	<u>Number of Employees</u>
Hartzell Industries, Inc.	Wood products	706
Piqua City School District	Education	491
Piqua Memorial Hospital	Hospital	432
Medalist--		
Allen A. Company	Clothing manufacturing	400
Aerovent, Inc.	Industrial air handling equipment	398
French Oil Mill Machinery Co.	Extraction machinery	320
Val Decker Packing Co.	Meats and provisions	270
Questor Corp.		
(Kantwet Division)	Infant care accessories	243
Container Corporation of America	Composite cans	236
Wayne Corp.		
(Miller-Meteor Division)	Hearses	180

Each of the 52 industries in the study area were asked to complete a set of questions (see Appendix) concerning the social, political, financial and primarily the technical aspect of their operation as it relates to district heating. Current production schedules and processes, (inputs and outputs), energy consumption and costs were also inventoried, providing a complete profile of existing service requirements and costs in all modes of the specific industry's operation. These differentiating characteristics of the industrial portion of the district heating market coupled with the following observations are critical in understanding the industrial market and ultimately obtaining contracts for the delivery of thermal energy:

- * With few exceptions, Piqua industries understand that, they need and buy BTU's.
- * The industrial community regularly participates in long term operational and financial planning.
- * Piqua's industries frequently make capital investments and utilize debt capital for expansion of capacity and increases in efficiency.
- * Industrialists recognize and understand the inevitable sharp increases in energy costs instore during the coming years.

Based upon the industrial survey research and the technical analysis contained in Section 4 following, the penetration rates for district heating within the industrial market are set at 47% for both the initial period and the post-operational period. Industrial process loads are accounted for separately.

INDUSTRIAL--% PENETRATION
OVER PROJECT LIFE

The Institutional Market

The market for thermal energy within the institutional sector is also analyzed and evaluated separately. The institutional sector of the market consists essentially of schools, hospitals, and other public buildings.

All schools and the Piqua Memorial Hospital were inventoried. In addition, a survey research instrument was applied to the public schools through the office of the School Superintendent in order to determine the specific service requirements of each public school building. Relying upon the technical analysis of the building and HVAC system characteristics of the schools and hospitals, a 100% penetration rate is established for this segment of the market. It is apparent from the analysis and especially from conversations with the institutional community that assuming reasonable in-building retrofit changes (nearly all buildings are presently heated with hot water systems), these specific institutional facilities will hook up immediately upon installation of the distribution system near their door.

TECHNICAL EVALUATION OF ALTERNATIVE RETROFIT SCHEMES FOR BUILDING HEATING AND COOLING SYSTEMS AND DOMESTIC WATER HEATING

An important consideration in the adoption of the district heating and cooling system is the large number of buildings which will have to be retrofitted in order to use the district heating and cooling system medium. The cost of retrofit and the technical complexity of retrofit schemes was addressed in detail. Three general building types were considered. They are: 1) residential 2) commercial 3) industrial.

Each type of residence has its own peculiarities due to age and size. Occupancy classifications also cause distinct variations in retrofit difficulty. By using the Hanselman-Eskew survey data, a preliminary estimate of retrofit difficulty was obtained.

The first major area of concern which was tested in the survey was the type of energy considered primary heating fuel. The anticipated results were that natural gas would be the dominant heating fuel and that electricity would be the second most common heating fuel. It was expected there would also be incidences of oil and LP gas heating systems. These expectations were borne out as depicted in the study wide results in Table 1-1.

TABLE 1-1
PRIMARY HEATING FUEL

Natural Gas	88%
LP Gas	1.4%
Oil	0.8%
Electric	7.4%

The second consideration was the fuel used to heat domestic water. Again, it was anticipated that the primary water heating fuel would be natural gas and the secondary important fuel would be electric. Surprisingly, there was a higher incidence of electric water heating than anticipated. This higher incidence of electric water heating is probably due to electric water heaters' competitiveness in the replacement market on a first cost basis. The study wide results are presented in Table 1-2.

TABLE 1-2
WATER HEATING FUEL

Natural Gas	78.7%
Electric	19.3%
Other	2.0%

Another area which was viewed as potentially detrimental to district heating retrofit was the homeowner's use of natural gas for cooking and clothes drying. It was felt that a high incidence of gas use for this area could require substantial additional cost for the replacement of cooking equipment and clothes drying equipment with electric models. Although it would be technically feasible to dry clothes using district heating energy, this option was not considered since no commercially available equipment can be obtained for this need. It was assumed that any retrofitted buildings would either continue to use natural gas for cooking and clothes drying or convert to electric energy for these needs.

Table 1-3 presents the study wide results of the survey questions dealing with cooking and clothes drying. Again, the high incidence of electric energy use for these areas is probably due to the lower first cost of electrical cooking and clothes drying appliances. This result was viewed as a positive result for the district heating retrofit scheme.

TABLE 1-3
COOKING AND CLOTHES DRYING FUELS

<u>COOKING</u>	
Natural Gas	20%
Electric	80%
<u>CLOTHES DRYING</u>	
Natural Gas	4%
Electric	70%
No Dryer	26%

AIR CONDITIONING

A significant question on the Hanselman-Eskew survey dealt with the existence of central air conditioning systems and the use of air conditioning in general. The climate of Piqua, Ohio, as previously discussed in the load section of this report, presents relatively few hours when air conditioning is required. There are less than 1100 hours during the year when the outdoor air temperature is above 80°F. These hours occur during the months of June, July, August and September.

As Table 1-4 illustrates, this relatively low seasonal requirement for air conditioning is reflected in the consumers' habits of purchasing and using central air conditioning systems. In general, it was found that most homes did not have central air conditioning and, where air conditioning was present, it was generally in the form of a single window unit used only sparingly. Even shops in the central business district were inclined to use large through-the-wall air conditioning units in lieu of central air conditioning systems.

TABLE 1-4
TYPE AIR CONDITIONING

Window Units	36%
Central A.C.	12%
No A.C.	52%

Early in the project it was decided that the low expected load durations for air conditioning and the survey results indicating a low incidence of central air conditioning systems would make it unfeasible to provide district cooling in the form of a chilled water medium similar to the hot water system. In lieu of a central cooling system, it is anticipated that large user central air conditioning systems may be supplied with chilled water from in-building absorption equipment powered from the district heating system as retrofit becomes practical. Residential absorption cooling systems powered with hot water are currently in the development stage by the solar heating and cooling industry. These units are not available commercially today. However, as demand for them increases in the solar industry they could be readily applied for use by district heating energy customers.

HEATING SYSTEMS

The Hanselman-Eskew survey asked each respondent to classify his heating system type. Table 1-5 presents the study wide results of the question concerning heating system types. It was anticipated that there would be a higher incidence of electric resistance heating and heat pump systems than was actually observed. It was also anticipated that certain zones would have much higher incidences of electric resistance and electric heat pump heating due to their newer development. This also turned out to be different from actual experience.

TABLE 1-5

TYPE HEATING SYSTEMS

Gas-Forced Air	67%
Gas-Boiler	3%
Gas-Space Heaters	9%
Oil-Warm Air	1%
Electric Baseboard	5%
Electric-Forced Air	1%
Heat Pump	1%
Converted Furnace	8%
Other	5%

As anticipated, the commercial and industrial sectors had a higher incidence of electric resistance heating than did the residential sector. We feel this is primarily due to a large amount of commercial renovation in downtown business structures and to the first cost advantages of electric resistance heating systems. In order to accurately determine precise heating system types and to better predict retrofit cost it is recommended that an engineering survey be conducted in all major commercial and industrial establishments during Phase II.

ZONE SUMMARIES--Production of the following zone summaries is the result of efforts directed toward reducing the multitude of data compiled from the residential, commercial and industrial questionnaires, field inventories, and records of the Miami County Auditor's Office, to a form more easily comprehensible on the zone level. Those characteristics in the residential, commercial and industrial sectors, determined crucial in the decision to retrofit (from the discriminant and factor analyses) have been included in each zone summary where applicable.

The summaries contain a brief physical description of the zone including its general location within the study area, its size in acres, and the number of residential, commercial and industrial units per acre.

Zone units are then categorized as either living units, business/professional units, or manufacturing units. Structure types, frequencies, and total floor areas are given. Also included are brief descriptions of space heating, air conditioning and water heating system types that are predominantly used.

In addition to the above information, the following characteristics are included for the residential sector; education level, mean number of persons per household and predominant annual income per residential unit. Each zone summary also contains the applicable residential, commercial, and industrial market penetration curves over the 20 year project life.

The zone summaries for the initial, Phase I, service area are located on the following pages. Zone summaries are presented in their entirety as part of Appendix 3.

Zone No. 2

Located in southwest quadrant of study area, bounded on the south by corporate limits, on east by Great Miami River

Physical Characteristics

- 80.4 acres
- Density: residential -- .0622 units/acre
commercial -- .0746 units/acre
industrial -- 1.405 units/acre

Residential Characteristics

- single family one story (A1, A2, A9) - 2415 sq. ft. (3 units)
- single family two story (A3 through A8, A10) - 2350 sq. ft. (1 unit)

Commercial Characteristics

- commercial/mixed use, single story (D1, D2, D9 through D13, F1, F2) - 10,941 sq. ft. (6 units)
- commercial/mixed use, two story (D3 through D5, D14, F3 through F5) - 1,584 sq. ft. (1 unit)

Industrial Characteristics

- industrial (E1 through E14) - 1,077,313 sq. ft. (113 units)
- natural gas predominant energy source used (50%)
- approximately equal incidence of liquid propane, oil, and electric usage (14%)

Market Penetration and Growth Projections

- Residential
 - initial penetration = 44.4% (study area average)
 - post operational penetration = 60.5% (study area average)
- Commercial
 - initial penetration = 34.2% (study area average)
 - post operational penetration = 54.8% (study area average)
- Industrial
 - penetration = 42.9%
 - existing floor area = 1,077,313 sq. ft.
 - projected growth = 55,000 sq. ft.
 - total, year 2000 = 1,132,313 sq. ft. (117.4 units) of E1 through E14

Zone No. 8

Located in northwest quadrant of study area - includes Piqua Historical Museum and the Central Business District

Physical Characteristics

- 43.8 acres
- Density: residential -- 3.790 units/acre
commercial -- 7.100 units/acre
industrial -- .0457 units/acre

Residential Characteristics

- single family one story (A1, A2, A9) - 3,564 sq. ft. (4 units)
- single family two story (A3 through A8, A10)-40,290 sq. ft. (17 units)
- two family two story (B3 through B7, B10)-45,730 sq. ft. (34 units)
- multi-family two story (C3 through C7) -21,840 sq. ft. (31 units)
- multi-family three story - 26,569 sq. ft. (24 units)
- commercial/mixed use two story (D3 through D5, D14, F3 through F5) - (51 units)
- commercial/mixed use three story (D6, D7, D8, F6 through F10)-(5 units)
- predominant income category = \$15,000 to \$20,000/year--above study area average
- persons per household = 3 -- study area average
- education level = high school complete -- above study area average
- predominantly older natural gas fired forced air and boiler heating systems, good to excellent condition, located in basement
- window air conditioning
- natural gas water heating

Commercial Characteristics

- commercial/mixed use one story (D1, D2, D9 through D13, F1, F2) - 201,517 sq. ft. (32 units)
- commercial/mixed use two story (D3 through D5, D14, F3 through F5) - 424,330 sq. ft. (98 units)
- commercial/mixed use three story (D6, D7, D8, F6 through F10) - 309,071 sq. ft. (58 units)
- commercial/mixed use four story (D6, D7, D8, F6 through F10) - 143,631 sq. ft. (98 units)
- commercial/mixed use five story (D6, D7, D8, F6 through F10) - 31,780 sq. ft. (5 units)
- predominantly older gas fired warm or forced air or boiler heating systems, good to excellent condition, located in basement or on first floor
- high incidence of central air
- natural gas water heating

Industrial Characteristics

- industrial (E1 through E14) - 30,000 sq. ft. (2 units)
- no present steam customers

Zone No. 8 - continued

Market Penetration and Growth Projection

- Residential
 - initial penetration = 50%
 - post operational penetration = 70%
 - existing floor area = 43,854 sq. ft.
 - projected growth = 89,677 sq. ft.
 - total, year 2000 = 133,531 sq. ft. (76 units of A1 through A10)
- Commercial
 - initial penetration = 36.5%
 - post operational penetration 53.3%
- Industrial
 - penetration = 100%

Zone No. 12

Located in northwest quadrant of study area - includes Piqua City School Board Office

Physical Characteristics

- 96.4 acres
- Density: residential -- 4.896 units/acre
commercial -- .1141 units/acre

Residential Characteristics

- single family one story (A1, A2, A9) - 28,380 sq. ft. (20 units)
- single family two story (A3, through A8, A10) - 642,356 sq.ft. (286 units)
- two family two story (B3 through B7, B10) - 105,417 sq.ft. (102 units)
- multi-family two story (C3 through C7) - 75,825 sq. ft. (63 units)
- commercial/mixed use two story (D3 through D5, D14, F3 through F5) - (1 unit)
- predominant income category = \$15,000 to \$20,000/year -- above study area average
- persons per household = 3.2 -- above study area average
- education level = high school complete, some post high school studies -- above study area average
- predominantly older gas fired warm or forced air heating systems, good to excellent condition, located in basement
- window unit air conditioning
- natural gas water heating

Commercial Characteristics

- commercial/mixed use one story (D1, D2, D9 through D13, F1, F2) - 14,867 sq. ft. (3 units)
- commercial/mixed use two story (D3 through D5, D14, F3 through F5) - 71,424 sq. ft. (8 units)

Market Penetration and Growth Projections

- Residential
 - initial penetration = 40%
 - post operational penetration = 68%
- Commercial
 - initial penetration = 34.2% (study area average)
 - post operational penetration = 54.8% (study area average)

Zone No. 14

Located in northwest quadrant of study area

Physical Characteristics

- 4.0 acres
- Density: commercial -- 2.5 units/acre

Commercial Characteristics

- commercial/mixed use one story (d1, D2, D9 through D13, F1, F2) - 16,609 sq. ft. (7 units) Hospital-Health Care
- commercial/mixed use two story (D3 through D5, D14, F3 through F5) - 9,600 sq. ft. (2 units) Hospital-Health Care
- commercial/mixed use three story (D6, D7, D8, F6 through F10) - 52,458 sq. ft. (1 unit) Hospital-Health Care
- boiler house, hot water/steam heating system

Market Penetration and Growth Projections

- Commercial
 - penetration = 100%

Zone No. 15

Located in northwest quadrant of study area - Nicklin Avenue Elementary School

Physical Characteristics

- 3.9 acres
- Density: commercial -- .2564 units/acre

Commercial Characteristics

- commercial/mixed use two story (D3, through D5, D14, F3 through F5) -- 21,906 sq. ft. (1 unit)
- older, gas fired boiler heating system (oil backup), excellent condition
- no air conditioning
- natural gas and electric water heating

Market Penetration and Growth Projections

- Commercial
 - penetration = 100%

Zone No. 16

Located in northwest quadrant of study area

Physical Characteristics

- 2.8 acres
- Density: commercial -- 2.5 units/acre

Commercial Characteristics

- commercial/mixed use one story (D1, D2, D9 through D13, F1, F2) - 67,055 sq. ft. (6 units)
- commercial/mixed use two story (D3 through D5, D14, F3 through F5) - 1,188 sq. ft. (1 unit)
- hot water/steam heating system
- central air

Market Penetration and Growth Projections

- Commercial
 - initial penetration = 34.2% (study area average)
 - post operation penetration = 54.8% (study area average)

Zone No. 17

Located in northwest quadrant of study area - Wilder Junior High School

Physical Characteristics

- 3.6 acres
- Density: commercial -- .2778 units/acre

Commercial Characteristics

- commercial/mixed use three story (D6, D7, D8, F6 through F10) - 43,860 sq. ft. (1 unit)
- older gas fired warm or forced air heating system, excellent condition
- no air conditioning
- natural gas and electric water heating

Market Penetration and Growth Projections

- Commercial
 - penetration = 100%

Zone No. 18

Located in northwest quadrant of study area, bounded on east by Great Miami River

Physical Characteristics

- 5.4 acres
- Density: industrial -- 1.667 units/acre

Industrial Characteristics

- industrial (E1 through E14) - 173,617 sq. ft. (9 units)
- no steam customers

Market Penetration and Growth Projections

- Industrial
 - penetration = 100%

Zone No. 25

Located in northwest quadrant of study area - Piqua Central High School

Physical Characteristics

- 2.3 acres
- Density: commercial -- .4348 units/acre

Commercial Characteristics

- commercial/mixed use four story (D6, D7, D8, F6 through F10) - 141,719 sq. ft. (1 unit)
- older gas fired boilers in excellent condition
- natural gas and electric water heating

Market Penetration and Growth Projection

- Commercial
 - penetration = 100%

Zone No. 52

Located in southwest quadrant of study area - Bennett Junior High School

Physical Characteristics

- 1.2 acres
- Density: commercial -- .8333 units/acre

Commercial Characteristics

- commercial/mixed use three story (D6, D7, D8, F6 through F10) - 47,448 sq. ft. (1 unit)
- district steam heating system
- no air conditioning
- natural gas and electric water heating

Market Penetration and Growth Projections

- Commercial
 - penetration = 100%

4.0 TECHNICAL REVIEW AND ASSESSMENT

4.1 INTRODUCTION

Recent "Energy Crises" have prompted the realization that the world's once abundant primary fuel resources are being depleted at an alarming rate. In light of that situation, the nation's policy makers have set about the task of fostering more effective energy management techniques which would allow us to get "more mileage" out of our energy resources. Several promising techniques have appeared in the general area of energy conservation. Two that appear to have widespread potential for application in the United States are the cogeneration concept and the idea of a centralized district heating system. Indeed, the two appear perfectly complementary when considered for application in one large scale system.

The techniques of cogeneration (although not referenced by that term until recently) has long been proven in industry, notably the pulp and paper industry.

The idea of a central district heating system has likewise long been proven through limited applications in the U. S. (many college campuses as an example) and extensive applications in Europe. The European countries, and notably the primary-fuel-resource-poor Scandinavian countries, have already responded to a situation which may become a reality for the U. S. in the next century. The extreme costs of importing scarce fuels into the Scandinavian countries (where as much as 98% of fuel resources are imported) has forced them to make the most efficient use possible of all available fuels. A natural outgrowth of this dire situation was the cogeneration - based district heating system. The Scandinavian systems have been developed over long periods of time, some back to the 1920's, as the major metropolitan areas developed.

In order to adapt this approach to the U. S. situation, however, an extensive retrofit program would be necessary. The existing extensive power utility industry can be regarded as a virtually unlimited source of thermal energy if the appropriate retrofit approach is technically and economically viable. The purpose of this chapter is to examine the Municipal Power Plant of the City of Piqua and explore in detail the retrofit options qualitatively discussed in Chapter 2.0. Four what could be termed "hardware options" for retrofit to some form of cogeneration cycle have been identified in the plant.

The feasibility and potential performance of each of these options will be discussed and a recommended schedule for phasing each of these options into an overall cogeneration plant plan will be presented. Further sections of this chapter will also discuss the alternatives for a thermal energy distribution network and examine the feasibility of retrofitting such a system to the City of Piqua.

4.2 ALTERNATIVE RETROFIT OPTIONS

4.2.1 OPTION 1 - OPTIMIZE OUTPUT OF EXISTING BACKPRESSURE TURBINE

As can be seen from the discussion in Chapter 2.0 of the existing low pressure system in the Municipal Power Plant, one of the turbine-generator units presently operates on a form of cogeneration cycle. Unit 5 is a 1000 KW capacity, backpressure turbine-generator set. Turbine exhaust is at 150 pounds per square inch gage (psig) pressure and is currently routed to the plant 150 psig steam header which supplies steam to several steam turbine drive auxiliaries and to the high pressure feedwater heater within the plant and to the community steam distribution system outside the plant. Currently, due to operation practices in the plant, in-house steam demand is minimized so that the bulk of the steam output from the unit can be distributed to the community steam system. Since this unit is governed strictly by the backpressure on its steam exhaust, it effectively "free-wheels" in response to the steam demand from the community. Consequently, the unit is put in service at the beginning of the heating season when steam demand begins to increase and is allowed to operate throughout the heating season and into the spring when moderate weather sets in and begins to drive the steam demand down. Typically, the unit can operate when outside steam demand is above approximately 20,000 pounds-mass per hour (typically around 4500 hours per year.) The average annual capacity factor of 50.4% reveals that, during the period this unit is in operation, only half of its electrical and thermal capacity is being utilized. Option 1 provides for the full utilization (Capacity factor = 100%) of this unit over the full 8760 hours in the annual cycle (Operational Availability = 100%) by providing a continuous demand for the 150 psig exhaust steam via the appropriate district heating equipment. Physically, this demand would be provided by fabricating a new piping connection to the existing 150 psig steam header and constructing a separate header for steam supply to the district heating system. This arrange-

ment would also allow for an indirect connection of boilers 4 and 5 to the district heating system through the existing pressure reducing valve (PRV) station between the main steam header (400 psig) and the 150 psig steam header. The configuration would then be as shown schematically in Figure 4-1.

FIGURE 4-1
BACKPRESSURE TURBINE RETROFIT FOR DISTRICT HEATING SYSTEM

The heat available from the turbine exhaust to the district heating system can be calculated as discussed below. For the purposes of a heat balance analysis, the system can be represented as shown in Figure 4-2.

FIGURE 4-2
 OPTION 1 HEAT BALANCE

System operation is as follows: 1) 400 psig main steam is drawn from the header and expanded through the turbine; 2) turbine exhaust flows into the 150 psig steam header; 3) steam at a mass flow rate equivalent to the throughput of turbine 5 is drawn from the 150 psig header and into the shell and tube closed heat exchanger in the district heating system where the remaining superheat and latent heat of vaporization is removed; 4) pressurized condensate then flows into the drain cooler where a portion of the remaining sensible heat is removed; 5) low temperature condensate is then returned to the plant condensate system.

Thus, the heat balance can be drawn according to the conditions depicted on Figure 4-2. The steam drawn into the district heating system is at the same conditions as the turbine exhaust (turbine exhaust conditions taken from the system heat balance presented in Chapter 2.0). Circulating water into the heat exchangers circuit is taken as 160°F (which is typical of European hot water systems). Circulating water out of the exchanger circuit is set at a mass flow rate which will fix the outgoing water temperature at 250°F and the leaving condensate at 170°F. The heat available from the turbine exhaust to the district heating system is thus expressed by the relation below:

$$Q = \dot{M}_3 (h_3 - h_5)$$

Substituting the values from Figure 4-2 yields:

$$\begin{aligned} Q &= 44,422 \frac{\text{LBM}}{\text{HR}} (1309 - 138) \frac{\text{BTU}}{\text{LBM}} \\ &= 52,018,162 \frac{\text{BTU}}{\text{HR}} \end{aligned}$$

The mass flow rate of water which can be heated to the specified distribution conditions can be calculated from the following relation:

$$Q = \dot{M}_A (h_B - h_A)$$

Again substituting from Figure 4-2 and the above calculation:

$$\begin{aligned} 52,018,162 \frac{\text{BTU}}{\text{HR}} &= \dot{M}_A \frac{\text{LBM}}{\text{HR}} (219 - 128) \frac{\text{BTU}}{\text{LBM}} \\ \dot{M}_A &= 571,628 \frac{\text{LBM}}{\text{HR}} \\ &= 1142 \text{ GPM (water @ 250°F)} \end{aligned}$$

Thus, with minimal modification to the low pressure system, a district heating sub-system could be retrofitted which would utilize steam at the base load capacity of the existing unit 5 to supply 50.152×10^6 Btu/hr to the district heating system at peak demand conditions. This option would serve as an excellent initial thermal energy source for the district heating system during the early stages of development.

4.2.2 OPTION 2 - MODIFY TURBINE-GENERATOR 6 FOR COGENERATION

The second hardware option identified at the municipal plant involves the internal modification of the existing condensing turbine generator No. 6. T-G 6 is an Elliott Company Type NCX turbine design with 18 rotating bucket and stationary diaphragm stages. A cross section of this turbine is pictured as Figure 4-3. The proposed modification of this unit would involve the removal of several of the last turbine stages in order to negate the machine's ability to expand the steam throughput to below atmospheric pressures. A review of basic turbine design theory shows that the turbine stage produces shaft torque by expanding the steam through nozzles (the stationary diaphragms) to convert the potential energy of steam pressure to the kinetic energy of high velocity steam, then directing this high velocity steam jet against the turbine bucket, forcing it to rotate about its axis, the centerline of the turbine rotor. The removal of the last several sets of turbine stages from Piqua's Unit 6 would thus prevent the machine from converting pressure energy lower than a certain point to kinetic energy. This modification effectively converts the machine to a backpressure configuration. The potential energy remaining in the steam (seen as steam pressure) would then be exhausted from the turbine shell, to be captured and utilized in the district heating system.

Of course, the exact nature of the modification and the unit's exact revised operating conditions would be contingent upon the recommendations of an engineering re-rate study performed by the manufacturer. However, preliminary examination of the turbine conditions curve for the unit, Figure 4-4, and of the turbine internal design reveals that a backpressure of approximately 28 psia could be achieved by removing the last seven stages of the turbine. The modified turbine exhaust conditions would then follow the new conditions line plotted on Figure 4-4. The turbine internal configuration would be as shown in Figure 4-5 (compare to the original configuration in Figure 4-3). Removal of several stages in this manner may modify the thrust loading on the rotor, making necessary some minor redesign of the machine's thrust and rotating bearings. The determination of the exact nature of these secondary modifications, however, is best left to the turbine engineers performing the re-rate study.

ELLIOTT CO. TYPE NCX
CONDENSING TURBINE
(EXISTING UNIT NO. 6)

FIG. 4-3

ELLIOT CO. TYPE NCX TURBINE
MODIFIED CONFIGURATION

FIG. 4-5

The removal of turbine stages obviously will affect the rated output of the machine by diminishing its ability to supply shaft torque to the generator. The affect on output can be quantified through a heat balance analysis which takes into account the revised operating conditions of the unit. For the purposes of analysis, the turbine can be represented schematically as shown in Figure 4-6.

FIGURE 4-6
MODIFIED UNIT 6 HEAT BALANCE DIAGRAM

The gross output of the turbine, with allowances for mechanical efficiencies of the unit, is expressed by the relation:

$$W_{\text{Gross}} = [\dot{M}_1 (h_1 - h_2) + (\dot{M}_1 - \dot{M}_2) (h_2 - h_3)] \times \eta_{\text{mech}}$$

Substituting values from Figure 4-6 yields:

$$\begin{aligned} W_{\text{Gross}} &= \left[101,131 \frac{\text{LBM}}{\text{HR}} (1389-1216) \frac{\text{Btu}}{\text{LBM}} \right. \\ &\quad \left. + (101,131-7358) \frac{\text{LBM}}{\text{HR}} (1216-1183) \frac{\text{BTU}}{\text{HR}} \right] \\ &\quad \times .9875 \\ &= 20,332,795 \text{ BTU/HR} \end{aligned}$$

The net work done by the turbine generator set is the gross output, W_{Gross} , adjusted by the generator efficiency, η_{Gen} , in the following manner:

$$W_{\text{Net}} = W_{\text{Gross}} \times \eta_{\text{Gen}}$$

Substituting values:

$$\begin{aligned} W_{\text{Net}} &= 20,332,795 \frac{\text{BTU}}{\text{HR}} \times (.97) \\ &= 19,722,811 \frac{\text{BTU}}{\text{HR}} \end{aligned}$$

Electrical power output is then calculated by using the proper conversion factor, thusly:

$$\text{Power} = \frac{W_{\text{Net}}}{3413 \frac{\text{BTU}}{\text{KWH}}}$$

$$\begin{aligned}
 &= \frac{19,722,811 \frac{\text{BTU}}{\text{HR}}}{3413 \frac{\text{BTU}}{\text{KWH}}} \\
 &= 5779 \text{ KW}
 \end{aligned}$$

Thus, the rated capacity of unit 6 would be reduced by approximately 42%, down to 5779kw from 10,000kw, if the proposed modification were performed.

This sacrifice in rated power output can be considered a worthwhile trade-off, however, when the benefit to the district heating system in the form of available thermal energy is considered. The exhaust steam from the newly modified turbine unit 6 will be utilized in an equipment configuration similar to that utilized in option one. However, in this case the turbine exhaust will be piped directly to the shell and tube heat exchangers on the district heating system. In addition, since the saturation temperature of the 13 psig steam supply is 246°F and the allowance for a 10°F terminal difference on the heat exchanger will further reduce the exit temperature to approximately 236°F, a "finishing" heat exchanger will be employed to raise the temperature of the leaving circulating water to the required 250°F. The general schematic configuration will be as shown in the heat balance diagram, Figure 4-7.

System operation is as follows: 1) 400 psig steam is taken from the main steam header and expanded through the turbine; roughly 7% is extracted for feedwater heating, and the remaining 93% is exhausted at 13 psig into the district heating system; 2) the exhaust steam is routed through the main shell and tube heat exchanger where the hottest heat of vaporization is removed; 3) steam at 150 psig is drawn from the plant header and routed through the finishing heat exchanger where its hottest heat of vaporization is utilized to bring the temperature of the leaving circulating water up to the required 250°F; 4) pressurized condensate from the finishing heat exchanger is routed through a steam trap, where approximately 21% of the mass flow flashes to steam @ 13 psig, and into the main heat exchanger where the hottest heat of vaporization of that position of steam is also removed; 5) the total condensate from the main heat exchanger is routed through a drain cooler where portions of the

FIGURE 4-7
 OPTION 2 HEAT BALANCE

remaining sensible heat is removed; 6) the low pressure, low temperature condensate is returned to the plant condensate system.

The various temperatures, pressures and flows pertinent to the heat balance are also shown on Figure 4-7. Suffice it to say that an iterative calculation process was necessary in order to balance the district heating circulating water flow through the system with the steam flow through the finishing heat exchanger. The conditions presented on the figure are the final result of that balance. With the operating conditions thus defined, the heat supplied to the district heating system can be calculated utilizing the expression below:

$$Q = \dot{M}_3 (h_3 - h_6) + \dot{M}_4 (h_4 - h_6)$$

Substituting from Figure 4-7 yields:

$$\begin{aligned} Q &= 93,773 \text{ LBM/HR} (1183 - 138) \text{ BTU/LBM} \\ &+ 23,628 (1196 - 138) \\ &= 122,991,209 \text{ BTU/HR} \end{aligned}$$

The corresponding mass flow rate of water which could be heated to the specified distribution conditions can be calculated from the following relation:

$$Q = \dot{M}_A (h_C - h_A)$$

Again, substituting from Figure 4-7 and from the above calculation:

$$\begin{aligned} 122,991,209 \text{ BTU/HR} &= \dot{M}_A (219 - 128) \text{ BTU/LBM} \\ \dot{M}_A &= 1,351,552 \text{ LBM/HR} \\ &= 2407 \text{ GPM} \end{aligned}$$

which corresponds to the flow rate illustrated on Figure 4-7.

Thus, with the appropriate modification to turbine No. 6 and the installation of district heating system heat exchangers to utilize the low pressure steam exhaust from the modified unit, Option 2 could provide thermal energy to the system at the rate of 122.99×10^6 BTU/HR at peak load conditions. Modifying the existing unit to supply this amount of energy represents a sacrifice in foregone electricity of 4221 KW. The ratio of thermal energy made available to electric energy sacrificed is 6.8 BTU/BTU, a quite attractive benefit ratio. (At this point, it should be noted that a portion of the total thermal energy was supplied with 150 psig steam.) This option could serve as an efficient base load thermal supply for a moderate sized district heating system. Operation of the district heating system would be especially flexible if Option 2 was installed in tandem with the Option 1 previously discussed. This arrangement would effectively provide for a base load and cyclic load thermal capacity on the district heating system.

4.2.3 OPTION 3 - RETROFIT EXISTING TURBINE-GENERATOR 4 WITH BACKPRESSURE TURBINE

Option 3 will provide a backpressure steam supply source for the district heating system that is similar in configuration to that proposed for Option 2. The thermal energy supply will be in the form of a backpressure turbine operating in the cogeneration mode to supply low pressure exhaust steam at approximately 20 psig to the district heating system. Rather than a turbine modification approach, however, the approach taken for this option will be to specify and install a new unit designed specifically for this application. The new turbine-generator unit will be selected of a configuration so as to allow for a direct replacement of the existing condensing unit. No modifications to the low pressure system will be necessary other than minor piping corrections and installation details. The new turbine-generator set will be selected as a multi-valve, multi-stage, straight flow, noncondensing turbine, direct coupled to a synchronous 3600 RPM, two pole generator. Electrical output will be 10,000 KW. One uncontrolled extraction at 40 psig (at full load conditions) will be provided for feedwater heating with mass flow of extraction steam equivalent to approximately 7% of main steam flow through the turbine throttle. Turbine exhaust will be at 20 psig at full load conditions. It should be noted at this point that the "cogeneration unit" to be specified for this installation is of a somewhat different configuration from what is usually referred to as a cogeneration unit. Cogeneration, even before that descriptive term was coined, was popularized in industries with sizeable process steam requirements, notably the pulp and paper industries. The typical cogeneration unit utilized for these installations provided for one or two automatic, variable flow extractions at relatively high steam pressures (250 psig and 150 psig are common ratings) to supply the high temperature, high quality steam necessary in the processes. The remainder of the steam flow not extracted for process needs is expanded through the turbine to very low pressures and exhausted into a below atmospheric pressure condenser. Such a unit is referred to as an Intermediate Take Off Condensing (ITOC) unit. However, in the case of this installation, neither very high temperatures nor high quality steam is required for the district heating system, so a turbine unit exhausting steam at comparatively low backpressures can be selected.

This approach has the advantage over the modification approach taken in Option 2 of avoiding the sacrifice in foregone electricity to make available thermal energy at useable conditions. The new unit, specified for compatibility with the district heating system, can deliver the noted electrical load of 10,000 KW in addition to providing adequate thermal energy.

With the conditions for turbine operation specified, the new rate of steam flow required through the turbine to product rated output can be calculated. The procedure for determining this parameter is the typical turbine heat balance and is presented below.

$$\eta_{\text{TURB}^1} = 81.22\%$$

$$\eta_{\text{TURB}^2} = 82.66\%$$

$$\eta_{\text{OVERALL}} = 84.11\%$$

$$\eta_{\text{MECH}} = 98.75\%$$

$$\eta_{\text{GENERATOR}} = 97.0\%$$

(FROM POTTER)

$$\dot{M}_{\text{EXTRACTION}} = .07 (\dot{M})$$

GROSS TURBINE OUTPUT

$$\text{NET POWER} = W_{\text{NET}} / 3413 \frac{\text{Btu}}{\text{KWH}}$$

$$\therefore W_{\text{NET}} = \text{NET POWER} \times 3413 = 10,000 \times 3413$$

$$= 34.13 \times 10^6 \frac{\text{Btu}}{\text{hr}}$$

$$W_{NET} = W_{GROSS} \times \eta_{GENERATOR}$$

$$W_{GROSS} = W_{NET} / \eta_{GENERATOR} = \frac{34.13 \times 10^6}{.97}$$

$$= 35.18 \times 10^6 \text{ BTU/HR}$$

INLET STEAM CONDITIONS:

$$T_1 = 750 \text{ }^\circ\text{F}$$

$$P_1 = 400 \text{ PSIG}$$

$$h_1 = 1389 \text{ BTU/LBM}$$

EXTRACTION STEAM CONDITIONS:

$$T_2 = 375 \text{ }^\circ\text{F}$$

$$P_2 = 40 \text{ PSIG}$$

$$h_2 = 1221 \text{ }^\circ\text{F}$$

EXHAUST STEAM CONDITIONS:

$$T = 295 \text{ }^\circ\text{F}$$

$$P_3 = 20 \text{ PSIG}$$

$$h_3 = 1186$$

TURBINE POWER

$$W_{GROSS} = [\dot{M} (h_1 - h_2) + (\dot{M} - \dot{M}_{EXTR}) (h_2 - h_3)] / \eta_{MECH}$$

$$34.13 \times 10^6 = [\dot{M} (1389 - 1221) + (\dot{M} - .07 \dot{M}) (1221 - 1186)] / .9875$$

$$\dot{M} = 168,055 \text{ LBM/HR REQUIRED STEAM FLOW}$$

With turbine operation now fully defined, the amount of thermal energy available to the district heating system from the turbine operating at rated loads can be determined. The calculation procedure will be a similar heat balance on the district heating system associated with the new unit 4 whose configuration is represented schematically as Figure 4-8. System operation will be as follows: 1) Steam at 400 psig is drawn from the main steam header and expanded through the turbine; 2) turbine exhaust steam at 20 psig flows into the main district heating system heat exchanger where the remaining superheat and the latent heat of vaporization is removed; 3) pressurized condensate then flows into the drain cooler where a portion of the remaining sensible heat is removed; 4) low temperature condensate is returned to the plant condensate system.

Thus, the heat balance can be drawn according to the conditions depicted on Figure 4-8. Circulating water into the heat exchanger circuit is taken as 160°F. Circulating water out of the heat exchanger circuit is set at a mass flow rate which will fix the outgoing water temperature at 250°F and the condensate leaving the drain cooler at 170°F. The heat available to the system is then expressed by the relation:

$$Q = \dot{M}_3 (h_3 - h_5)$$

Substituting the values from Figure 4-8 yields:

$$\begin{aligned} Q &= 156,291 \text{ LBM/HR. } (1186 - 138) \text{ BTU/LBM} \\ &= 163,792,968 \text{ BTU/HR} \end{aligned}$$

The mass flow rate of water which can be heated to the specified distribution conditions can now be calculated from the expression:

$$Q = \dot{M}_A (h_E - h_A)$$

Again substituting from Figure 4-8 and from the above calculation:

FIGURE 4-8
OPTION 3 HEAT BALANCE

$$163,792,968 \text{ BTU/HR} = \dot{M}_A (219 - 128)$$

$$\dot{M}_A = 1,799,923 \text{ LBM/HR}$$

$$= 3601 \text{ GPM (water @ 250°F)}$$

Thus, the equipment retrofit and heat exchanger system proposed as Option 3 could deliver thermal energy to the district heating system at a rate of 163.79×10^6 BTU/HR in the form of water heated to the required 250°F. It is apparant when the output of this option is compared to that of Option 2 that an increase of approximately 33% was obtained at a significant increase in capital expenditures for the new turbine-generator set. However, it was felt that this option would prove economically viable when the corresponding expansion in capacity was considered. In light of the present system growth rate and considering that the economics of constructing a system such as this are generally improved when large capital expenditures are postponed until late in the project planning period, it is likely that this option could be delayed until later in the planning period when the additional electrical capacity is needed and the thermal demand on the district heating system is more fully developed.

4.2.4 OPTION 4 - INSTALL NEW COGENERATION POWER UNIT

The fourth hardware option identified for a cogeneration cycle at the Municipal Power Plant would involve the construction of a completely new power unit in the vacant south end of the power plant. The cogeneration cycle for this unit would be based upon a fairly standard and available turbine design which could be specified for the coincident generation of power and usable thermal energy. The turbine would be selected as a multivalve, multi-stage, straight flow, condensing turbine direct coupled to a synchronous 3600 RPM, two-pole generator. Electrical output will be 30,000 kw. Three uncontrolled extractions would be provided for feedwater heating with steam at 150 psig, 50 psig, and 30 psig. Two automatic, variable flow extractions will also be specified to provide steam to the district heating system at 15 psig and 24" HqA. Turbine exhaust will be specified at 2.0" HqA, to exit into a standard condenser employing a once-through cooling system. This turbine design, which can be classed in the intermediate take-off condensing (ITOC) category, has the added advantage of the ability to close both variable extractions and operate at full condensing capacity when there is low coincident thermal demand or when peak electrical demand conditions dictate that full power output is necessary. Additionally, since the extractions for the district heating system are in the lower segment of the turbine operations curve, a relatively small portion of the rated power output is sacrificed when the unit changes over from full condensing operation to full cogenerating operation.

The attendant boiler and steam/condensate/feedwater system would be designed according to standard power plant design practices and would produce a system flow schematic similar in many respects to the existing high pressure system at the Municipal Power Plant. Boiler main steam output conditions will be specified to be compatible with the existing Boiler No. 6, making possible a cross-connection on a common steam header system. Boiler output will be 400,000 pounds per hour steam flow at 850 psig and 900° F. The condenser will be specified to handle full steam flow (less extraction flow at rated load) in order to affect full condensing operation when necessary. The system schematic will be as shown in Figure 4-9.

FIG. 4-9
COGENERATION SYSTEM
FLOW DIAGRAM

Preliminary discussions with turbine manufacturers indicate that, for a turbine of the ITOC design such as this, a "rule of thumb" limit for extraction flow is approximately 15% of rated steam flow through the turbine. In addition, another 10% of rated steam flow is required through the turbine exhaust in order to provide proper blade cooling for the last stages of turbine buckets and diaphragms. This leaves an approximate 75% of rated steam flow available for extraction from the turbine that could be made available to the district heating system. For the capacity turbine specified in Option Four, nominal rated steam flow at full cogeneration capacity is 340,900 pounds mass per hour. The portion of that rated steam flow that would then be available to the district heating system would be approximately 256,000 pounds mass per hour, to be divided between the two automatic extraction points.

The accompanying district heating system would be of a similar configuration to those of the foregoing options, employing shell and tube heat exchangers to utilize the thermal energy from the steam extracted from the turbine. The general equipment configuration is as shown in the heat balance diagram, Fig. 4-10, and system operation is as follows: 1.) steam at low pressures, approximately 24" HgA, is extracted and routed through the first shell and tube heat exchanger where the latent heat of vaporization is removed; 2.) the low pressure condensate is routed through a steam trap and allowed to expand to near vacuum conditions, flashing to the condenser; 3.) higher pressure steam is extracted at approximately 15 psig from the turbine and routed to the second shell and tube heat exchanger in the circuit where it gives up the latent heat of vaporization as the circulating water is raised to the required 250° F; 4.) condensate from the second heater is piped through a steam trap and allowed to expand to the lower pressure present in the initial heat exchanger shell, where approximately 5% of the fluid flow flashes to the steam; 5.) the heat then remaining as the latent heat of vaporization is removed in the first exchanger; 6.) additional condensate is expanded through the steam trap to the condenser.

With the fluid flow paths then defined, the heat balance can be drawn according to the conditions depicted in Figure 4-10. Circulating water into the heat exchanger circuit is taken as 160° F. Circulating water out of the

FIGURE 4-10
 OPTION 4 HEAT BALANCE

circuit is set at a mass flow rate which will fix the outgoing water temperature at 245° F. It should suffice to say that, for this system configuration, an iterative calculation process was required in order to balance the low and high pressure extraction steam flows. The conditions presented on the figure are the final result of that balance. With the operating conditions thus defined, the heat supplied to the district heating system can be calculated utilizing the expression below

$$Q = \dot{M}_1 (h_1 - h_4) + \dot{M}_2 (h_2 - h_4)$$

Substituting from Figure 4-10 yields

$$\begin{aligned} Q &= 110,000 \text{ LBM/hr } (1109-170) \frac{\text{Btu}}{\text{LBM}} \\ &+ 133,667 \text{ LBM/hr } (1164-170) \frac{\text{Btu}}{\text{LBM}} \\ &= 236,154,998 \text{ Btu/hr} \end{aligned}$$

The corresponding mass flow rate of water which could be heated to the required distribution conditions can be calculated from the relation

$$Q = \dot{M}_A (h_c - h_a)$$

Again, substituting from Figure 4-10 and from the above calculation

$$\begin{aligned} 236,154,998 \frac{\text{Btu}}{\text{Hr}} &= \dot{M}_A (214-128) \frac{\text{Btu}}{\text{LBM}} \\ \dot{M}_A &= 2,745,988 \text{ LBM/hr} \\ &= 5494 \text{ GPM} \end{aligned}$$

which corresponds to the flow rate from the heat balance of Figure 4-10.

Thus, the construction of the totally new 30,000 kw cogeneration unit as proposed for Option 4 would make available to the district heating system thermal energy at a rate of 236.155×10^6 Btu/hr at rated conditions. Obviously, this option would not be viable if considered strictly as a thermal source whose entire capital cost should be borne by the district heating system. Rather, it should be considered an improvement to the power plant coincident with the initiation of, or improvement to, the district heating system in the Municipal Power Plant, with the capital costs to be allocated accordingly. In view of the high capital investment required for this option, it is likely that the cost and energy effectiveness of the installation of this cogeneration unit could be increased if it were phased into an already well developed system.

4.2.5 SYSTEM PHASING

In light of the myraid of options available as thermal sources to a potential district heating system installed at the Municipal Power Plant, and considering the high potential within the community for attracting end-users to such a system, a phased approach to system construction encompassing each of the four aforementioned "hardware options" has been developed. It was obvious from the inspection of the computer outputs which projected the quantities of thermal load which could reasonably be expected to connect to the district heating system that the growth of the system after implementation would quickly outstrip the thermal energy supply capability of any one of the cogeneration options at the power plant. Thus, provisions were made for phasing in each of the hardware options examined in the study at some point during the study period as conditions warrant. It is this phased construction plan which forms the basis for the construction cost estimates for the in-plant modifications. The design and costing of the initial system provides for, in addition to adequate system capacity to immediately utilize the thermal supply capacity of option one, the expansion of the in-plant system to accommodate options four, three, and two, in order, as thermal demand grows. The cost estimates for each consequent system expansion will therefore reflect the incremental cost of bringing the system to full capacity as defined by the limits of the thermal supplies. The paragraphs that follow describe the design and costing of the initial system and the sequential system expansions.

INITIAL SYSTEM - PHASE I

The initial district heating system to be installed at the Municipal Power Plant provides for the utilization of the option one system. System layout is as shown on Drawings 1 and 2.

Drawing 1 illustrates the proposed system layout as it would be constructed on the base slab of the plant. In order to make room for the major piping runs and equipment of the district heating system, the existing equipment now occupying the two northernmost bays of the power plant (Boilers 1 and 2 and auxiliaries, turbine-generators 1 and 2, and their associated condensers) will be removed and disposed of as salvage. The district heating system steam supply header is designed to interconnect with the existing 150 psig plant

INITIAL SYSTEM CONFIGURATION

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-78-C-02-4976

TEAM MEMBERS CITY OF PIQUA, OHIO

GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESKEW AND ASSOCIATES

Drawing 1

PIQUA MUNICIPAL
POWER PLANT
BASE SLAB FLOOR PLAN

SHEET OF

	DATE
DRAWN	12/10/87
CHK'D	
APPR'VD

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

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GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESKEW AND ASSOCIATES

Drawing 2

PIQUA MUNICIPAL
POWER PLANT

OPERATING FLOOR PLAN

SHEET

OF

DRAWN *KMI* DATE *4-16-77*
CHKD _____
APPR VD _____

steam service header, adjacent to the backpressure turbine exhaust connection. Also, the new header would tie-in to the existing main steam header from Boiler No. 6 through a pressure reducing valve (PRV) station, in order to utilize any excess steam capacity from the boiler as a back-up or supplemental steam source. Additionally, Boiler No. 3 will be derated to supply saturated steam at approximately 250 psig through a PRV and attemperator station to the district heating system steam header. Immediately after the tie-in to the No. 3 Boiler, the piping is routed through the partition on the base slab and underneath the main operating floor of the plant. All steam piping will be overhung from the "ceiling" over the base slab (the underside of the operating floor slab) to minimize obstructions on the base floor level.

The main system water piping will also be constructed at the base slab level. A new low-level building annex of pre-engineered building design will be constructed on the northwest corner of the existing structure to house the main distribution pump station, main water supply and return piping, the system instrumentation and control system and console, and the major electrical facilities for the system. The main return trunk line will enter the D.H.S. building annex in the pump pit at approximately 10' below grade. The main piping loop enters the main building along the north wall. For the initial system, one expansion tank of 500 gallon capacity is provided with pressurization system in order to prevent steam flashing at the low pressure end of the system. A valved and capped pipe extension is also provided to facilitate expanding tank capacity in the future. On the outgoing leg of the trunk line water take-off for each of the heat exchanger circuits are provided. The first, second and third pairs of piping connections are valved and capped during this phase but are installed to facilitate system expansion in subsequent phases as new heat exchanger circuits are added. The fourth pair of piping connections is installed in conjunction with the cold and hot water headers on the heat exchanger circuit. As with the steam piping, all water circuit piping is overhung to avoid obstructions. The main outgoing trunk line is routed back into the distribution pump pit to form a pump suction header. For the initial phase, two high temperature distribution pump and motor sets will be installed, each with a capacity of 3000 GPM at 350 feet of total head. Pump output is into the main trunk line supplying the community distribution system.

The main heat exchangers are installed on the operating floor slab as shown in the layout on Drawing 2. The heat balance schematic presented in previous section shows one large heat exchanger and drain cooler set. However, in the actual system design, in order to keep the equipment sizes manageable, the thermal load was split between three shell and tube exchangers and drain cooler sets. Each of the three heat exchangers is specified to handle a nominal 50,000 pounds of mass per hour flow at 150 psig on the steam side with water flow at a nominal 100 GPM. Steam and water piping connections are made at below floor level to the appropriate headers. A booster pump is provided on the outgoing leg of each heat exchanger water circuit in order to provide the impetus for water flow out of the main trunk line and into the heat exchanger water circuit. Each booster pump is sized at a maximum output of 1500 GPM at 50 feet total head. System Schematic 1 illustrates the initial system configuration.

Construction cost for this initial phase including the D.H.S. building annex, main trunk piping inside the plant, expansion tank, electrical and equipment costs, is estimated at \$966,336.00 for in-plant system construction, of which \$902,984.00 is allocated to the district heating system and \$63,352.00 is associated with modifying the No. 3 boiler to serve as a peak period steam supply source. Costs for major equipment (heat exchangers, pumps, motors, and expansion tanks) were obtained from equipment manufacturers; Means 1979 Building and Mechanical and Electrical Cost Data were consulted for field constructed materials and installation costs. Detailed cost estimate worksheets are included in Appendix C.

For the purposes of the economic analysis, initial system construction is scheduled to start at the beginning of the study period, 1/1/80, and undergo a two year construction/start-up period. Commercial service will commence on January 1, 1983.

SYSTEM EXPANSION - PHASES II, III, IV

Drawings 3 and 4 illustrate the ultimate system configuration which incorporates all of the four "hardware options" previously discussed. In order to optimize system performance and economics, a tentative schedule, based upon the projections of connected thermal loads throughout the study period and considering the economic ramifications of capital expenditures for plant

SYSTEM SCHEMATIC I **INITIAL DISTRICT HEATING SYSTEM INSTALLATION**

CITY OF PIQUA

MIAMI COUNTY, OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-78-C-07-4878

TEAM MEMBERS CITY OF PIQUA, OHIO
GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESKEW AND ASSOCIATES

Drawing 3

**PIQUA MUNICIPAL
POWER PLANT
BASE SLAB FLOOR PLAN**

SHEET OF

DATE	
DRAWN	10/1/78
CHKD	10/1/78
APPR'VD	10/1/78

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-78-C-07-4936

TEAM MEMBERS CITY OF PIQUA OHIO

GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HENSELMAN - ESKIN AND ASSOCIATES

Drawing 4

PIQUA MUNICIPAL
POWER PLANT
OPERATING FLOOR PLAN

SHEET OF

DRAWN *KML* DATE *4-14-77*
CHKD _____
APPRVD _____

expansions, has been developed for construction phasing.

Construction for Phase II is scheduled to start in 1984, with the new expansion to commence operation in 1986. This phase involves the addition of the 30 MW cogeneration power unit in conjunction with the district heating system plant expansion. The turbine and its associated auxiliary equipment (feedwater heaters, pumps, etc.) will be housed in the vacant bay at the south end of the existing plant. Due to space constraints within the existing building, though, the boiler will be housed outside the existing building. The unit will be free-standing with its own superstructure and will be enclosed in a transide-type boiler house. Figure 4-11 details the general location and layout of the boilerhouse addition.

The space provided in the original building design for the addition of a new boiler will then be occupied with the district heating equipment associated with the cogeneration turbine.

Drawing 3 illustrates the layout of the steam and water circuit piping. Headers for both automatic, variable flow extractions from the turbine are overhung over the base slab and routed along the south wall into the general vicinity which was originally intended for the boiler. Piping for the water circuit is connected at the first pair of piping connections on the main trunk line and routed toward and then along the east wall and into the southeast corner of the building. As with the steam piping, all water piping on this leg is also overhung underneath the operating floor slab. Expansion tank capacity is expanded in this phase with the addition of another 5000 gallon tank in the area adjacent to the initial tank installation. Two additional distribution pumps, 3000 GPM at 350 ft. total head, are included in this expansion.

A bank of six heat exchangers is located on the operating floor level in the southeast corner of the building. Steam and water piping is routed through the floor slab to connections underneath on the appropriate headers. Booster pumps, 50 ft of head and 2200 GPM, are provided on the outlet side of the second exchanger in the series to provide the flow impetus through the water leg. System Schematic 2 illustrates the ultimate system configuration.

The incremental cost for this in-plant system expansion is estimated as

FIGURE 4-II
OPTION 3 CO-GENERATION UNIT ADDITION
BOILER AND ENCLOSURE

\$563,177.00 for the district heating system and \$29,157,800.00 for the Boiler-Turbine cogeneration cycle power unit. Detailed cost estimates are included in Appendix C. Of the costs associated with the new cogeneration unit, it is suggested that approximately 93% (\$27,000,000.00) of the capital expenditure be allocated to the improvement of the electric plant, with the remainder to be allocated to the district heating system as the incremental cost of specifying the cogeneration capacity from the unit. This contention is reflected in the input to the computer simulation for the economic analysis.

Construction for Phase III is scheduled for 1991 with operation to commence in 1993. Hardware option 4 is implemented with the modification of the existing unit 6 to cogeneration capacity. The district heating system expansion is accomplished in much the same manner as the Phase II expansion with the addition of the appropriate steam and water headers, heat exchangers, booster pumps, and one distribution pump. The estimated construction cost for this incremental increase in capacity is \$426,794.00, with approximately 78% (\$332,817.00) going to D.H.S. construction and the remainder (\$93,977.00) going to turbine modifications. A detailed cost accounting is presented in Appendix.

Construction of Phase IV is scheduled for 1994 with operations to commence in 1996. Hardware option 3 is implemented with the retrofit of a new cogeneration turbine-generator set to replace the existing unit 4. The district heating system is completed with regards to in-plant additions as this phase goes into operation. Expansion is performed in the same fashion as for the two previous phases. The estimated construction cost of this incremental step in thermal capacity is \$4,019,696.00, with approximately 92% (\$3,683,626.00) of the capital cost going to replacement of the existing turbine. Detailed cost accounting is presented in Appendix. It was decided that the full cost of turbine retrofit would be borne by the district heating system since only a marginal increase in plant electrical capacity would result.

It should be emphasized that this scheduling is tentative and was assumed on the basis of the engineering and economic judgment of the team members. The schedule and the order in which the hardware options are phased is subject to change as the economic effectiveness of the project can be optimized through variations in the computer simulation.

4.3 ASSESSMENT OF ALTERNATIVE RETROFIT OPTIONS

At the outset of the project, it was anticipated that the most concise manner in which to evaluate the effectiveness of this cogeneration project would be to perform a standard engineering cost/benefit analysis. However, once the complexities of system planning dynamics were explored, it was quickly realized that no one optimal plant configuration could be selected upon which to base a cost/benefit analysis. Moreover, the sensitivity of one or another of the identified alternatives to the influences of inflation, escalation of the costs of primary fuel resources, etc. adds another dimension to the determination of the optimal system and its economic viability. It was decided that a dynamic model simulating the economic consequences of implementing the various system retrofit options would best serve the purposes of both the cost/benefit analysis and the economic analysis. The essential elements of a cost/benefit analysis - i.e. cost of retrofit options, fuel costs, net costs to end-users, revenues from ownership and operation, etc. - are included as inputs to the computer system economics simulation. Thus, it is suggested that, especially since the ultimate decision on the effectiveness of such a cogeneration system will be made on the basis of its economic viability, the economic evaluation stand in the stead of the engineering cost/benefit analysis. The end product of the analysis will necessarily assume a different format, but the end result is the same: the optimal system configuration will be defined based on the relative economic viability of each, and a quantitative comparison is made relative to the existing alternatives. Discussion of the optimization process followed through the economic evaluation is presented in Chapter 6.0.

4.4 ASSESSMENT - MODES OF OPERATION

The retrofit of existing power plants to serve in a cogeneration cycle as thermal energy sources for district heating systems will necessarily influence a change in the modes of operation of plant equipment. The utilization of certain machines, or power generating units, especially those of the back pressure configuration, may depend upon the coincidence of thermal and electrical energy demands. This coincidence will obviously be site-specific and vary on an hour-by-hour basis. However, general trends in equipment operation can be identified and considered when making projections on plant operations. The most useful aid in assessing the mode of operation of a particular piece of equipment or subsystem is the pair of operational status factors, Operational Availability and Capacity Factor, introduced previously in the characterization of the operation of the subject plant.

Current operation of the equipment at the Municipal Power Plant reflects the typical operating practices which may be seen on a larger scale in the operation of individual plants in large, investor-owned utilities. The PMPS has under one roof the same variety of units that may be scattered over several locations in a large system. Namely, these service categories for power units are base-load, cyclic load, and peak load type units. All units currently in service at the Piqua plant, with the exception of one small unit, one condensing-type turbine and as such are limited only by the incidence of electric demand. Piqua's Unit 7, which has been out of service for a period of time, will re-assume the duty of base load service for the Municipal System, operating with a typical operational availability of approximately 85-95% and at an average output of 80% of rated capacity. Units 4 and 6 provide the cyclic portion of community power demand and operate typically at 50% operational availabilities and 50-65% capacity factors. During periods of low demand, one unit or the other may be taken out of service and held on stand-by until such time as the demand level rises. The gas turbine provides peaking power when necessary at an operational availability of approximately 3-5%. Average capacity factors for peaking units of this type are in the 75-85% range. However, due to the relatively low peak levels experienced by the Piqua system at the present, the gas turbine peaking capacity is underutilized.

In the event that one or several of the cogeneration options are implemented at the Piqua Power Plant, it is anticipated that some adjustment in operating procedures will be necessary. In general, it is expected that the cogeneration units, especially those of the back pressure configuration, will see heavy baseload utilization during the periods of high coincident thermal load. The proposed 30 MW cogeneration unit, when phased into the system, is expected to see extensive duty as a combination electrical/thermal baseload supply during the heating season and, by virtue of its flexible capacity, significant electrical base load duty during the summer. The backpressure turbine-generator units, which are limited strictly by the coincidence of thermal and electrical loads, will see reduced service during the summer (cooling season) months. A more extensive analysis of the projected utilization of the cogeneration units which could be installed on the Piqua system is pending a final system-optimized computer simulation and will be included in the final report. Some insight into the projected utilization of the cogeneration units can be gained from the examination of the computer simulation outputs found in the Appendix.

4.5 ASSESSMENT OF OPERATING CONDITIONS

INTRODUCTION

A significant concern in the analysis of cogenerating power plants is the degree of concurrent thermal and electrical loads. This is especially important in a case like Piqua's where both the thermal and electrical loads will vary on a monthly and diurnal cycle. Over the study period the magnitude of the peak thermal and electrical load and the amount of thermal and electrical energy will be constantly growing in response to system load growth. This extreme number of variables presented an extremely complex situation with a number of options to be considered. Figure 4-12 is an illustration of how the electrical and thermal loads are expected to vary on the daily cycle. It can be seen that the peak electrical and thermal loads do not occur simultaneously and in fact tend to be almost 180 degrees out of phase. The result is that peak electrical loads occur during the periods of low thermal loads. Correspondingly, peak thermal loads occur in the early morning hours when electrical loads are relatively light.

4.5.1 THERMAL AND ELECTRICAL LOAD-DURATION CURVES

Monthly load-duration curves of steam output and heating load output were derived from the system distribution records as previously described. Temperature dependent space heating loads were estimated using temperature duration data for the Dayton area. Temperature dependent space heating loads are comprised of heat losses through building shells and tempering outside air from ambient conditions to comfort conditions within building spaces which occurs due to infiltration or mechanical ventilation.

The annual energy consumptions predicted previously by the zone by zone analysis were used in conjunction with the monthly temperature duration curves to approximate the monthly heating loads.

These, along with estimated domestic water heating requirements and thermal losses from piping distribution systems, were used to simulate load duration curves for the thermal components.

ANALYSIS OF POWER PLANT OPERATION

A method was sought to approximate energy consumption of the cogeneration

TYPICAL DAILY THERMAL AND ELECTRICAL LOAD PATTERNS
PIQUA, OHIO

FIG. 4-12

retrofit to the Piqua Municipal Power Plant which would use the monthly data available. Unfortunately, it was obvious that a reasonably accurate estimation procedure was not available when given only monthly electrical and thermal consumption data. It was determined that a method must be developed to estimate with smaller time increments that would allow for the simulation of the power plant's meeting concurrent thermal and electrical loads. Obviously, an hour by hour load calculation and system simulation would be preferable for detailed analysis of plant operation.

Sufficient data on thermal and electrical demands was not available on an hourly basis to justify the use of an hour by hour simulation during this phase of the demonstration. In order to do this, a vast amount of data would have to be collected and coded into usable formats from the power plant electrical log sheets and distribution records.

In order to perform the operational analysis on the monthly load data, a computer simulation program which takes all monthly inputs and simulates average daily conditions was developed.

4.5.2 LOAD SIMULATION

For the purpose of simulating the dynamic response of the power plant to the changing thermal and electrical loads, it was decided that a reasonable representation of the coincidence of daily thermal and electrical load cycles could be made by inverting the monthly load duration curves such that the period of peak electrical load correspond to the minimum thermal load and a corresponding peak thermal load occurs at the minimum electrical load. This inverted thermal/electrical configuration was then divided into 24 time periods to represent an average daily configuration. Figures 4-13 and 4-14 illustrate how the process was conceived.

Figure 4-13 is an inverted load duration for a typical winter month. Significant thermal demand is always present from the system due to the high incidence of temperature dependent loads. Figure 4-14 is an inverted load duration curve for a typical summer month. This figure illustrates that during the summer months there will be a great incidence of low thermal loads corresponding to the high electrical loads. There will be some small incidence of temperature dependent thermal loads and possibly some times when there will be

FIG. 4-13

FIG. 4-14

no thermal load at all.

A model can be constructed using the finite periods of the inverted load duration curves which approximates a typical daily cycle of concurrent thermal and electric loads.

Figure 4-15 is a representation of what the actual concurrent loads on a typical day would be versus the finite integral model assumed in the simulation. There are times when the model does not assume the exact concurrent thermal and electrical loads which would actually occur. However, it was found that, when the results of the computer program analysis were checked against actual operating data, the results agree quite closely. Additionally, since the same methodology was used to predict base energy consumption versus actual energy consumption, the discrepancies tend to cancel out in the comparative analysis.

For use in the power plant simulation, the monthly load duration curves were broken into 24 segments. Each resulting segment was multiplied by the respective hours in the month. Each sector contained the number of hours corresponding to the number of days within the monthly period. For example, January's periods would contain 31 hours, February's periods would contain 28 hours, and May's periods contains 30 hours.

An estimated electrical and thermal demand was determined for each period so that the combined sum of each period's demand, multiplied by the number of hours contained within the period, equalled the total thermal output or total electrical energy output on a monthly basis. In essence, the electrical energy and thermal energy output were simulated by a finite integration approach. The same approach could, of course, be used with smaller increments but was considered undesirable for the purposes of this study.

One drawback to using this approach is that the averaging technique tends to assume lower peak demands seen by power plant equipment and increases the minimum demand seen by the system. This is not considered overly important in the annual analysis of the power plant and the projection of fuel consumption, but is critical for design considerations. It is estimated that these averaging techniques caused an under estimate of peak demands by approximately 7% and an over estimate of minimum demands by 8 to 10%.

ILLUSTRATION OF FINITE
INTEGRAL SIMULATION-
CONCURRENT THERMAL AND ELECTRICAL LOADS
-TYPICAL DAY

FIG. 4-15

The finite integral estimation procedure resulted in 24 periods per month for the 12 months of each year of the study period. The study period was then extended through load growth projections of the thermal and electrical systems for a period from 1981 to the year 2000.

4.5.3 ANALYSIS OF POWER PLANT OPERATION

Once a concurrent thermal and electrical load for each period was estimated, a determination of how the thermal and electrical requirements would be satisfied using the power plant's equipment was simulated. Figure 4-16 is a flow chart of the decision methodology utilized in determining how the thermal and electrical load components were satisfied. The configuration of equipment was changed during the study period to simulate the four basic options under consideration for the power plant retrofit. The power plant operational simulation takes into account each piece of equipment available in each of the four different configurations and utilizes a decision matrix to determine which pieces of equipment are operated and what part of the load they satisfy. In general, the methodology of the decision tree requires that the plant satisfy thermal loads first, utilizing all available cogenerating equipment and then utilize peak heat supplied from coal fired boilers or an oil peaking boiler. Once all thermal loads are satisfied, the electrical load is then satisfied.

The operational strategy requires that the remaining electric load be satisfied with condensing type turbine-generator assemblies within the Piqua Power Plant System, the peaking oil turbine, or finally with additional purchased power from the Dayton Power & Light System.

Several unique considerations had to be included in the analysis of the Piqua Municipal Power Plant in meeting thermal and electrical load dispatch. These considerations included:

- 1.) From an emergency back-up standpoint and to maintain the ability to extract and input power into the power grid it is desirable to maintain an interconnect agreement with the Dayton Power & Light Company. An example of this current interconnect agreement with DP&L is included in Appendix. This agreement consists of a minimum firm purchased power segment including fixed charge per KW of firm purchased power and an energy charge per Kilowatthour for firm power service.

PIQUA MUNICIPAL POWER PLANT OPERATIONAL SIMULATION COMPUTER PROGRAM FLOW CHART

FIG. 4-16

Obviously, it is desirable to contract for the minimum amount of firm purchased power that is anticipated. Secondly, there are provisions that additional power may be purchased from DP&L on an emergency basis or for extremely short term requirements. This provision is available only if DP&L has power available for purchase. In actual operating conditions a decision must be made on an hour-by-hour basis whether it is more economical to generate power in house, use the combustion turbine, or purchase power from DP&L. Provision was made in the simulation which assumes that a specified minimum amount of firm electric power is purchased every period from DP&L. A flag in the program input allows the analysis to increase the minimum purchased power segment during specified months. This is generally considered necessary when certain base load operating units are taken out of service for maintenance and repair.

- 2.) For each turbine-generator set, the peaking turbine, and each boiler, minimum and maximum loads are specified. This is critical when determining which units are used to meet the load segments since at times the incremental load segments may be insufficient to bring an additional unit on line. This program makes the assumption that each unit is loaded to 100% capacity before successive units are added to meet remaining loads. In actual practice it is not uncommon during transitory loading periods to decrease loads supplied by operating units in order to bring an incremental piece of equipment into operation at a load higher than its minimum load. This allows some overlapping of operation between full load of one piece of equipment and minimum of a second piece of equipment. Again, it is not considered to be a significant discrepancy in the simulation over the entire life of the analysis period.
- 3.) The availability of multiple boiler and turbine sets and several interconnecting steam header situations within the power plant allow peak heating loads to be satisfied with excess available capacity in coal boilers in lieu of going to a direct fired oil peaking system. This may be untrue in large base-load power plants where turbine-generator sets and boilers are independently piped and controlled. The ability to accomplish this peaking by using existing boiler systems

substantially reduces the amount of oil needed for oil type peaking boilers in the Piqua plant.

FUEL USE

Once the operating configuration of the power plant for the period in question is determined, the Btu requirements of each piece of equipment are summed and charged to their respective boiler units. Peaking capacity required for the district heating system is then supplied from any excess capacity available in the boiler systems or from the oil fired boiler system. The efficiency of each boiler at its current load is then evaluated and used in determining fuel input for that period. Oil consumption for the gas turbine assembly is also determined utilizing its prorated heat input. The resulting fuel input to each piece of equipment is then totalled for each period during the year to arrive at an annual figure.

PUMPING POWER

The energy required to pump the district heating system's thermal transfer medium is accounted for during each period by the following method:

- 1) A dynamic pumping head is determined during each period by using the average flow rate per period.
- 2) This average dynamic head was then used to determine the brake horsepower required for pumping. A pump efficiency of 80% is assumed to determine shaft horsepower for pump work.

Once the total shaft work for pumping is determined during the period it is divided into two segments to approximate actual energy required for pumping. The first segment assumes that 40% of the required pumping shaft work was supplied by electric drive pumps. The required kilowatthours are then added to the required electrical production of the period.

The remaining 60% of required pumping shaft work is assumed to be supplied by turbine drive pumps. The Btu requirement for turbine drives was added to the required thermal output of the plant during the time interval.

So that the pumping energy could be evaluated as to its effect to the system, an annual total for required electrical and thermal pumping energy was included in the program output.

ANALYSIS OF CONVENTIONAL CONFIGURATION

The plant analysis program was written in such a manner that the conventional plant configuration could be analyzed as well as cogenerating configurations. This analysis was conducted by supplying the computer with the appropriate plant equipment data and setting the space heating load and domestic water heating load components of the thermal requirements section equal to zero. This then caused the program to supply the same amount of electricity as the cogenerating plant and the assumed constant steam requirements of the industrial customers now connected to the system.

4.6 Effect on Utility Capacity

Obviously, system modifications of the scope of those proposed herein will have significant effect upon the subject utility's capacity to meet the energy needs of the community. In general, the retrofit plan to be followed in converting the Piqua Municipal Power Plant to a combined power and heat plant will show significant beneficial effects on the utility's capacity in that the electrical generating capacity of the subject plant will be upgraded and the capacity to supply a major portion of the community's thermal energy requirements will be added (the existing steam distribution system notwithstanding). In the sections that follow, the specific impacts on utility capacity arising from the implementation of each of the four identified hardware options are discussed.

4.6.1 Option 1 - Optimize Output of Existing Backpressure Turbine

Option 1 provides a convenient initial step in establishing a district heating system co-located at the Municipal Power Plant. Annual operations statistics for this unit reveal that unit 5 is being utilized to only an approximate 25% ($\text{availability} = .5096 \times \text{capacity factor} = .5040 = .2568$) of its annual electrical and thermal capacity. Inclusion of this unit as a thermal energy source on the district heating system will enable the more complete utilization of the capacity of this unit by providing a base thermal demand of sufficient quantity to allow almost continuous full load operation. Since for a backpressure turbine-generator unit of this type electrical production is governed by thermal demand, an increase in annual KWH production will also be noticed.

Potential annual electrical production (allowing 2 weeks for scheduled maintenance) is approximately 8,424,000 KWH as opposed to the 2,249,764 KWH produced by unit 5 during the 12 month base period, an increase of approximately 274%. This additional production would directly offset a portion of the purchased power requirement of the Municipal system.

4.6.2 Option 2 - Retrofit Turbine-Generator 6 for Cogeneration

Option 2 will involve a substantial reconfiguration of the existing turbine-generator unit 6 and as such will present the most drastic adverse

effect of any of the four options on the Municipal Power System's capacity. The removal of the last seven stages of the existing turbine rotor will effectively convert this machine to a backpressure configuration which could supply low pressure steam (28 psig) to the district heating system. At the same time, however, a portion of the machine's ability to deliver shaft work to the generator is sacrificed. From the heat balance for this option (presented in Section 4.2.2), approximately 42% of the turbine's nominal capacity of 10,000 KW will be sacrificed in order to make thermal energy available for district heating. The trade-off is quite attractive for this application - 6.8 Btu's of thermal energy made available per Btu of sacrificed electrical output, but the sacrifice in plant capacity is significant - 4221 KW.

In the long term the impact on the utility's capacity of modifying this unit as proposed will be two-fold. First, system operation during the summer and winter peak demand periods will likely require increased utilization of the combustion turbine to supply peak power and portions of the cyclic load which were previously supplied by unit 6. An increase in purchased power may also be necessitated. However, since the combustion turbine is at this time significantly underutilized, this situation would not be expected to cause system load balance problems. Secondly, the reduction in plant capacity will ultimately make necessary the installation of additional generation capacity sooner than would be required if the unit was left unmodified. Assuming the 3% annual growth rate of peak demand projected from a mathematical regression on historical system data, current plant peak capacity will be expended in approximately 14 years. The modification of unit 6 requires the sacrifice of 4221 KW of capacity and the corresponding date for expending peak capacity is then 17 years. Planning for adequate system capacity would then be put on a shorter time frame.

4.6.3 Option 3 - Retrofit Existing Turbine-Generator 4 with Backpressure Turbine

Option 3 will provide a backpressure steam supply source for the district heating system but will avoid the sacrifice in foregone electricity typical of the approach taken for Option 2. The new backpressure turbine-generator unit which will replace the existing unit 4 will be specified at

a nominal rated load of 10,000 KW, thus increasing system capacity by 2500 KW. Routine system operation during periods of high coincident electrical and thermal loads will not be significantly affected by this modification. However, operation of this unit could be curtailed during periods of low thermal demand.

Long term effects will be essentially opposite of those of Option 2. The additional 2500 KW of capacity will effectively postpone the date when system peak capacity is expended through approximately 15 years.

4.6.4 Option 4 - Install New Cogeneration Power Unit

The implementation of hardware option 4 will have perhaps the most far-reaching impact on the capacity of the Piqua Municipal Power System. This option involves the installation of a 30 Megawatt Rankine cycle power unit specified explicitly for cogeneration service. The turbine-generator unit will be specified as a full condensing turbine with two automatic, controlled extractions provided as the thermal energy supply for the district heating system. Operation of this unit can thus range from full condensing to full cogenerating operation. This design offers the most flexible arrangement for unit operation and will allow the utility to operate the unit in a thermal and electrical base load capacity during periods of high thermal load on the district heating system and in simply an electrical base load capacity during low thermal demand periods. Of course, the addition of this unit, an approximate 50% increase over the existing plant capacity, will necessitate a reassessment of the capabilities of the existing equipment and a major revision of plant operating strategies. However, this task would be fostered by a situation which any utility would welcome and could be easily accomplished as the new unit is put into service. In addition to providing a major portion of the thermal energy supply capability which would ultimately be required for the district heating system, the installation of this unit would also provide electric generating capacity for the community which should be adequate for many years into the future, if the system continues its historical 3% annual growth trend. Based on the current trend, the Power System's capacity, with this proposed addition, should be adequate for approximately 27 years.

Based on current projections, existing system capacity, 61,000 KW, is adequate for approximately 14 years, through 1993. The projected peak demand at the end of the planning period, the year 2000, is projected at 75,700 KW, an excess over existing capacity of 14,700 KW. Thus, some expansion over the existing capacity will become necessary at some point in the foreseeable future whether or not the cogeneration-district heating scheme is put into effect. The approach proposed for option 4 will therefore have the added advantage of being able to allocate a major portion of the unit's capital cost to the improvement of the existing electrical plant. The district heating plant will bear only the incremental cost of the added cogeneration capacity of the new unit.

4.6.5 Summary

An overall indirect effect upon the utility of the establishment of the district heating system will be a noticeable reduction in electrical demand during the heating season due to the displacement of a portion of the electrical (heating) load with the direct supply of thermal energy. An approximately 9% of the residences in the study area currently use electric resistance type heating. It is anticipated that a significant portion of the users of this type of heating can be induced to change over to district heating, if it is made available, due to the very favorable economic incentives inherent in the comparative energy costs.

A second and related indirect effect upon utility capacity will be a slight leveling of the rate of escalation of electrical demand due to the increased availability of thermal energy in a non-fuel form (i.e. as a thermal utility service). The availability of this service will effectively displace whatever remaining market there is for new electric heating systems in favor of district heating.

It should be noted that each of the option's discussed above is a self-contained approach to providing a cogeneration thermal energy source for a district heating system. The implementation of any one option is therefore not contingent upon the implementation of the others. However, any number of the options can be combined and implemented as a composite thermal energy

source for the district heating system; indeed, all of the four options can be combined into a perfectly complementary overall cogeneration scheme for the Municipal Power Plant, as suggested in Section 4.2.5 which details system phasing. The overall result of the implementation of the plan discussed therein is expected to be a beneficial impact on the Municipal system's capacity.

4.7 DISTRIBUTION NETWORK SCHEMES

INTRODUCTION

The thermal transmission and distribution system should be capable of conveying the thermal energy produced in the cogeneration plant to the consumers economically and efficiently. In the case of cogeneration systems the energy of the district heating system comes as a by-product from the power plant. Either steam extracted at intermediate pressures from the turbine or exhaust steam can serve as source of energy. This steam can be transported directly to the distribution network if steam is the heat transport media or it can transfer heat to water in a heat exchanger (condenser) if hot water is used. Extracted or exhaust steam pressures and temperatures are selected so as to satisfy the heating requirements and at the same time allow for the increase in electrical output and overall efficiency of the cogeneration plant. The proposed cogeneration scheme at Piqua is a modification of the existing power generation facility and includes the retrofitting of existing power plant components such as turbines, heat exchangers and the alteration of operating conditions to allow for the simultaneous supply of thermal energy for the district heating system. The several alternatives of the power plant retrofitting scheme have been discussed previously.

In what follows, a general discussion of the thermal distribution system will be presented and special problems with the Piqua scheme will be identified. A conceptual design of the proposed thermal distribution system will be presented so that it will lead to the selection and phasing of power plant retrofit schemes.

The art and practice of district heating and cogeneration has been in existence for several decades in Europe and North America and the technology is well developed. For a detailed discussion of all the items discussed in this section, Appendix 4 should be consulted.

The requirements of the thermal distribution system include the following:

- i) the system should deliver energy to the consumers efficiently and economically.
- ii) the system should allow for the best utilization of the thermal

energy available in the cogeneration plant resulting in maximum output of electrical power and overall efficiency.

iii) the system should be reliable and easily maintainable.

iv) the system should be easily adaptable at minimum cost to the consumers.

In view of these requirements, the selection and design of each of the components of the thermal distribution system take into consideration:

i) the capital cost of the distribution system that includes the pipe lines and conduits, valves, pumps, fittings, insulation, construction of trenches, etc.

ii) the cost of operation which is dependent on the thermal losses, leakage, drainage, maintenance, etc.

iii) reliability, safety and ease of maintenance.

iv) the selection of the transport media and other operational problems such as storage, metering, etc.

In what follows, some of the important items leading to the selection of the distribution system are discussed.

4.7.1 TRANSPORT MEDIA

Both steam and water have been used as heat transfer media in district heating systems in Europe and the United States. The majority of the existing district heating systems in the United States use steam, whereas in Europe the number of district heating systems using steam or hot water vary depending on the country and the particular situation. However, in recent years due to the relatively lower efficiencies and the operational problems associated with steam, water is being preferred for district heating schemes. European experience seems to confirm this trend. The factors that influence the selection of the heat transfer media are discussed in the following paragraphs.

Steam contains a greater amount of energy per unit mass than water, but on a volume basis, the thermal content of steam is far less compared to water. For example, the enthalpy of steam at atmospheric pressure and 212°F is 970 Btu/lbm compared to 180 Btu/lbm for water under the same conditions, whereas the density of steam at the same pressure and temperature is 0.0373 lbm/ft^3

compared to 59.83 lbm/ft^3 for water. But, on a volume basis the internal energy content of water would be 268 times that of steam. However, at higher pressures and temperatures this ratio would not be so high. Table 4-1 contains data on the characteristics of water and steam, such as density, energy ratio per unit volume, mass ratio, etc., for the usual range of temperatures and pressures encountered in district heating practice.

These characteristics have a strong bearing on the size of the pipe lines, storage, heat losses, insulation, etc., and the costs associated with steam and hot water distribution systems.

TABLE 4-1

Temp. T	Pressure psia	u_f water Btu/lbm	u_g steam Btu/lbm	ρ water lbm/ft^3	ρ steam lbm/ft^3	mass ratio per ft^3 $\frac{M_{\text{water}}}{M_{\text{steam}}}$	energy ratio per ft^3 $\frac{E_{\text{water}}}{E_{\text{steam}}}$
212	14.7	180.11	1077.6	59.83	0.0373	1604.02	268.1
250	20.82	218.49	1087.9	58.82	0.0753	781.14	156.88
300	66.98	269.52	1100.0	57.313	0.1545	370.96	90.89
350	134.53	321.35	1109.8	55.593	0.2988	186.05	53.87
377.6	190.00	350.39	1114.0	54.552	0.4158	131.20	41.27
400	247.10	374.27	1116.6	53.654	0.5359	100.12	33.56
450	422.1	428.6	1119.5	51.46	0.90818	56.662	21.693

It is least difficult to extract and transport steam from the central station to the distribution network. This is especially advantageous in areas where there are numerous high rise buildings. But steam condenses due to heat loss from the pipe lines so that steam traps and other arrangements for the drainage of the condensate at several points are necessary. Also, the design restrictions for steam pipe lines will be restrictive to allow for the contours of the ground and prevent reverse flow of the condensate. In the case of the hot water system, although the water lines are required to be economically sized, there are requirements such as the grading of the pipe lines and making

provision for drainage etc. Hot water systems require considerable amounts of pumping energy however.

The steam condensate in the return lines, if return lines are used, is usually rich in oxygen and can corrode the pipe lines. If return lines are not used, there is some energy and water loss due to disposal of condensate.

H.W.C. Aamot and G. Phetteplace, in their analytical studies on the relative merits of hot water and steam for the long distance transmission of thermal energy have concluded that heat is transmitted more economically with hot water than with steam. Some of the European district heating engineers favor hot water for district heating. However, it has also been observed that when a good proportion of the thermal demand is in the form of industrial process steam, steam has an advantage in that the demand does not fluctuate as much with season of the year.

Components of the Thermal Distribution System:

- i) long distance transmission piping: This includes supply and return pipe lines and usually include consumer connections. The supply lines carry transport media water or steam at high pressure and temperature from the power plant to the sub-stations near the areas to be served. Return pipe lines carry low temperature water or steam condensate back to the power plant. The sub-stations may consist of storage reservoirs, pressure reducing apparatus, or booster pumps.
- ii) distribution piping: flow and return mains or branches connecting the sub-station and the consumers.
- iii) pipe trenches, conduits, tunnels, ducts in which the pipes are laid.
- iv) valves and fittings, expansion joints, pipe supports, insulation, etc.
- v) manholes, air vents, drains
- vi) pumps

THERMAL TRANSPORT MEDIA - SUPPLY CHARACTERISTICS

According to the information obtained from the Hanselman-Eskew Survey, a good percentage of end users have central warm-air systems and hot water systems and a small percentage of end users have steam and electric systems. This suggests that 'hot water to air' heat exchangers can be used in place of gas and oil furnaces. It has already been established that hot water is preferable to steam as a transport media. In places where steam heating systems exist, hot water at 250° F can be used to generate steam at approximately 5 psig by means of a steam converter at the end user location. Hot water can also be used as an energy source for absorption chillers for air conditioning.

Additionally, the lower temperature levels of the fluid streams in the heat exchangers would cause the efficiency of the heat transfer systems to be higher than those of the gas and oil furnaces.

WATER TEMPERATURE AND PRESSURE LEVELS:

In the selection of water temperatures, the following considerations apply.

- i.) Water temperature levels should be high enough to cope with space heating and domestic service hot water loads.
- ii.) They should allow for reasonable capital investment and thermal losses of the distribution system.
- iii.) The temperature levels should provide a reasonably good range for control, to allow for the variations in outside air temperature.
- iv.) Water temperature levels should allow for electricity generation from the cogeneration system without severe penalty to generating capacity.

Higher supply temperatures will allow smaller system flow rates and reduce capital costs, however, thermal losses from the distribution system will be increased. In addition, the static pressure level of the hot water system would be increased to prevent the water from flashing to steam.

In Swedish district heating practice, a supply water temperature of 248° F and a return water temperature of 158° F are commonly used.

In the case of the Piqua District heating scheme, water supply and return temperatures of 250° F and 150° F, respectively, were considered the most practical for preliminary design. These low temperatures result in reasonable thermal losses and operating pressures. Furthermore, the low supply temperature will allow us to use low temperature pre-insulated pipes with less expensive urethane insulation resulting in reduced investment costs.

4.7.2 PIPING SYSTEM ALTERNATIVES

The choice of a piping system to carry the transport media depends on the space heating and cooling requirements, the service hot water requirements, the transport media (hot water or steam), and on total cost considerations. In general, the type of transport media and the cost of transporting the energy determine the type of system to be used. There are four types of piping systems employed in district heating and cooling practice. They are:

- Single-pipe system
- Two-pipe system
- Three-pipe system
- Four-pipe system

The single pipe system consists of a supply line only and is commonly used when steam or high temperature water is the transport medium. Once media is used for the heat transfer process it is discharged by the end-user.

This system has an advantage in that its capital cost is lower compared to other systems due to the absence of the return line. Its main disadvantage is the energy loss associated with the discharge of relatively warm media or condensate. Energy losses in the range of 20-30% have been reported. The single pipe system has been used in the United States and in some European countries.

In two-pipe systems there is a supply line which carries either steam or hot water back to the central station. In the two-pipe steam system, the condensate return line is much smaller in diameter compared to the steam supply line. In two-pipe hot water system both the supply and return pipes are of equal size.

The advantage of the two-pipe system is the saving in energy due to the return of the warm transport medium. However, return piping involves additional capital investment.

In the three-pipe system, there is a smaller third pipe which is used for the supply of service hot water. The third pipe can also be used for space heating during periods of low demand. By this arrangement the main hot water supply pipe can be shut off during periods of low space heating demand resulting

in a reduction of the heat loss from the distribution network. This arrangement will also permit an increase in the electrical output of the cogeneration plant. Installation of the third pipe involves additional capital cost.

In the four-pipe system, two pipes are used for space heating and two pipes are used for the supply and return of service hot water. The four-pipe system can also be used where there is a need for both space heating and cooling, in which case, two pipes are used for space heating and service water needs and two pipes are used for the supply and return of chilled water. In cases where pure hot service water is supplied through the piping system for direct consumption, there is a saving in the cost of a separate heat exchanger for service water heating by the consumer. However, the main disadvantage of the four-pipe system is its additional capital cost and maintenance.

PIPING SYSTEM CHOICE

In the case of the City of Piqua, a study of the existing heating and cooling loads revealed that the cooling loads are very low. Also, from historical weather data, it was observed that the cooling loads last only for a short duration. On the basis of this information it was concluded that separate chilled water lines were not economically feasible. Further, it appears that the advantages of a three-pipe or four-pipe system that might be considered in new situations cannot be realized in the case of retrofitting an existing community system due to the increased costs of piping.

Therefore, a two-pipe hot water heating system was selected for our preliminary study and would provide heating media only. By using a separate heat exchanger at each consumer location, the main hot water supply can also provide domestic hot water needs. The hot water system may also serve as an energy source for absorption chillers for air conditioning where attractive.

Based on our study of the district heating schemes in the United States and Europe, the two-pipe system - a supply pipe and a return pipe - appears to be the most common distribution arrangement. The two-pipe arrangement with connections for space heating and domestic hot water supply is shown in Figure 4-17.

TWO PIPE DISTRICT HEATING SYSTEM SCHEMATIC

FIG. 4-17

PIPING SYSTEM CONFIGURATIONS

Piping system configurations are designed to minimize capital investment costs, the thermal losses from the piping network, and frictional losses due to flow of water, and the energy required for media pumping. In addition to these factors, allowance should be made for future increases in heating demand and for the expansion of the network since there will not be 100% penetration of the market in the initial stages of development. The energy delivered, the mass rate of flow of hot water, the diameter of the pipe, the velocity of water, the pumping energy and heat loss are related by the following equation:

$$Q = \dot{M} \cdot C \cdot (T_{\text{supply}} - T_{\text{return}}) \quad (1)$$

where Q = energy delivered to a particular zone or sub-zone to satisfy the heat load
 $\dot{M}$ = mass rate of flow of water
 C = specific heat of water
 and T = temperature of water

$$\dot{M} = \rho \cdot \frac{\pi D^2}{4} \bar{V} \quad (2)$$

where ρ = density of water
 D = diameter of pipe
 and $\bar{V}$ = velocity of water

$$E_{\text{pump}} = \dot{M} (H_f + H_L) \quad (3)$$

where H_f = head loss due to friction
 H_L = difference in static head

$$H_f = \frac{f L \bar{V}^2}{2gD} \quad (4)$$

where f = friction factor which depends on the relative roughness of pipe and Reynolds number (flow criteria)
 and L = length of pipe

The relationship between Q , $\dot{M}$, D and $\bar{V}$ and H_f are indicated in Figures 4-18, 4-19, 4-20.

HEAT LOSS

Heat loss from underground piping systems depend on the diameter of the pipe, the thickness and thermal conductivity of insulation, the depth of the insulated pipe, the thermal conductivity of soil, the depth of the insulated pipe from the ground surface and the surrounding ground temperature. For the case of single pipe buried underground, the heat loss is given by

$$q = K_p (T_w - T_g) \text{ Btu/hr}$$

FIG. 4-18

FIG. 4-19

MASS FLOW RATE vs THERMAL LOAD

$$\Delta T = T_{\text{SUPPLY}} - T_{\text{RETURN}}$$

FIG. 4-20

where T_W = water temperature °F
 T_g = ground temperature °F
 and K_p = heat transfer factor.

K_p is given by Reference

$$\frac{1}{K_p} = \left(\frac{1}{C}\right)_{\text{pipe}} + \frac{6 \text{ hr}}{\pi K_S} \left[\frac{d}{r} + \sqrt{\left(\frac{d}{r}\right)^2 - 1} \right]$$

where d = depth of the insulated pipe (conduit) from the ground surface, ft.

r = radius of the conduit, ft.

K_S = thermal conductivity of the soil, $\frac{\text{Btu-inch}}{\text{hrft}^2\text{F}}$

and $\left(\frac{1}{C}\right)_{\text{pipe}}$ = total resistance of the conduit, including the resistances of the outer jacket, insulation, pipe metal, inside film.

Since preinsulated pipes are available in a variety of configurations of insulation, air space, jacket etc., it is recommended that a certain quantity of heat loss, a percentage of the energy carried by the medium, be specified instead of the thickness of insulation. Usually the heat loss associated with a given preinsulated piping system is given by the manufacturer with reasonable accuracy.

PIPES AND INSULATION

Pipes and insulation used for the underground thermal distribution system will be required to conform to rigid specifications since failure can be costly in terms of repair or replacement. According to the case histories of heat distribution systems, the main cases of failure are pipe corrosion, leakage and failure of insulation. To avoid these problems the pipes should be corrosion resistant and should be capable of withstanding operating temperatures and pressures greater than will be encountered in normal service. They must also be cost effective.

In recent years, advances in the technology of underground distribution systems has resulted in the development and manufacture of preinsulated piping systems. These piping systems are fabricated in the factory with insulation

such as polyurethane, calcium silicate etc. and are provided with an outer protective jacket. The inside pipe carrying the working fluid is called the "carrier pipe". Carrier pipes are made of steel, copper, or poly vinyl chloride (PVC) etc. In our case steel is recommended for the carrier pipe.

These preinsulated piping systems are available in lengths of 20 ft, 40 ft or more. Since they eliminate the work for field insulation, they are less difficult to install than individual components and result in reduced installation time and costs.

Preinsulated piping systems are available in a variety of configurations, two of which are shown in Figure 4-21.

FIG. 4-21

PIPE INSTALLATION

For installation of underground piping systems the procedures recommended by manufacturers, Federal and local codes were consulted. In our study manufacturers such as Ric-will, Johns Manville Co., and Perma-Pipe were consulted extensively.

In the majority of cases, factory fabricated pre-insulated pipes can be

buried directly in trenches. The depth of the trench depends on the size of the pipe and the extent of the load on the overhead ground surface due to moving vehicles, structures, etc.

In the usual procedure a trench is excavated with bottom and sides sloped to prevent cave-in. Next, a bedding of loose fill is prepared for laying the pipes. After pipes are placed in the trench and joined by welding a partial backfill is made leaving the joints for inspection. Hydrostatic tests are then conducted at pressures greater than the expected operating pressures within the pipe.

After the hydrostatic test, the final backfill is made of selected earth tamped in 4" to 6" layers to a minimum of 12" over the top of the outer casing of the pipe. Backfilling is done simultaneously on both sides of the pipe to avoid damage due to unequal side pressures.

The remainder of the backfill should be free from large rock, foreign matter etc., and should be spread uniformly. A cross section of the pipe trench and backfill procedure is shown in Figure 4-22.

FIG. 4-22

Information on underground soil conditions is important to the installation and potential corrosion problems encountered with the thermal distribution system. Soil characteristics that are suitable for trench excavation and piping systems are good workability, gentle slopes, absence of rock, out crops and big stones, absence of flooding hazard and an absence of high seasonal water table. Other favorable soil characteristics include low corrosivity, low shrink-swell potential and good permeability.

A soil survey of Miami County, Ohio, conducted by the United States Department of Agriculture in cooperation with the Ohio Department of Natural Resources and the Ohio Agriculture Research and Development Center provides soil maps and some information on the engineering properties of soils pertaining to the City of Piqua. According to this survey, the soil series in many of the high thermal density areas appears to have favorable characteristics as shown in Table 4-2.

Since other varieties of soil are present in varying amount throughout the City, additional investigations will be necessary in Phase II of the program to determine potential problems in installation and maintenance of the piping system.

TABLE 4-2
SOIL PROPERTIES

SOIL SERIES	DEPTH TO SEASONAL HIGH WATER TABLE (FT)	DEPTH TO BED ROCK (FT)	DEPTH FROM SURFACE INCHES	USDA TEXTURE	PREMEABILITY INCHES/HOUR	SHRINK- SWELL POTENTIAL	CORROSIVITY TO STEEL	OTHER INFORMATION
Eldean	75	78	0-12	Loam Still Loam Gravelly Loam	0.6-2.0	Low	Low	Soils are well drained, near level to gently sloping
			12-23	Clay Clay loam	0.6-2.0	Moderate	High	
			23-30	Gravelly Clay loam	0.6-6.0	Low	Moderate	
			30-60	Stratifical sand and gravel	6-20.0	Low	Low	

4.7.3 PIPING DISTRIBUTION SYSTEM COST ESTIMATES

The most significant single cost component of the district heating system is the thermal distribution system. This component consists of trunk distribution piping, distribution mains and branches within each zone and run-outs from the distribution mains into the end-user buildings. The significance of the total distribution system cost is emphasized by European experience where distribution costs may range from 50 to 70 percent of total district heating utility capital costs.

In order to estimate total system costs in any given year the total distribution system was estimated in three components: 1) Trunk piping system, 2) Distribution and branch networks within a zone, and 3) Run-out piping from the distribution mains to the end-users. All piping system costs were estimated using a preinsulated direct buried piping system.

The installed cost of the piping system consisting of a pair of supply and return pipes includes the following items:

- Excavation costs
- Site removal of excavation materials
- Pipe bedding
- Pipe installation
- Backfilling
- Repairing and patching of streets
- Cost of preinsulated pipes

These costs may vary depending on the degree of difficulty with which these operations are performed and local situations. For our computations typical Piqua conditions with bituminous road surfaces were assumed.

Means Costs Data was used as a guide for the calculation procedure. To allow for unforeseen costs, 10% has been added to the actual computed cost. Costs of valves, fittings, manholes, etc., are excluded. These are considered separately in the cost calculation for thermal zones.

TABLE 4-3
TRUNK PIPING SYSTEM
PRIMARY LOOP DISTRIBUTION
INITIAL INSTALLATION

PIPE SIZE	LF ^①		COST/FT	TOTALS COST
8"	1,530	x	131.02	200,460
14"	2,300	x	224.95	517,385
18"	2,500	x	295.18	737,950
20"	1,410	x	325.71	459,250
24"	2,940	x	385.15	1,132,340
28"	3,530	x	467.42	<u>1,649,990</u>
TOTAL SYSTEM				\$4,697,375
10% ALLOWANCE FOR MANHOLES				<u>469,735</u>
TOTAL				\$5,167,110

① MEASURED ALONG CENTER LINE OF TRENCH (2 PIPES)

TABLE 4-4
TRUNK PIPING SYSTEM
PRIMARY LOOP DISTRIBUTION
YEAR 2000

<u>PIPE DIAMETER</u>	<u>L.F.</u> ^①		<u>COST/FT.</u>		<u>TOTAL COST</u>
4"	2,350	x	68.67	=	161,375
6"	9,120	x	100.14	=	913,275
8"	3,095	x	131.02	=	405,505
10"	10,295	x	166.64	=	1,715,555
12"	19,700	x	186.01	=	3,664,395
14"	10,295	x	224.95	=	2,315,860
16"	2,420	x	231.31	=	559,770
18"	7,060	x	295.18	=	2,083,970
20"	1,410	x	325.71	=	459,250
24"	2,940	x	385.15	=	1,132,340
28"	3,530	x	467.42	=	<u>1,649,990</u>
TOTAL SYSTEM					\$15,061,290
ALLOWANCE FOR MANHOLES & VALVES (10%)					= <u>1,506,129</u>
TOTAL					= \$16,567,419

^① MEASURED ALONG CENTER LINE OF TRENCH (2 PIPES)

The piping distribution mains and branches within each zone were too extensive to be estimated on an assumed design. In order to evaluate zone costs, a series of models were used which are dependent on the number of district heating system subscribers within a unit area and the thermal demand of those subscribers.

In these models, structures of floor areas and characteristics similar to those used in the zone load estimates were assumed. Corresponding land areas for 4, 8, 16, and 64 structures were used. Approximate lengths for the sub-mains, branches and connections were estimated along with pipe diameters needed to deliver the assumed quantity of thermal energy for design heat loads. The procedure for estimating lengths of piping illustrated with reference to Figure 4-2 3.

The number of structures and their associated areas are as follows:

<u>Number of Structures</u>	<u>Included Area</u>	<u>Land Area (Acres)</u>
4	A	1.15
8	A+B	2.29
16	A+B+C+D	4.57
64	ENTIRE AREA OF MODEL	18.30

SAMPLE OF PIPE LENGTH

Pipe system lengths for 4 structures;

Sub-mains (a) = 222'

Branches (b) = 126'

Connections (c) = 32'

The same procedure was repeated for 8, 16 and 64 structures. The pipe sizes were chosen to deliver the quantity of district heating system supply water to satisfy the design heat loads appropriate for the type and number of structures. Based on these lengths and diameters, pipe system costs were estimated using the unit costs previously determined. It was assumed that pipe fittings, valves, manholes etc., would cost approximately 10% of the installed pipe costs. The costs of the main trunk pipe systems are not included since they were considered separately.

Buildings for commercial and mixed use located in downtown areas do not usually have the surrounding land area associated with residential structures, however, some buildings may have parking areas connected with their businesses. For purposes of estimating the thermal density, an additional 30% of the projected floor area occupied by the buildings is used for the surrounding land area. Referring to Figure 4-23, the following pipe lengths are assumed for this configuration.

For 4 structures (A):

mains (a)	160'
branches (b)	120'
connections (c) =	32'

The number of structures greater than 16 were not considered since building patterns in downtown areas are not homogeneous to that extent.

The third component of the distribution system cost is the run of piping from the street main into the end-user's premises and building. This cost was estimated at an average of \$2,060 per connection point and determined on an annual basis by the number of end-users connected to the system. Metering costs are included in this cost estimate.

Figure 4-24 is a schematic of the typical piping connection and metering arrangement.

A summary of annual distribution costs is presented as Table 4-5.

FIG. 4-23

TYPICAL METER
AND
SERVICE INSTALLATION

FIG. 4-24

TABLE 4-5
DISTRIBUTION SYSTEM COSTS

<u>YEAR</u>	<u>TRUNK LINES</u>	<u>ZONE DISTRIBUTION</u>	<u>RUN-OUTS & METERING</u>
1983	\$5,165,000	\$1,632,580	\$1,159,780
1984	670,580	143,000	166,860
1985	670,580	147,000	168,920
1986	670,580	4,165,800	3,075,580
1987	670,580	3,665,800	1,701,560
1988	670,580	2,576,890	2,039,400
1989	670,580	888,030	484,100
1990	670,580	869,030	488,220
1991	670,580	1,547,200	1,470,840
1992	670,580	959,940	510,880
1993	670,580	3,933,460	2,704,780
1994	670,580	1,220,290	589,160
1995	670,580	1,220,290	597,400
1996	670,580	1,210,290	587,100
1997	670,580	1,217,290	599,460
1998	670,580	1,218,290	587,100
1999	670,580	1,210,290	603,580
2000	<u>670,580</u>	<u>1,210,290</u>	<u>591,220</u>
TOTAL	\$16,564,860	\$29,035,760	\$18,125,940

TOTAL ULTIMATE PIPING NETWORK COST - YEAR 2000

INSTALLED PIPE COSTS

Installed pipe costs may vary depending on the degree of difficulty with which the operations of excavation, trenching etc., can be performed. Exact costs can be obtained only from contractors and by the examinations of site specific conditions. In our computations rural conditions are assumed and the following cost items were considered.

- Site removal
- Excavation
- Pipe bedding
- Back-filling
- Installation
- Pairing and patching
- cost of pair of pre-insulated pipes

The costs of valves, fittings, manholes etc., are not included. They are considered separately in the cost calculation of pipe systems. Means Cost Data (1979) was used as a guide for our computations.

COST OF PIPING SYSTEM:

The cost of the piping system consisting of a pair of pipes - supply and return - includes the following items:

- Site removal
- Excavation costs
- Pipe bedding
- Pipe installation
- Backfilling
- Pairing and patching
- Cost of pre-insulated pipes

These costs may vary depending on the degree of difficulty with which these operations can be performed and on the local situation. For our computations rural conditions and bituminous road surfaces are assumed.

SAMPLE CALCULATION PROCEDURE: per linear foot of system (2 pipes)

PIPE SIZE = 1 1/2"

JACKET SIZE = 4"

CY = Trench Volume, cubic yards

SY = Surface area for site removal, patching and paving, square yards

CY = $(4 \times 2.25 \times 1)/27$

= 0.333

SY = $(2.25 \times 1)/9$

= 0.25

EXCAVATION COSTS = \$2.58/CY, Volume = 0.333 CY

PIPE BEDDING = \$5.45/CY, Volume = $\frac{2.25 \times .5}{27} = 0.152$ CY

BACKFILLING = \$11.25/CY, Volume = $(.333 - .152) = 0.181$ CY

SITE REMOVAL = \$1.65/ SY, Surface Area = 0.25 SY

PATCHING & PAVING = \$6.40/ SY, Surface Area = 0.25 SY

PIPE INSTALLATION = From Means Cost Data

PIPE COSTS = From manufacturers (see separate table)

Using these rates, the appropriate volumes and surface, the breakdown of costs are as follows:

Excavation $(2.58 \times .333)$ = \$0.86

Pipe Bedding $(5.45 \times .152)$ = \$0.83

Backfilling $(11.25 \times .181)$ = \$2.04

Site Removal $(1.65 \times .25)$ = \$0.41

Patching & Paving $(6.40 \times .25)$ = \$1.60

Pipe Installation (5.61×2) = \$11.22

2 Preinsulated Pipes (8.95×2) = \$17.90

\$34.86

Add 10%, 3.48

Cost of piping system of 2
pipes per foot length \$38.34

Costs for each pipe size were arrived at in a similar manner for other pipe sizes and are presented in detail in Appendix. Individual pipe costs are presented in Table 4-6. The pipe system costs used are shown in Table 4-7.

TABLE 4-6
COST OF STEEL PIPE WITH INSULATION

<u>NOMINAL PIPE SIZE</u>	<u>INSULATION THICKNESS</u>	<u>COST/FT</u>	<u>JACKET O.D.</u>
1"	1.03"	\$6.88	3"
1¼"	1.11"	\$7.65	3½"
1½"	1.00"	\$8.22	3¾"
2"	1.00"	\$7.52	4"
2½"	1.00"	\$9.45	4½"
3"	1.00"	\$11.03	5"
4"	1.16"	\$15.75	8"
5"	1.22"	\$18.36	8"
6"	1.70"	\$23.12	10"
8"	1.70"	\$32.93	12"
10"	1.65"	\$42.83	14"
12"O.D.	1.50"	\$50.96	16"
14"O.D.	2.03"	\$62.90	18"
16"O.D.	2.50"	\$72.47	21"
18"O.D.	2.33"	\$83.00	21"
20"O.D.	2.00"	\$90.00	24"
24"O.D.	2.00"	\$106.50	28"
28"	2.00"	\$135.00	33"

TABLE 4-7
APPROXIMATE INSTALLED PIPING COSTS*
(TWO-PIPE SYSTEM)

PIPE DIAMETER (INCHES)	INSTALLED COST TWO-PIPE SYSTEM (\$/FT)
1½"	38.35
2"	38.31
2½"	44.71
3"	51.26
4"	68.41
5"	81.51
6"	99.75
8"	131.02
10"	166.64
12"	186.01
14"	224.95
16"	231.31
18"	295.18
20"	325.71
24"	385.15
28"	467.42

*Cost includes site removal, excavation, pipe bedding, back-fill, patching and paving, installation.

- ASSUMPTIONS -
- 1) Bituminous roads
 - 2) Valves and fittings, and related labor costs are not included.
 - 3) City conditions for labor and actual situations are not considered.
 - 4) Means Data (1979) is used as a guide.
 - 5) Pipe costs have been averaged, although there might be slight differences in pipe quality, manufacturers, specifications etc.
 - 6) Work sheets show configurations

DETERMINATION OF INITIAL SERVICE AREA AND ESTIMATION OF SYSTEM GROWTH

For the district heating system to be successful both technically and financially it was anticipated that the initial service area needed to be composed of those zones providing the greatest thermal energy load per unit area. In that manner, thermal energy supplied to end-users could be made more cost effective by low initial investment in a piping distribution system.

It was also anticipated that the higher density zones would prove the system more favorable and that the positive impact of success in those zones would promote other subscribers to district heating in the immediate future. In essence, the initial service zones were chosen so that the system would have the best possible chances of economic success.

Table 4-8 is a summary of the zones chosen for initial inclusion in the service area. The table presents those zones included in the initial service area, their ultimate thermal loads per acre and the initial thermal loads based on the penetration factor determined from the Hanselman-Eskew survey.

TABLE 4-8

ZONE	NO. OF UNITS	ADJUSTED NO. OF UNITS	HEATING PENET FACT	COOLING PENET FACT	TOTAL AREA	TOTAL ADJ. AREA	TOTAL HEATING	TOTAL COOLING	ADJUSTED TOTAL HEATING	ADJUSTED TOTAL COOLING
2-P	123	59.0	.400	.400	.109E+07	.525E+06	.122452E+09	.266970E+06	.587771E+08	.126146E+06
8-P	423	232.7	.550	.550	.257E+07	.141E+07	.191278E+09	.398543E+08	.115202E+09	.219198E+08
9-P	286	143.0	.500	.500	.425E+06	.212E+06	.266297E+08	.447051E+07	.133149E+08	.223528E+07
18-P	33	10.7	.400	.400	.410E+06	.197E+06	.52395E+08	.410495E+06	.217150E+08	.196846E+06
12-P	402	327.4	.600	.600	.938E+06	.638E+06	.580730E+08	.469315E+07	.394896E+08	.659134E+07
14-P	10	18.0	1.000	1.000	.707E+05	.707E+05	.615036E+07	.127770E+07	.615036E+07	.127776E+07
15-P	1	1.0	1.000	1.000	.219E+05	.219E+05	.17550E+07	.347608E+06	.17550E+07	.347608E+06
16-P	6	3.3	.550	.550	.671E+05	.369E+05	.565199E+07	.118276E+07	.311974E+07	.650519E+06
17-P	1	1.0	1.000	1.000	.439E+05	.439E+05	.332658E+07	.696058E+06	.332658E+07	.696058E+06
18-P	9	4.3	.400	.400	.174E+06	.833E+05	.195172E+08	.936827E+07	.936827E+07	0.
24-P	1	1.0	1.000	1.000	.107E+05	.107E+05	.860467E+06	.170444E+06	.860467E+06	.170444E+06
25-P	1	1.0	1.000	1.000	.142E+06	.142E+06	.101588E+08	.224938E+07	.101588E+08	.224938E+07
52-P	1	1.0	1.000	1.000	.474E+05	.474E+05	.360888E+07	.753000E+06	.360888E+07	.753000E+06

In the initial service area, the significant milestone which must be reached is the installation of the first major trunk distribution piping main from the power plant to a point on the north side of the city adjacent to the Miami River. The terminal point of this line was deemed a pivot point from which the distribution system could be expanded to meet additional loads and respond to the market for thermal energy. This pivot point becomes the key from which future distribution mains and transmission lines are extended.

Once the initial service area is constructed and in operation it is anticipated that the thermal transport system would be installed and expanded in response to the market for thermal energy. Table C-1 in the Appendix is a listing by year and by zone of the anticipated expansion of the distribution system to serve the expanding thermal market. This scheme was developed by adding zones in a logical manner to pick up increased thermal load and to follow expected building growth due to economic expansion. The units given are number of subscribers. Table C-2 in Appendix is the expected thermal space heating load by zone and year which was developed in a similar manner to Table 4-8. Figure 4-25 is an illustration of the initial piping system main trunk lines which will be installed to serve the initial service zones. It is important to note that the lines are oversized for the current thermal loads in anticipation of future expansion.

Figure 4-26 , is a map of the ultimate service area of the district heating system which will be serviced from the Piqua Plant. Once the system concept is proven by serving the initial markets it is anticipated that the trunk distribution system and interconnecting community piping will be expanded over the growth period to meet market demands. As is the normal practice with thermal distribution networks, the growth of the system will allow for interconnection and looping which will provide greater system reliability and lower pumping costs due to decreased frictional losses. Figure 4-27 is a map of the projected trunk piping system serving the ultimate district heating system. Appropriate line sizes and interconnection points are shown to illustrate the network's reliability should one segment of the system be incapacitated and need to be taken out of service for repair.

FIG. 4-25
CITY OF PIQUA
DISTRICT HEATING SYSTEM
PROPOSED DISTRIBUTION MAIN LAYOUT

NORTH

INITIAL DISTRIBUTION

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO. EM-78-C-02-4978

TEAM MEMBERS CITY OF PIQUA OHIO

GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESKEW AND ASSOCIATES

THERMAL ZONES

CITY OF PIQUA & SURROUNDING
COMMUNITY

SHEET

OF

	DATE
DRAWN	1-8-78
CH'D	1-9-78
APPR'D	

Figure 4-26

CITY OF PIQUA

MIAMI COUNTY

OHIO

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

PREPARED FOR DEPARTMENT OF ENERGY - CONTRACT NO EM-78-C-02-4976

TEAM MEMBERS CITY OF PIQUA, OHIO
GEORGIA INSTITUTE OF TECHNOLOGY - ENGINEERING EXPERIMENT STATION
HANSELMAN-ESKEW AND ASSOCIATES

TRUNK PIPING SYSTEM

THERMAL DISTRIBUTION NETWORK
YEAR 2000

SHEET

OF

Figure 4-27

4.7.4 INTERFACE WITH END-USER

In order to interface the district heating system with the typical end-users in the service area a general retrofit and connection criteria was developed.

A criteria for the design and operation of building systems connected to the district heating system is required in order to obtain maximum utility from the district heating system, minimize overall costs, and provide for the safety of building occupants. These criteria are as follows: 1) District heating water media will not be consumed directly by end-users. Energy from the district heating system will be exchanged on the end-users' premises through a water-to-water heat exchanger. The end-user will then be able to utilize energy from the district heating system for space heating or domestic water heating. Indirect use of the district heating system media in this manner minimizes exposure by building occupants to the high temperature and high pressure characteristics of the district heating system, minimizes the possibility of contamination of the district heating system media by end-users, and allows building systems to use lower cost materials for building heating components than would be used with the higher temperature and pressure district heating water. 2) Sufficient pressure differential will be provided between the district heating mains to force water through a reasonable series of valves, metering devices, heat exchangers, and associated equipment without the need for additional pumping. No secondary pumping of distribution system water will be allowed unless specific permission is given by the district heating system operator. This regulation will prevent hydraulic imbalance situations which can occur in small distribution mains with primary-secondary pumping situations. 3) The water returned from building systems to the district heating system must be a minimum of 80°F cooler than supply water temperature. At design heating conditions, this temperature differential should be 100°F. Special allowances will be made for those individuals generating low pressure steam used in the building system, however, an additional charge may be made for those systems. This criteria will provide for maximum heat transfer by the distribution system at a minimum first cost for piping. 4) Double wall heat exchangers will be required between domestic hot water and district heating system water. This criteria will ensure the maximum protection against contamination of potable water by the district heating system. In addition, every effort will be made by the district

heating system operators to use chemicals for treating district heating system water which will not present extreme health hazards to the public should some cross contamination occur. 5) Building systems will generally comply with local heating and air conditioning codes with respect to safety and performance.

RESIDENTIAL SYSTEMS

Residential space heating and domestic water heating systems present the most straightforward and simple application of district heating energy. It is unfortunate, however, that in the United States, lack of market for residential heating systems utilizing district heating media as the energy source has made domestic commercial equipment of this type virtually non-existent. However, numerous brands of equipment are available from European sources.

It should be noted that the several domestic manufacturers who were contacted were willing to supply packaged type equipment if a market were demonstrated. It is also felt that there are small manufacturing companies that would be willing to produce limited runs of district heating system packages for demonstration communities. Additionally, there is the possibility of using slightly modified versions of home heating systems designed and manufactured by the solar heating industry.

Figure 4-28 is a schematic of equipment and piping that would typically be desirable for residential application in new construction. The system is essentially comprised of a packaged heat exchanger assembly. Installation would be accomplished by a mechanic or plumber who would make necessary field connections to the district heating system and to the building heating system. Installation would be no more complex than a similar installation of a conventional, natural gas or oil fired furnace and associated air conditioning system. It is anticipated that the desire for central air conditioning in most new residences will dictate that the building heating system be of the forced air type suitable for central cooling applications. European experience, on the other hand, tends to favor a radiator or convector type system within the home without the use of forced air. Figure 4-29 is an illustration of what the homeowner might expect a typical system to look like from connection point to end-user.

From an operational standpoint, the district heating system user would

TYPICAL PIPING SCHEMATIC
RESIDENCE & SMALL BUSINESS

FIG. 4-28

TYPICAL RESIDENTIAL
INSTALLATION

FIG. 4-29

still control his heating and cooling system from a space mounted thermostat with "on-off" and "heat-cool" selector sub-base. The only significant difference between conventional gas or electric home heating system and the district heating system might be a longer fan cycle time during cold periods due to district heating system unit capacity being closer to the actual design load and is less likely to be oversized than conventional heating units.

RESIDENTIAL RETROFIT

For residential systems it is anticipated that both the space heating system and domestic water heating system will be retrofitted to use district heating system energy. Connection to the district heating system will be made with standard piping to a packaged heat exchanger/pump/control unit. This unit will be the same type as would be used for new systems and will be of a size adequate to provide for the building's space heating and domestic water heating requirements.

DOMESTIC WATER SYSTEM RETROFIT

It is apparent that the retrofit of existing domestic water heating systems will be relatively simple to accomplish since the district heating system heat exchanger and small circulating pump may be directly connected to the existing hot water piping system. The existing hot water storage tank would be used for hot water storage. Current energy supply to the existing hot water storage heater could be disconnected without additional capital expense. No other functional problems are anticipated once the district heating system is connected to the existing hot water system and placed in operation (Figure 4-30). Flue connections in the case of natural gas water heaters should be capped and insulated to prevent additional heat loss from the water heater storage tank. Also the vent flue to the outside of the building should be capped so that warm air is not lost from the building interior. Circulating piping from the district heating heat exchanger to the storage tank should be insulated to prevent excessive heat loss.

HEATING SYSTEM RETROFIT

Residential heating systems will be somewhat more difficult to retrofit because of their varied nature and design. In general, it is anticipated that

DOMESTIC WATER HEATER
CONVERSION
FIG. 4-30

four conditions will be encountered in the majority of cases. These conditions are as follows: 1) the existing heating system will consist of low pressure steam radiators or convectors throughout the house. 2) there will be an existing forced air heating system with or without central air conditioning 3) there will be a warm air heating system utilizing natural convection for heating of building rooms 4) the house will be heated on a room-by-room basis from electric baseboard heat, electric radiant heaters, natural gas space heaters, or some other form of room-by-room heat. A brief discussion of the retrofit procedure for each of these categories is outlined in the following sections.

ROOM-BY-ROOM HEATING SYSTEMS

The most difficult type of system to retrofit will be the room-by-room heating system approach. In general, a completely new heating system will be required for this type of application. A determination will have to be made depending on the specific case as to whether the new heating system should be of the forced air type or radiator type in each individual room. From a functional standpoint the use of a forced air system would actually upgrade the capability of the residence heating system since a forced air system would have the potential to add air conditioning at some future time. Interestingly enough, the forced air system type of retrofit may be the most cost effective in most cases.

STEAM SYSTEM RETROFIT

Existing residential steam systems will be of the low pressure variety utilizing room radiators or convectors to satisfy heating requirements. Since these systems cannot be directly retrofitted to use hot water it will be necessary to use a hot water to steam converter instead of a district heating system water-to-water heat exchanger. It is anticipated that this system will not be encountered to any great degree and it will be the exception rather than the rule to the retrofit case. The major disadvantage of this type of system is that the leaving water temperature from the steam to water converter cannot be lower than the saturation temperature of the steam produced. This will cause the return water temperature to the district heating system to be higher than normal even though domestic hot water needs can be satisfied from the water leaving the water to steam converter. It is this type of case that

must be handled individually as an exception to the district heating system connection criteria.

The conversion of this type of system will not appreciably upgrade the homeowner's heating system. Central air conditioning is not an option when this system is considered. The homeowner will, however, gain the advantage of reduced maintenance costs since he will not longer have to care for a steam boiler system. It is also anticipated that most systems of this type which are encountered in Piqua will be at least 15 years old and nearing the end of their depreciable life span. This is viewed as an advantage for the district heating system since the typical homeowner can expect to replace his boiler system in a relatively short time in any event.

FORCED AIR SYSTEMS

Forced air heating systems represent the majority of the homeowners surveyed in Piqua. The forced air heating system also presents one of the most attractive retrofit situations. An illustration of the typical forced air heating system is presented in Figure 4-31. As with other systems, a district heating system to building hot water system heat exchanger package is used as the interface with the district heating system. Heat transfer to the air used for space conditioning is accomplished by the addition of a hot water coil in the supply air duct work. When the retrofit is accomplished, the existing energy supply for heating, either electric or natural gas or oil, is simply disconnected and all existing fan and control systems remain as currently installed.

Two major obstacles are presented with a forced air system retrofit. The most obvious obstacle is the modification of ducting systems to accept a hot water coil from the new district heating system. Numerous types of hot water coils are available in many standard sizes. These coils are composed of copper tubes with aluminum fin sections encased in a galvanized steel housing. Figure 4-32 is an illustration of typical hot water heating coil retrofit installation. The coils may be purchased for slip-in type installation which will be preferable in most cases or for flange-type installation which may be necessary for duct transitions.

Except where severe space limitations exist, the modification of ducting systems to accept hot water coils is a problem routinely experienced by the

TYPICAL FORCED AIR FURNACE INSTALLATION

FIG. 4-3I

TYPICAL FORCED AIR FURNACE RETROFIT

FIG. 4-32

heating and air conditioning industry. Standard sheet metal transition procedures as recommended by the Sheet Metal Contractors Association (SMACNA) may be used in the installation of the district heating hot water coils.

The second major problem which will be incurred in the retrofit of forced air heating systems will be the additional air pressure drop caused by the inclusion of the hot water coil in the supply air duct work. Residential warm air heating systems typically operate at static pressures below .50 inches W.C. Any significant increase in pressure drop in the duct system will result in a severe air flow limitation. The severity of pressure drop limitations will, of course, need to be evaluated on a case by case basis.

Typically, the solution to the air flow problem may be approached in one of three manners. First, existing damper systems may be opened to reduce down stream restrictions and other pressure drop components in the air system. In all but a few cases this will probably not be sufficient to overcome the additional pressure drop of the new coil. Second, the existing electric coil or gas heat exchanger in the warm furnace may be removed to increase available static pressure in the system. Again, this may prove to be difficult since warm air furnace assemblies are not usually designed for complete removal of the heat exchanger of the furnace. In the case of electric heating systems, this option may prove helpful and actually increase available static pressure. Third, the existing fan assembly may be modified or replaced to provide additional static pressure capability for the newly installed heating coil. In the case of direct drive fans an additional motor speed tap may be available for this purpose. This will be especially true on systems having central air conditioning which normally have multiple speed motors which use the lowest speed for the heating season. Belt drive fans may be modified by sheave changes which will produce higher RPM's. All these modifications will be limited by the horsepower available from the attending motor. In some cases a complete motor change may be necessary. In order to evaluate the effects of a coil addition and determine the required coil size for a given heating capacity, Figure 4-33 and 4-34 were developed. In Phase II, these charts will be expanded to aid retrofit contractors.

GRAVITY TYPE WARM AIR HEATING SYSTEMS

A very difficult system to retrofit occurs when the building heating system

FIG. 4-33

AIR SIDE PRESSURE DROP
8 Fins

FIG. 4-34

is of the gravity warm air type, Figure 4-35. It is generally felt that a hot water heating coil placed in this type of heating system will not provide sufficient temperature differential to produce warm air circulation by natural convection. For this reason some type of forced air mechanism must be added. In some cases it will be possible to simply add a fan assembly to the existing duct system and add a hot water coil similar to those used to convert forced air heating systems. In most cases, however it is anticipated that the existing furnace assembly will be removed and a new fan coil assembly will be used to replace it. Fan coil units, Figure 4-36 are available in a variety of capacities and include a coil and fan in a steel casing assembly. This type of modification will require the installation of duct transitions, a new fan-coil assembly, and associated piping and heat exchangers. It is not anticipated in our cost estimates that these types of systems will be upgraded by the installation of duct insulation or special registers which would allow for the inclusion of central air conditioning. This possibility does exist however. Figure 4-37 is an illustration of how such a retrofit would be accomplished.

TYPICAL GRAVITY TYPE WARM AIR FURNACE
INSTALLATION

FIG. 4-35

FAN-COIL UNIT
FIG. 4-36

TYPICAL GRAVITY TYPE WARM AIR FURNACE
REPLACEMENT
FIG. 4-37

COMMERICAL BUILDING SYSTEMS RETROFIT

The commercial sector uses the most varied types of in-building systems than either residential or industrial users. Types of in-building heating, ventilating and air conditioning systems vary widely in commercial establishments depending on age, size and usage. Typical systems encountered in the Hanselman-Eskew survey include central steam systems, central hot water systems, gas and electric forced air systems, gas and electric space heaters, and self contained roof mounted equipment.

A thorough description of retrofitting each of the various types of system which will be encountered will not be pursued in this report. It is an accurate statement, however, that those systems utilizing circulating hot water systems will be the least difficult to retrofit and those making use of room by room space heaters will be the most difficult to retrofit.

In some cases it may be advantageous to retain an existing low pressure steam heating system by using a water to steam converter in place of a district heating system heat exchanger, Figure 4-38. As with the residential applications, the use of this type of system will be evaluated on a case by case basis and generally allowed where the distribution network can supply adequate energy at the reduced temperature differentials required.

Figure 4-39 is a schematic of a typical commercial building heating system with several types of in-building systems which utilize district heating system energy. Except in the case of commercial kitchens and laundries the typical domestic water heating load will be somewhat less for commercial establishments than for typical residential establishments.

INDUSTRIAL HEATING SYSTEMS

Industrial space heating systems were generally found to be of the steam or natural gas direct fired unit heater type. This type of system is comprised of individual unit heating assemblies located in the ceiling area of industrial spaces. In the case of direct fired unit heater assemblies gas piping is brought to the unit and then used in a combustion chamber/heat exchanger similar to that found in residential furnaces. A small propeller type fan forces space air through the heat exchanger to provide heating for the industrial space. Steam unit heater assemblies have a steam heating coil

STEAM GENERATOR

FIG. 4-38

LARGE COMMERCIAL OR INSTITUTIONAL BUILDING
PIPING SCHEMATIC

FIG. 4-39

which is connected to the in-plant distribution main and steam condensate is returned via the condensate return system. A similar propeller type fan forces air through the steam coil to provide heating for the industrial building space. Neither of these systems is considered a candidate for direct retrofit and use of district heating system energy.

In both cases it will be necessary to replace the existing unit heater systems with hot water type unit heater assemblies designed for use with hot water circulating piping systems. Some salvage value would be obtainable from the removed unit heating assemblies. Figure 4-40 illustrates the various unit heating assemblies and a corresponding hot water type unit heater. Heat exchanger connection to the district heating system will be similar to that for commercial and residential buildings.

Industrial plants having both air conditioning and heating and office areas similar to those found in commercial buildings would be treated in a manner similar to the commercial sector. Obviously, the most difficult retrofit situation occurs in large industrial plants utilizing roof mounted heating and air conditioning equipment. This type of equipment would be retrofitted by the addition of hot water heating coils, or a supplemental heating system installed in the space utilizing hot water unit heaters. Situations requiring radiant heating for personnel comfort would not be retrofitted since district heating system temperatures are not sufficient for radiant type heating.

Domestic hot water heating may be accomplished by an in-line heat exchanger system or by a district heating system coil bundle in a storage type heater. No significant difference between industrial type systems and commercial systems is realized.

INDUSTRIAL PROCESS LOADS

The preliminary feasibility analysis did not consider extensive connection of industrial process loads. It was felt however, that the majority of Piqua's industrial facilities could meet a substantial portion of their energy needs with the district heating system. These needs are primarily space heating and water make-up heating. Some process loads such as water and tank heating for the textile and electroplating industries could be met directly from the district heating system energy. With

FIG. 4-40
INDUSTRIAL PLANT
UNIT HEATER CONFIGURATIONS

significant retrofit expense in the plants, clean medium temperature air streams could also be provided for such needs as drying and textile finishing.

The desirability of providing higher water temperature was also explored in several industrial sector meetings. The decision was made that should the industrial process need be significantly concentrated and sufficient commitment obtainable from the industrial community, a peaking type boiler system and secondary piping loop could be established to meet an industrial park's high temperature needs. This type of system could generate water supply temperatures in the order of 400°F for use by industrial plants in the production of medium pressure steam or other higher temperature process needs. The actual implementation of such a scheme would depend upon the timeliness and degree of industrial commitment obtainable at the time district heating distribution systems were installed.

UPGRADING OF EXISTING SYSTEMS

An interesting tendency in the retrofitting of establishments for the use of district heating will be the tendency toward upgrading the quality of existing heating systems when retrofit is accomplished. This will especially be true for those systems requiring modifications of the heating system beyond the water-to-air heat exchange point. In systems where fan coil units and duct work are installed there should be a significant tendency to add central air conditioning at the time the heating system is installed.

The addition of central air conditioning would not have been possible without the accompanying duct and fan system as in the case of a replacement of a steam radiator system or room by room radiant heating system. At the same time duct work and heating system components are installed it may be advantageous to refurbish surrounding areas by painting or adding interior furnishings such as lighting or suspended ceiling systems.

The net effect is that at an extremely small cost differential over the base heating system renovation, substantial additional value is gained through the addition of central air conditioning and modernization of building

spaces. However, this benefit is not quantifiable in a cost of retrofitting existing building systems.

USE OF ABSORPTION AIR CONDITIONING

Significant potential exists for the use of absorption type air conditioning systems supplied with energy from the district heating system. This will be attractive for larger commercial establishments and institutional buildings having chilled water air conditioning systems already. Retrofit of chilled water type air conditioning systems should be relatively simple since existing water chilling equipment would be replaced by an absorption water chiller. In most cases, existing pumps and auxiliary equipment may be utilized with the new absorption type water chiller.

Operation of the absorption type air conditioning equipment will allow the building user-owner to pipe district heating water directly into an absorption type machine. Return water from the absorption machine could then be circulated through domestic water heating equipment in a similar fashion to the district heating system water-to-water heat exchanger. Figure 4-41 is a schematic of the piping required for this type of air conditioning system load.

From an energy balance standpoint it is desirable that new air conditioning loads be served with absorption type equipment from the central district heating system. By adding new air conditioning demand in the form of heat required for absorption equipment it is possible to continue generation of electricity for existing air conditioning equipment at peak air conditioning load demand by absorption equipment.

It is worthy to note that one of the considerations in the selection of the maximum supply water temperature for the district heating system was the availability of standard hot water fired absorption machines. Materials limitations for standard construction machines generally limit entering water temperature to 250°F. Temperatures above this range require hot water mixing using tempering valves or special construction.

BUILDING SYSTEM COST ESTIMATES

To aid in estimating retrofit costs of building systems during the study period several hypothetical cases were configured for each type

FIG. 4-41
ABSORPTION TYPE WATER
CHILLING UNIT USED WITH
DISTRICT SYSTEM

of commercial, residential, and industrial retrofit situation that would be encountered. Cost estimates for these building types were generated and then applied to the proposed district heating service area during each year of the study period. A brief description of the retrofit configuration and cost estimate for each situation is presented in Appendix C.

Table 4-9 is a summary of the unit cost figures generated by this procedure. Figures were obtained from equipment suppliers and the Means Mechanical and Electrical Cost Data for 1979.

The methodology used in applying the various cost estimates to the zone by zone analysis and ultimate district heating service area was to determine an average cost per unit for retrofitting each of the residential, commercial and industrial sectors in each zone and to apply this weighted average cost to the units within that zone.

TABLE 4-9
BUILDING RETROFIT COSTS
\$ PER 1000 BTU
PEAK LOAD

	<u>TYPICAL COST</u>	<u>MAXIMUM COST</u>
RESIDENTIAL	\$51.14	\$95.65
SMALL COMMERCIAL	\$33.35	\$53.05
LARGE COMMERCIAL	\$23.30	\$40.95
INDUSTRIAL	\$26.95	-

4.8. THERMAL STORAGE OPTION

Energy can be stored in thermal storage tanks during periods of low thermal demand or electrical demand using hot water, and the stored energy can be supplied to the community during peak demand periods. Thermal storage will, therefore, allow effective use of the cogeneration system. Thermal storage tanks and hot water boilers have been used to meet peak thermal demands in several cogeneration schemes. These peaking units can, therefore, reduce the capacity of the cogeneration unit and hence, a reduction in capital investment associated with turbogenerator units. In this preliminary study, the thermal storage tank and the heat only hot water boiler are analyzed with respect to their costs.

For purposes of our study, a thermal storage tank that can store and deliver thermal energy at the rate of approximately 17×10^6 BTU/hr (5 MW) for 4 hours will be considered. A hot water boiler that will serve the same purpose will be compared.

The details of calculations for heat loss, pumping energy, costs, etc., are shown in Appendix

THERMAL STORAGE TANK

- Hot water supply temp. = 250° F
- Hot water return temp. = 100° F
- Heat demand = 12×10^6 BTUH
- $17 \times 10^6 = \dot{m} C_p (T_{\text{supply}} - T_{\text{return}})$
- where C_p = Specific heat of water = $1.0 \text{ BTU/lb}_m \text{ }^{\circ}\text{F}$
- $\dot{m}$ = mass rate of flow of hot water lb_m/hr
- $\dot{m} = 17 \times 10^4 \text{ lb}_m/\text{hr}$
- Mass of hot water storage to supply energy for 4 hours =
 $68 \times 10^4 \text{ lb}_m$

Tank size and structure (Figure 4-42)

- Tank shape: spherical tank
- Tank volume = 13,400 ft³ (approximately 100,000 gals.)
- Diameter = 29.46 ft
- Surface area = 2727 ft²
- Mass of water at 250° F = 68 X 10⁴ lb_m (when tank is filled to approximately 86% of its capacity)
- Thickness of insulation (Fiber glass) = 4"

For this structure, the overall heat transfer coefficient based on outside surface area U_o is calculated in Appendix . That is

$$U_o = 0.225 \text{ BTU/hr Ft}^2 \text{ } ^\circ\text{F.}$$

The heat loss from the storage is given by

$$Q = U_o A_o (T_i - T_o)$$

where

$$T_i = \text{inside water temperature} = 250^\circ \text{ F}$$

$$T_o = \text{outside air temperature.}$$

For the design outside air temperature of 0° F, the heat loss from the thermal storage tank is:

$$Q = 0.225 (2727) (250 - 0)$$

$$Q = 153394 \text{ BTU/hr.}$$

The approximate temperature drop of the thermal storage when there is no water flow, can be estimated by

$$\frac{dE}{dt} = Q$$

SPHERICAL STORAGE TANK

FIG. 4-42

where E = MCT = internal energy of water storage
 M = mass of water in storage = 17×10^4
 C = specific heat = 1.0
 T = temperature of water
 t = time in hours.

It is found that the approximate temperature drop of water over a period of 8 hours would be about 1° degree.

COST COMPARISON

INVESTMENT COST OF THERMAL STORAGE

CAPITAL COST:

STEEL TANK =	\$125,000	
(INSTALLED)		
FOUNDATION =	20,000	
EXPANSION TANK =	20,000	
PUMP =	4,500	
(1000 gpm)	\$169,500	period of amortization = 20 yrs.

COST OF ENERGY

Annual Investment Cost (capital recovery @ 7½%)	=	\$16627.95
Maintenance and operations cost/year (@5% of capital cost)	=	\$19615.95

CHARGING COST PER YEAR

(250 hours of operation)	=	\$ 340.65
Dollar equivalent of heat loss	=	\$ 150.82
Cost of Heat delivered per year	=	<u>\$20381.13</u>
Total Annual Cost/year		\$57116.50

4.9 SCARCE FUEL CONSERVATION POTENTIAL

The district heating system and power plant retrofit for cogeneration offer Piqua a significant opportunity to alter energy use patterns within the community and to conserve scarce fuels. In Piqua's case, all end-user's within the service area would normally rely on natural gas or electricity for the energy needs which could be supplied by the district heating system.

In order to evaluate scarce fuel conservation potential, the operational analysis data generated by our computerized load simulation of the power plant under the conventional configuration and the cogenerating configuration was used.

The entire service zone was treated identically since their source of energy for heating is the same - i.e. natural gas and electricity.

The energy consumption for gas fueled appliances in the conventional plan was determined for the heating and cooling requirements projected by the computerized load estimate. An efficiency factor of 65 percent was used for combustion equipment.

The procedures outlines in the ASHRAE Standard 90-75; ENERGY CONSERVATION IN NEW BUILDING DESIGN, SECTION 12, for determining Annual Fuel and Energy Resource Utilization were followed in order to compare energy consumption of the conventional system to the district heating equipment.

For a comparison of conventional system versus the district heating system primary fuel utilization efficiency and cumulative resource utilization, Figures 4-43 and 4-44 were prepared. It is interesting to note the changes in primary resource utilization due to changing load patterns and system configuration modifications.

Only the thermal energy consumed by the area served by the district heating system is considered in the study so that natural gas savings are directly proportional to the thermal market served in any one year.

FIG. 4-43

FIG. 4-44

5.0 INSTITUTIONAL ASSESSMENT

INTRODUCTION/SETTING

The City is located in Miami County in southwestern Ohio, approximately 25 miles northwest of the City of Dayton. The City was incorporated in 1843.

The City's 1970 population of 20,471 made it the 61st largest city in the State. Estimated 1978 population is approximately 23,000 (estimated by Hanselman-Eskew and Associates). The City and County are included in the Dayton Standard Metropolitan Statistical Area ("Dayton S.M.S.A.") which ranks 5th in population in the State and 41st in the United States. Within a 60 mile radius of the City is an estimated 1977 population of 833,100 persons.

The City is served by diversified transportation facilities. Immediate access is to State Highways 33, 66, and 185 and Interstate Highways 70 and 75. The City is served by Conrail and the Chessie System railroads, as well as by the Piqua Municipal Airport located in the City and the James M. Cox Dayton International Airport located in Dayton.

The City is provided with banking facilities by five major commercial banks and savings and loan associations located in the City. One local daily newspaper and two Dayton newspapers serve the City. The City is within the service area of eleven television stations and nine AM and FM radio stations.

Within commuting distance of the City are 20 colleges and universities with a total enrollment of more than 50,000. Several of these institutions are within the immediate area, including the Piqua Academic Center of Wright State University, the University of Dayton and Sinclair Community College.

There is one general hospital located in the City, Piqua Memorial Hospital, with a 150 bed capacity. Nearby Dettmer General Hospital has a 200 bed capacity, as well as a 115 bed capacity for special services, such as extended care, pediatric care, coronary care and mental health care. Five general hospitals, two children's hospitals, an Air Force hospital and a facility for veterans are located in the Dayton area.

Extensive recreational opportunities are available to City residents including public parks, boating and fishing, one private and one public golf course, swimming, bowling and Y.M.C.A. and Y.W.C.A. health clubs.

The Piqua, Ohio District Heating Project will be implemented in a community environment or setting. This setting has evolved over time--influencing individual consumer and community efforts--affecting both private and public enterprise. The setting conditions the development of district heating alternatives as well as the ultimate selection of service areas, phasing and other policy issues. The setting consists of prevailing attitudes, community resources, law, and previous experience and direction. The setting is national and regional as well as local in that consumer attitudes and opinions are shaped by a broad set of experiences and events extending far beyond Piqua, Ohio. Resource limits, law and competing demands are also shaped both in the City and in other areas.

The following discussion summarizes a range of prevailing issues, attitudes, problems, experiences and thoughts which collectively depict the setting for the district heating project. They are both hopeful and disturbing.

TRUST AND CONFIDENCE

Throughout the nation, people's trust and confidence in existing institutions appears to be at an all time low. Government generally has not avoided this censure. Local, state and national events all shape this attitude. Citizens sense not only legal and moral betrayal but also disillusionment in the development process. These officials point directly to goal formulation and policy development as prime areas of citizen involvement. Need identification, plan development and monitoring are also cited for increased citizen activity.

Officials, however, see present citizen involvement methods as generating input that is slow to form; ambiguous in nature; and providing little policy direction. Citizens appear to have little interest in policy and plan development, especially future-oriented activities such as energy planning or land use planning; and prefer to become active only when their narrow set of property rights is "being threatened".

PRESENT ORIENTATION VS. FUTURE THINKING

We are not oriented to the future--future thinking--future problems--or future solutions and directions. Infrequently we do set goals and test tomorrow's actions against them. We seldom anticipate problems and begin the search for new directions and solutions.

Crisis or immediate problem orientation prevails in society. Failure to relate issues of today and evolving issues of tomorrow persist. We merely seem to project present problems a short distance forward--the same problem only bigger, longer or broader.

LIMITS ON THE CITY

Piqua City Government cannot solve all of the energy problems facing the Piqua community today. The City Commissioners face resource and time constraints which place limits on their ability to implement solutions for a wide range of problems. Piqua City Commissioners have no control of OPEC nations and little control of community energy consumption habits.

CONFLICTING EVIDENCE REGARDING ENERGY PROBLEMS

Almost daily Americans are bombarded with conflicting "facts" and testimonials of public officials, technocrats and industry spokesmen regarding the "energy crisis". While private market economics blythly assume perfect knowledge of the market place for rational decisions, consumers continue to muddle forward as the ball bounces from the Mideast to Mexico to Ohio coal to solar energy to consumer ignorance.

5.1 PIQUA, A BODY CORPORATE AND POLITIC

The City operates under and is governed by its Charter which was first adopted by the voters in 1929, and which has been and may be amended by the voters from time to time. The City is also subject to some general laws of Ohio which are applicable to Chartered Home Rule cities. In addition, the City may exercise all powers of local self-government under Article XVIII, Section 3 of the Ohio Constitution. The Charter provides for a Commission-Manager form of city government.

Legislative authority is vested in a five-member Commission, the five of which are elected from wards, for four-year terms. The Commission enacts ordinances and resolutions to provide for, among other subjects, City services, tax levies, appropriations of money, borrowing money and licensing and regulating those engaged in business and trade. The Commission also has the power to fix compensation of City officials and employees. The presiding officer is

the Mayor who is elected at-large from among the Commission members for a four-year term and serves as head of the City for all ceremonial purposes. The Charter establishes certain administrative departments; pursuant to Charter provisions, the Commission may establish divisions thereof or additional departments.

The chief executive and administrative officer of the City is the Manager who is appointed by the Commission to serve at its pleasure. The City Manager may be removed by a vote of a majority of the members of the Commission.

The Manager appoints the directors of the several departments of the City to carry out administrative responsibilities. The major appointed officials are the Directors of Power Systems, Public Works, Finance and Law. The Commission also has the power to appoint members to a number of boards and commissions.

The current elected City officials and major appointed City officials are:

<u>Elected Officials</u>	<u>Name of Incumbent</u>	<u>Beginning Service Date</u>	<u>Expiration Date of Present Term</u>
Members of Commission:			
Mayor	James Henderson	1/1/76	12/31/79
Vice-Mayor	Joseph C. Goetz	1/1/68	12/31/79
	Charles Tyler	9/7/78	12/31/79
	Cletus Peltier	1/1/74	12/31/81
	Robert Von Aschen	1/1/78	12/31/81
Appointed Officials			
Manager	Frank Patrizio, Jr.	1/15/79	at Commission's pleasure
Director of Power Systems	Houston E. Hastings	9/19/77	at Manager's pleasure
Director of Public Works	Ray N. Miller	3/28/77	at Manager's pleasure
Director of Finance	Robert N. Slagle	6/26/78	at Manager's pleasure
Director of Law	Stephen E. Klein	10/30/78	at Manager's pleasure

PIQUA CITY COMMISSION

CITY MANAGER

PIQUA MUNICIPAL
POWER SYSTEM

PIQUA PUBLIC WORKS
DEPARTMENT

PIQUA FINANCE
DEPARTMENT

PIQUA LAW
DEPARTMENT

CITY OF PIQUA
ORGANIZATIONAL STRUCTURE

OVERLAPPING GOVERNMENT ENTITIES -- The major political subdivisions or other governmental entities overlapping all or a portion of the territory of the City are:

1. A portion (19.28% of the assessed valuation) of the County, which performs the traditional functions allocated to counties by Ohio law.
2. A portion of the Piqua City School District (73.36% of the assessed valuation), which includes 100% of the territory within the City, which school district is charged with educational responsibilities for children from kindergarten through the twelfth grade.
3. A portion (16.67% of the assessed valuation) of the Upper Valley Joint Vocational School District, which operates a vocational education program.
4. A portion (19.28% of the assessed valuation) of the Miami County Park District, which owns and operates recreation areas.
5. A portion of the Miami Conservancy District.

Each of these entities operates independently under and is governed by Ohio law, with its own budget, tax rate and sources of revenue. Only those listed as 1 and 2 above have the power, as does the City, to levy ad valorem property taxes within applicable limitations without a vote of the electorate.

5.2 LEGAL AND REGULATORY ASSESSMENT

INTRODUCTION

The legal assessment of the City of Piqua and its Municipal Power System's ability to proceed with the District Heating and Cooling Project requires reiteration of the basic point--the City of Piqua is a Chartered Home Rule city constituted under the authority of the Ohio Consitution, and as such is not subject to most of the laws which govern private corporations and public, investor-owned utility corporations. The nature of the Piqua Municipal Power System influences nearly all legal, ownership, institutional, and financial issues which are subject to the consideration of this District Heating Feasibility Analysis and Evaluation.

A good example of the influence of public ownership is the "search for innovative ownership schemes which will allow the district heating project to take advantage of tax exempt financing". The Piqua Municipal Power System is publicly owned and tax exempt. The City may issue tax exempt, revenue bonds and tax exempt, general obligation bonds for modifications and improvements. On the surface it still seems appropriate to explore these "Innovative Ownership Schemes" in order to take advantage of syndicated tax losses in the form of lower debt service and subsequent relatively lower rates. However, it is important to realize that the City of Piqua and the PMPS are essentially prevented from "selling stock" in that the City already has stock holders--those individuals that are residents of the City of Piqua.

Notwithstanding the above points, there still may be some advantage to "Innovative Ownership Schemes" applied to the distribution system only. Once again, the nature of the City and its ownership of the power plant is the overriding influence. The sale of stock/private ownership of the distribution system would place that corporation (private or non-profit) under the direct control of the Ohio Public Utilities Commission. Once under the statutory control of the PUCO, all of the problems inherent in establishing equitable district heating rates come into effect.

In summary, it is determined that the Piqua Municipal Power System, all cogeneration additions/modifications, and the entire distribution system will be owned by the City of Piqua, Ohio.

5.2.1 PIQUA MUNICIPAL POWER SYSTEM WITH DISTRICT HEATING -- A SINGLE UTILITY

The question of whether or not a proposed, central source, district heating and cooling system will result in the creation of a separate utility, or whether the retrofit merely uses the same generation facilities and by-products is a critical point. A finding that the district heating system constitutes a separate utility would decrease the city's ability to establish equitable rates for electricity and thermal energy.

An analysis of this question by the city's attorney finds that "by the authority and example of the Priest v. Balmer cases and the Ohio Constitution, the District Heating and Cooling System would be considered

a single integrated public utility". The Law Director's opinion in this matter is presented in its entirety starting on page 407.

5.2.2 REGULATION OF THE DISTRICT HEATING AND COOLING SYSTEM

THE PUBLIC UTILITIES COMMISSION OF OHIO -- The question of outside, or state control, of the Piqua Municipal Power System (and consequently the district heating system) is much different than that of a public, investor-owned utility. The Public Utilities Commission of Ohio regulates investor-owned utilities such as Dayton Power and Light, Cincinnati Gas and Electric or the Ohio Bell Telephone Company. However, since the Piqua Municipal Power System is part of the City of Piqua, a Charter Home Rule city under the constitutional provisions of the State of Ohio, the Ohio Public Utilities Commission has no control nor does it exercise any purview over the ownership or operation of the Piqua Municipal Power System. The Law Director's opinion dated January 22, 1979, and included at the end of this section, summarizes by saying:

"Briefly, then, it is my opinion, and you are so advised, the chapter 4905, R.C. (general powers of the PUCO) does not apply to the Piqua Power Plant . . ."

Conversations with representatives of the PUCO confirmed the fact that they concur with this opinion. The PUCO does not even maintain a reasonable data base regarding municipally-owned utilities.

THE OHIO POWER SITING COMMISSION -- the State of Ohio had adopted power siting regulations and has constituted the Ohio Power Siting Commission. The purpose of the five member commission is to review and essentially approve the construction of power generating facilities in the State of Ohio. The question then is: Does the Ohio Power Siting Commission have purview or exercise control over the actions of the Piqua Municipal Power System? The Law Director's opinions dated January 22, 1979, and February 2, 1979, regarding the relationship between the Piqua Municipal Power Plant and the Ohio Power Siting Commission thoroughly analyzes and evaluates this question. These opinions are included at the end of this section in their entirety.

In summary, the February 22, 1979 opinion by the Law Director, Mr. Steven E. Klein states:

"Whether or not a Certificate must be ultimately applied for, a Letter of Intent must be submitted. In fact, one of the stated purposes of this Letter of Intent is to qualify jurisdictional questions with respect to replacements of existing facilities with like facilities, substantial additions or other jurisdictional questions."

Additional communication between the Law Director and the Ohio Power Siting Commission clarifies the situation. During the course of the investigation regarding the single utility concept, discussed in Section 5.1.1, the Ohio Power Siting Commission was contacted. In response to the City of Piqua's inquiries, the Ohio Power Siting Commission responded with a letter dated February 28, 1979, attached to the Attorney's opinion of February 2, 1979 (included in the Section 5.1.1). In this letter the Ohio Power Siting Commission states:

"We understand that the proposed project will not effect generating capacity at all but rather will enable the City to use cooling water discharge from the generation of electricity to provide space heating and domestic hot water to nearby customers. Please be informed therefore, that inasmuch as this capacity of the City's power plant will not be affected by the proposed conversion to cogeneration, the Ohio Power Siting Commission does not have jurisdiction in this matter. The City may proceed with the proposed project without obtaining OPSC approval."

The responsibilities of the Ohio Power Siting Commission will not affect the Piqua Municipal Power System's district heating project during the early phases. However, a Certificate from the Ohio Power Siting Commission may be required when the City installs the 30 MW cogeneration boiler and turbine during later phases of the district heating project.

5.2.3 BOUNDARIES OF CERTIFIED TERRITORIES OF ELECTRIC SUPPLIERS

The "service area" of the Piqua Municipal Power System borders the service areas of the Dayton Power and Light Company and the Pioneer Electric Rural Cooperative. The "borders" between the three utilities are not definitive. In the fringe areas between the utilities there are places where the service

areas of the Piqua Municipal Power System and DP&L, or that of the PMPS and Pioneer Electric appear to overlap. In these areas the different utilities compete for customers.

In response to this statewide issue, the Ohio legislature is in the process of finally and definitively delineating the boundaries between the many electric utilities throughout the state. However, the section of the Ohio Revised Code which establishes the process for certifying territories of electrical suppliers is quite vague about the question of contiguous boundaries between municipal utilities and investor held utilities. During the drafting of the law, Ohio legislators most likely intentionally avoided dealing with this issue. The artful legislative dodge allowed the enactment of the law while tossing the sticky question to the courts. Law Director Klein's opinion in this matter can be found in its entirety at the conclusion of this section. Briefly he states:

"In summation, it is my conclusion and you are so advised that Sections 4933.81 through 4933.90 of the Revised Code is not applicable to the District Heating and Cooling Project for the following reasons:

1. The District Heating and Cooling System does not fit the definition of an "electric supplier";
2. The District Heating and Cooling System does not provide "electric service" as that term is defined;
3. The formulation of boundaries according to "distribution lines" has no practical application to the District Heating and Cooling System; and
4. The application of these statutes to municipal utilities would violate Article XVIII of the Ohio Constitution."

5.2.4 THE STATUTORY MANDATE TO SERVE ALL CUSTOMERS

Once again the nature of the City of Piqua, i.e. an Ohio Charter Home Rule city, structures the finding. Law Director Klein finds in his opinion of May 25, 1979:

"Therefore, it is my opinion, and you are so advised, that neither constitutional nor statutory restrictions exist which would fetter the sound judgment of the City of Piqua by mandating public utility service to all inhabitants without qualification."

The Law Director's opinion is included in its entirety at the conclusion of this section of the report.

5.2.5 THE MUNICIPAL POWER SYSTEM'S RELATIONSHIP TO THE AREA GAS SUPPLIERS -- DAYTON POWER AND LIGHT

The Dayton Power and Light Company, with corporate headquarters in Dayton, Ohio, is the local distributor of natural gas. DP&L's gas is purchased from the Columbia Gas Company and reaches DP&L's distribution system via an interstate natural gas trunk line. Section 4.0 of this report quantifies the natural gas displaced as a result of implementing the district heating and cooling project. Since the Dayton Power and Light Company has installed a natural gas distribution system throughout the City of Piqua and currently services many customers, the gas company may feel financially damaged. In view of the above: Will the Piqua Municipal Power System suffer potential liability by depriving competing public utilities of customers as a result of implementing district heating and cooling?

Even though a competing utility may try to fashion a tort claim, under the circumstances the Piqua Law Director finds that:

"In all probability no successful cause of action can be framed under the circumstances which could prevent or hinder competition between the district heating and cooling system and other utilities or customers. Clearly, these traditional types of action are inapplicable here because no unfair competition is evident."

It is conceivable that a second type of claim could be made, i.e. franchise infringement. Here the Law Director finds that as long as the district heating and cooling system sells hot water and not natural gas, there can be no franchise infringement. DP&L does not have an "energy franchise". The opinion states:

"Clearly such license to create a competing municipally owned utility within the district of a privately owned but franchised utility demonstrates the conclusion that any existing energy supplier cannot prevent the growth of the proposed district heating and cooling system."

Mr. Klein's opinion on this matter follows in its entirety at the conclusion of this section.

5.2.6 PIQUA HAS THE AUTHORITY TO PROCEED WITH THE PROJECT

The City of Piqua's ability to proceed is not incumbered by any constitutional or statutory restrictions. The Law Director's opinion, included at the conclusion of this section of the report, states:

"Therefore, it is my opinion and you are so advised, that the City of Piqua possesses an authority, free of constitutional or statutory restrictions, to implement the proposed district heating and cooling system."

5.2.7 RIGHT-OF-WAYS, EASEMENTS AND LAND ACQUISITION

The City of Piqua currently controls the required land and Right-of-Ways or can control them in a timely fashion. Permits and certificates are generally not applicable.

- 1) Public Right-of-Ways and Public Easements -- the distribution plan alternative presented in Section 4.0 of this analysis calls for the distribution system to be constructed essentially within existing public right-of-ways and publicly held easements or public right-of-ways and easements which will be dedicated in the future. The City of Piqua owns all of the right-of-ways related to the street and alley system within the City of Piqua and will own future dedications. No permits or certificates of convenience are required for the City of Piqua to use these right-of-ways. Obviously, care must be exer-

cised during planning and construction to avoid any underground "obstacles" within the R-O-W.

- 2) Public Right-of-Ways Outside the City -- installation of the distribution system in zones outside of the City of Piqua will essentially be located in public right-of-ways which are the domain of Miami County. In these situations a permit from the Miami County Engineer will be required. Currently, the City of Piqua and the PMPS have numerous power lines, sewer lines and water lines in these areas. The City and Miami County work closely on a regular basis. The actors personally know one another and work well together. No problems are anticipated; however, in the event serious obstacles arise, the City can appropriate (condemn) the easement. A complete analysis of this authority is contained in the following paragraphs.
- 3) Private Property -- during the planning and construction of the entire distribution system, it must be anticipated that relatively minor portions of private property will be required. The City of Piqua, a Chartered Home Rule city within the State of Ohio, has the complete and unrestricted authority to secure right-of-ways and easements through negotiation or appropriation. In exercising the take (condemnation authority), the City must of course follow due process and find that the land is required for the public business or public purpose. The public purpose is broadly defined and interpreted in the State of Ohio. The district heating system certainly falls within the definition. The following paragraphs fully explain the City's power and authority in this matter.
- 4) Miami Conservancy District Land -- the Demonstration Team has analyzed and evaluated the use of Miami Conservancy District land along the Great Miami River. The distribution

system planning presented in Section 4 calls for the use of a portion of this land for the extension of selected sections of the main trunk line from the power plant to, and around the Central Business District. Use of the river corridor land owned and/or controlled by the MCD minimizes the amount of public streets that would have to be trenched and resurfaced. Further use of this land allows the distribution system to avoid traversing sections of Main Street through the heart of the Central Business. Avoiding the Main Street/Central Business District route not only lowers costs but also avoids a specific area where construction disruption would be most hotly debated.

The Miami Conservancy District is a local unit of government with broad powers relating to the prevention of floods within the valley of the Great Miami River. The Miami Conservancy District was formed under state law following the 1913 flood and was charged with the construction of a series of flood control dams (dry-dams) which retard the flow of flood waters at critical times. In addition, the MCD acquired either fee simple title or in easement form essentially the entire course of the Great Miami River through southwestern Ohio. The Miami Conservancy District maintains a full planning and engineering staff which continually improves the flood control system and maintains the dams, channels and levies.

The Demonstration Team met with the Chief Engineer and other staff members of MCD regarding the use of their land, specifically the levy areas and floodways. During this meeting, the entire District

Heating and Cooling Project was presented to MCD; and various alternatives were presented for the use of land under their control. Each alternative was thoroughly discussed. The results of the meeting were:

- * MCD officials decided that there were specific problems related to installation of the thermal lines above ground, on top of the levies. These problems were access to the river corridor and maintenance/mowing of the levies.
- * The Miami Conservancy District understood that the levies would be "penetrated" during construction periods. MCD indicated that this is not an uncommon occurrence during the construction and installation of utility lines; and further indicated that the staff would work with the Demonstration Team to plan the expedient construction through the levies.
- * The Chief Engineer decided that the least disruptive design would be to install the main trunk line underground, through the flood plain areas at the foot of the levy.
- * MCD officials revealed that the Piqua Ski Club leases a beach area and access point near the proposed course of the distribution line. It was agreed that the MCD, City of Piqua and the local club would easily arrive at a mutually beneficial solution.

Following the meeting, the Demonstration Team analyzed and evaluated the results of the discussion and the possibilities/limitations posed by the MCD. It has been determined that those portions of the distribution line which are best located in the MCD control property can

be constructed there without serious obstacles. The Demonstration Team will continue to work closely with the Miami Conservancy District staff in the months ahead.

The following excerpts from the Ohio Constitution and the Piqua Charter fully establish the City's powers of appropriation. The three sections of the Constitution work together. Section 3 of the Constitution of the State of Ohio, Article 18 states:

"Municipalities shall have authority to exercise all powers of local self government and to adopt and enforce within their limits such local police and sanitary and other regulations not in conflict with general laws."

Section 4, Article 18 of the Constitution of the State of Ohio states:

"Any municipality may acquire, construct, own, lease and operate within or without its corporate limits, any public utility that products or services of which is, or is to be supplied to the municipality or its inhabitants; and may contract with others for any such product or service. The acquisition of any such public utility may be by condemnation or otherwise, and a municipality may acquire thereby the use of or full title to the property and franchise of any company or persons, supplying to the municipality or its inhabitants, the service or product of any such utility."

Section 10 of Article 18 of the Constitution of the State of Ohio states:

"That a municipality appropriating or otherwise acquiring property for public use may in furtherance of such public use appropriate or acquire an excess over that actually to be occupied by the improvement, and may sell such excess with such restrictions as may be appropriate to preserve the improvement made."

The Charter of the City of Piqua provides for the use of the above powers and authority. Specifically, Section 99 of the Piqua Charter states:

"Property within or without the corporate limits of the city may be appropriated for any public or business purpose, and subject only to limitations imposed by the Constitution of the State. Such appropriation shall be made as herein provided. By such appropriations the City may acquire a fee simple title or any less estate, easement or use. Appropriation shall be made according to the requirements of and as provided by general law."

5.2.8 PROJECT TAXES

There are three basic issues to be considered on the tax status of the system:

- 1) Bonds and notes issued for system financing -- under existing law the interest on the bonds and/or notes is exempt from federal income tax, the Ohio personal income tax, the Ohio corporate franchise tax, and from municipal income taxes in Ohio. The bonds and/or notes are subject to the Ohio intangible property taxes to the same extent as other obligations not specifically exempted from such tax.
- 2) Tax on the system itself -- no power plant improvements nor the distribution system will be subject to any property tax, in that city property is exempt from such taxes in Ohio. The system is not part of the tax duplicate just as the existing power system is not included.
- 3) Tax on end-user systems -- Part of the value of district heating retrofit improvements on private property will be included in the assessed valuation at the next reappraisal. The following memorandum briefly describes tax incentives/exemptions available for end-users.

MEMORANDUM ON TAX INCENTIVES FOR RETROFITTING EQUIPMENT OWNED BY COMMERCIAL, INDUSTRIAL AND RESIDENTIAL CONSUMERS FOR COGENERATION

TO: HANSELMAN-ESKEW AND ASSOCIATES
FROM: STEPHEN E. KLEIN, ATTORNEY

In response to your request for information on possible tax incentives for industrial, commercial and residential participants of the proposed Dis-

istrict Heating and Cooling System, please be advised as follows:

STATE TAX EXEMPTIONS FOR INDUSTRIAL & COMMERCIAL PARTICIPANTS

Pursuant to Section 5709.45 of the Revised Code:

"Thermal efficiency improvement facility" means any property or equipment designed, constructed or installed in a commercial building or site or in an industrial plant or site for the primary purpose of recovering and using waste heat or waste steam produced incidental to electric power generation ..."

Assuming that the apparatus to be purchased by industrial and commercial users to participate in the District Heating and Cooling System fits within the definition, Section 5709.50 of the Revised Code, an exemption from the following taxes will be permitted:

Sales Tax

Use Tax

Real Property Tax

Personal Property Tax

Franchise Tax

STATE INCOME TAX CREDIT FOR HOME OWNERS

Pursuant to Section 5747.052 of the Revised Code, an income tax credit of up to sixty-five dollars shall be allowed for the total cost of a "home improvement" defined as "the repair or other physical alteration in the structure of a home that results in a total cost of at least three hundred dollars," including the installation of plumbing and hot water heaters.

Assuming the above definition of a "home improvement" is applicable, this tax credit on state income tax is permitted.

MUNICIPAL INCOME TAX CREDITS FOR INDUSTRIAL, COMMERCIAL AND RESIDENTIAL PARTICIPANTS

Although the present municipal income tax ordinance for the City of Piqua does not provide tax credits for purchasers of apparatus to participate in the District Heating and Cooling System, nothing prevents an amendment to the ordinance to provide an income tax credit to industrial, commercial and individual tax payers within the City of Piqua.

The Federal energy tax credit expired on January 1, 1979, and is questionable whether district heating and cooling improvements would have been eligible for tax credits under that program. It is our opinion that federal tax credit programs would have a beneficial impact on end-users, and that the energy credits should be renewed and expanded to include improvements resulting from a district heating and cooling program.

The improvements made to the end-user system will be subject to real property taxes as would any improvement to real property. Real property is appraised sexennially, and rates are adjusted to reflect the values of the properties triennially. Property was appraised in the City of Piqua in 1977. The City of Piqua has the ability to abate taxes on real property levied for improvements made to property. It is anticipated that the City of Piqua will pursue such an abatement strategy in conjunction with other locally initiated incentives for end-user participation.

5.2.9 CONFORMANCE WITH CITY CODES

The following applicable codes are analyzed and evaluated as they relate to the district heating retrofit plan alternatives. Again, it is important to note that these codes are adopted and enforced by the City of Piqua pursuant to the city's goals and objectives.

ZONING CODE AND MAP--There are no zoning issues which will inhibit implementing the district heating system or that cannot readily be overcome by the city.

- 1) construction of the district system and power plant retrofit occur on properly zoned parcels, i.e. power plant modifications and any booster stations will be located on industrial zoned areas;
- 2) end-user retrofits will not affect non-conforming uses status unless the cost of retrofitting exceeds 50% of the property valuation, a situation not likely to occur;
- 3) no land use patterns will be altered;
- 4) the City of Piqua can make any changes necessary to implement the project.

HOUSING CODE--There are no regulations or provisions that impede retrofit for district heating and cooling.

BUILDING CODE--The retrofit of residential, commercial and industry structures for district heating and cooling will require permits for installation, as would any central heating or cooling system. Generally, the code and the permit process will not impede retrofit of end-user buildings; however, issues raised by the following sections of the code should be recognized:

Section 115.32, Cost of Permit--fee is insignificant.

Section 151.35 Certificate of Occupancy-- will not generally apply to residents; however, may apply to buildings if retrofit causes temporary vacation of structure.

Section 151.174, Radiators--specifications to be met.

Section 151.384, Steam and Hot Water Pipes and Unit Heaters--outlines specifications.

Section 151.440, Plumbing--outlines permit and inspection, testing and certificate process.

Section 151.440, Plumbing--requires that contracted or fee paid work must be done by licensed plumbers.

5.2.10 ENVIRONMENTAL REGULATIONS

A complete analysis and evaluation of federal and state environmental standards/regulations as they relate to the PMPS and district heating retrofit is presented in Section 5.4, Environmental Impact.

MEMORANDUM ON "SINGLE UTILITY CONCEPT" AS APPLIED TO CO-GENERATION
PROJECT

TO: HANSELMAN-ESKEW & ASSOCIATES

FROM: STEPHEN, E. KLEIN, ATTORNEY

DATE: MARCH 8, 1979

In response to your request for my opinion as whether the proposed retrofitting of the Piqua electric generating plant to permit "co-generation" would result in the creation of two public utilities, please be advised as follows:

Apart from the statutes which define the public utilities which are within the purview of such statutes, it is difficult to construct a definition of a public utility which would fit every conceivable case. See 45 O.Jur.2d, 165 et. reg. Obviously, it is possible to treat a heating or cooling company when engaged in the business of supplying water or steam through pipes or tubing to consumers for heating or cooling purposes as a "public utility." In fact, Section 4905.03 (A) (9) of the Revised Code does just that, although that statutory definition is made expressly inapplicable to municipally-owned public utilities such as Piqua's. The true touchstone by which this issue is resolved, is contained in Section 4, Article XVIII of the Ohio Constitution which states in pertinent part:

Any municipality may acquire, construct, own, lease and operate within or without its corporate limits, any public utility the products or service of which is or is to be applied to the municipality or its inhabitants...

This constitutional provision was construed in Priest v Wapakoneta, 24 O.L. Abs. 214, 224 (C.A., 1937) as follows:

The phrase "the products or service of which is or is to be supplied to the municipality or its inhabitants," modifies the phrase "any public utility" as used in Section 4 of Article XVLLL. As applied to an electric public utility it is obvious that the words "the products or service" refer to the generation of electricity, while the words "to be supplied" refers to its distribution, and that within the meaning of said section an electric public utility is not complete unless it comprises both a generating plant and a distributing system (emphasis added). cited with approval in Vollmer v Village of Amherst, 65 O.App. 26, 18 O.Ops 266 (C.A., 1940).

According to my understanding of the co-generation project, the only significant construction pertains solely to the establishment of a distributing system for the pressurized hot water. The generating plant which produces the hot water already exists. Therefore, by the authority and example of the Priest and Vollmer cases and the Ohio Constitution, the District Heating and Cooling System would be considered a single integrated public utility.

Moreover, the Ohio Power Siting Commission which issues certificates for the construction of all "major utility facilities" in Ohio, has ruled that the District Heating & Cooling Project is outside their jurisdiction, i.e. that Piqua's project does not constitute a major utility facility (See "Exhibit A" attached).

Power Siting Commission

361 E. BROAD ST. P.O. BOX 1735 COLUMBUS, OHIO 43216 614/466-6422

February 28, 1979

Stephen E. Klein, Esq.
Director of Law
City of Piqua
219 West Water Street
Piqua, Ohio 45356

Dear Mr. Klein:

This is to acknowledge and respond to your February 14, 1979 letter regarding the proposed "District Heating and Cooling System" for the City of Piqua.

Based on the information contained in your letter as well as in the February 26 telephone conversation between yourself and Mr. Andrew Meko, Commission Counsel, it is the staff's understanding that no additional electrical generating capacity is to be added to the Piqua system in conjunction with the proposed cogeneration project. Indeed, stated in its simplest terms, we understand that the proposed project will not affect generating capacity at all but rather will enable the City to use the cooling water discharge from the generation of electricity to provide space heating and domestic hot water to nearby customers.

Please be informed, therefore, that inasmuch as the capacity of the City's power plant will not be affected by the proposed conversion to cogeneration, the Power Siting Commission does not have jurisdiction in this matter. The City may proceed with the proposed project without obtaining OPSC approval.

Thank you for notifying us of the City's plans, and please do not hesitate to contact me if I may be of any further assistance.

Sincerely,

William B. McGorum, Jr.
Secretary

WBM:ACM:dw

CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

5.2.2.

DATE: January 22, 1979

MEMO TO: Hanselman-Eskew & Associates

FROM: Stephen E. Klein, Attorney

RE: State Control of Piqua Municipal Power Plant

In response to your request for my opinion on the jurisdiction of the Public Utilities Commission of Ohio over municipally-owned power plants such as Piqua's, you are hereby advised as follows:

The City of Piqua derives its authority to own and operate a power plant directly from the Constitution of the State of Ohio. In pertinent part, Section 4, Article XVIII of the Ohio Constitution has read since 1912 as follows:

Section 4: "Any municipality may acquire, construct, own, lease and operate within or without its corporate limits, any public utility the product or service of which is or is to be supplied to the municipality or its inhabitants....

Because of this constitutional provision, a "public utility" as defined in Section 4905.02 of the Ohio Revised Code "includes every corporation, company...defined in Section 4905.03 of the Revised Code...but excepting such other public utilities as are owned or operated by any municipal corporation...." Thus, by definition, Sections 4905.01-.69 of the Revised Code which covers the general powers of the Public Utilities Commission do not apply to the Piqua Power Plant. See Ohio Power Co. v Attica, 19 O. App. 2d 89 (1969).

However, the statutory authority of the Public Utilities Commission to control the "power siting" of a municipally-owned power plant is not so clear. Chapter 4906 of the Revised Code deals with power siting and nothing therein exempts municipal power plants, either in the definition of a "major utility facility" (Section 4906.01), powers and duties of the power siting commission (Section 4906.02) or the exemptions from certificate requirement contained in Section 4906.05.

January 22, 1979

Memo to: Hanselman-Eskew & Associates

Page 2

Although the general rule is that the municipal power to acquire and operate public utilities is the most expansive of The Home Rule powers, because it is more free from state control than any other Home Rule power and despite the absence of either express or implied constitutional limitations upon municipal utility power (which has led courts to hold repeatedly that the state cannot deprive, lessen, limit, curtail, modify, condition, restrict, interfere with, burden or circumvent municipal constitutional power), exceptions have been made.

Bearing in mind that no court has yet determined whether the state power siting statutes apply to municipal power plants, it is my opinion that such statutes do apply to the Piqua Power Plant for the reason that Chapter 4906 (power siting) can be considered as an exercise of the state's "police power" and municipal power, no matter how extensive, must be reconciled with the broad and essential state police power. In City of Akron v. PUCO, 149 O. St. 347, 78 N.E. 2d 890 (1948) (relating to a natural gas shortage) and City of Canton v. Whitman, 44 O. St. 2d 62, 337 NE 2d 766 (1975) (relating to fluoridation of city water) it was held that municipal utility authority was subject to state police power exercised for the public health and safety. Because one of the duties of the power siting commission is to evaluate environmental values of proposed sites (Section 4906.03) and because the state directors of environmental protection and of health are members of the power siting commission, it is reasonable to assume that the state courts would decide that Chapter 4906 is a valid exercise of the state's police power and; therefore, municipal power plants are subject to its provisions. For an in-depth discussion of this subject, see Vaubel, Municipal Home Rule in Ohio, p. 1396-1408 (1978).

Briefly, then, it is my opinion and you are so advised that Chapter 4905, R.C. (general powers of the P.U.C.O) does not apply to the Piqua Power Plant but Chapter 4906, R.C. (power siting) does apply to the Piqua Power Plant.

CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

5.2.2.

DATE: February 2, 1979

MEMO TO: Hanselman-Eskew & Associates

FROM: Stephen E. Klein, Project Attorney

SUBJECT: The Ohio Power Siting Commission and its Application
to the Piqua District Heating and Cooling Systems.

As a consequence of my January 22nd memorandum wherein I concluded that municipal power plants such as Piqua's were not exempt from the provisions of Chapter 4906 of the Revised Code, I have been requested to provide a detailed analysis of the operation of the Power Siting Commission and how it may affect the Piqua District Heating and Cooling Systems.

As previously stated, the fact that a power plant is municipally-owned does not, therefore, exempt it from the provisions of Chapter 4906, R.C. Nevertheless, a close examination of these statutes reveals at least three possible exemptions from the authority and control of the Commission.

Basically, the Power Siting Commission is a board of five members (Sec. 4906.02) endowed with the following functions (Sec. 4906.03)

1. Review, comment and make public the ten-year forecasts of facility demands filed by all major utility facilities;
2. Compile and publish information on locations of power plants and transmission lines;
3. Conduct appropriate studies and investigations;
4. Adopt rules establishing criteria for evaluating the effects on environmental values of power sites and projected needs for electric power and such other rules as are necessary and convenient.

For our purposes, the crucial statute in this chapter is Section 4906.04, R.C., making the construction of a major utility unlawful without a certificate:

No person shall commence to construct a major utility facility in this state without first having obtained a certificate for the facility. The replacement of an existing facility with a like facility, as determined by the Power Siting Commission, shall not constitute construction of a major utility facility. Such replacement of a like facility is not exempt from any other requirements of state or local laws or regulations. Any facility, with respect to which such a certificate is required, shall thereafter be constructed, operated and maintained in conformity with such certificate and any terms, conditions and modifications contained therein. A certificate may only be issued pursuant to Chapter 4906, R.C.

A corollary to the above-quoted statute is Section 4906.05 which states that although no certificate is required for any major utility facility already in operation when this law went into effect, a certificate is required for any substantial addition to a facility already in operation and the term "substantial addition" shall be defined by the Power Siting Commission.

Ultimately, of course, the above statutes apply only to "major utility facilities", a key phrase defined in Section 4906.01, R.C. as follows:

"Major utility facility" means:

1. Electric generating plant and associated facilities designed for, or capable of, operation at a capacity of fifty megawatts or more;
2. An electric transmission line and associated facilities of a design capacity of one hundred twenty-five kilovolts or more;
3. A gas or natural gas transmission line and associated facilities designed for, or capable of, transporting gas or natural gas at pressures in excess of one hundred twenty-five pounds per square inch.

"Major utility facility" does not include electric, gas, natural gas distributing lines and gas or natural gas gathering lines and associated facilities as defined by the Power Siting Commission....

Before it becomes necessary to determine how the Piqua District Heating and Cooling System is to comply with the provisions of Chapter 4906, R.C., we must determine whether we must comply at all. In other words, what applicable limitations on the authority of the Power Siting Commission exist in the statutes? For our purposes,

there are perhaps three (see underlined portions quoted above) which are discussed below with reference to the administrative rules promulgated by the Power Siting Commission.

THE REPLACEMENT OF AN EXISTING FACILITY WITH A LIKE FACILITY, AS DETERMINED BY THE POWER SITING COMMISSION, SHALL NOT CONSTITUTE CONSTRUCTION OF A MAJOR UTILITY FACILITY.

In order to determine whether the Piqua District Heating & Cooling System could be considered as a "replacement of an existing facility with a like facility". According to Ohio Administrative Rule #4906-1-02 (P), the definition of that phrase is as follows:

"Replacement of an existing facility with a like facility" means replacing an existing major utility facility, not operating under a certificate, which is in compliance with state and local laws and regulations, with a major utility facility of equivalent rating and operating characteristics. The environmental and social impact of the replacement shall be equal to or less than that of the existing equipment which is to be replaced.

If the Piqua project can be identified with the above-quoted definition; then no certificate need be applied for. Nevertheless, because it is within the sole authority of the Power Siting Commission to determine whether the Piqua project would be a replacement or not, a letter of intent must be submitted to the Commission in order to obtain that determination.

"MAJOR UTILITY FACILITY" DOES NOT INCLUDE ELECTRIC, GAS, NATURAL GAS DISTRIBUTING LINES AND GAS OR NATURAL GAS GATHERING LINES AND ASSOCIATED FACILITIES AS DEFINED BY THE POWER SITING COMMISSION.

It is obvious that if the Piqua project can be considered to consist of "electric, gas, natural gas distributing lines and gas or natural gas gathering lines and associated facilities," then no certificate need be obtained. But it is equally obvious that the above-quoted phrase does not include "steam lines" so analogies must be drawn if this exclusion is to apply. In this regard, the following definitions from Ohio Administrative Rule #4906-1-02 are pertinent:

- (E) "Electric distributing line and associated facilities" is any line and associated facilities within an electric distribution system.

- (F) "Electric distribution system" means all land, structures, conversion equipment, lines, line transformers, and other facilities employed between the primary source of supply (i.e., generating station or point of receipt in the case of purchased power) and the point of delivery to customers, which are not includible in transmission systems, as defined in paragraph (H) of rule 4906-1-02 of the Administrative Code whether or not such land, structures, and facilities are operated as part of a transmission system or as part of a distribution system.
- (1) Where poles or towers support both transmission and distribution conductors, the poles, towers, anchors, guys and rights-of-way shall be classified as a transmission system.
 - (2) The conductors, crossarms, braces, grounds, tiewire, insulators, etc. shall be classified as transmission or distribution facilities according to the purpose for which they are used.
 - (3) Where underground conduit, contains both transmission and distribution conductors, the underground conduit and right-of-way shall be classified as a distribution system.
 - (4) Land (other than rights-of-way) and structures used jointly for transmission and distribution purposes shall be classified as transmission or distribution according to the major use thereof.
 - (5) Stations which change electricity from transmission to distribution voltage shall be classified as distribution stations.
- (J) "Gas distribution line and associated facility" means a pipeline and associated facilities other than a gathering or transmission line in a distribution area.
- (K) "Gas gathering line and associated facility" means a pipeline and associated facilities which transport gas from a current production facility to a transmission line or main.

Once again, the final determination as to whether the Piqua project falls within the above-quoted definitions, lies with the Power Siting Commission after its review of the letter of intent Piqua would have to file.

A CERTIFICATE IS REQUIRED FOR ANY SUBSTANTIAL ADDITION TO A FACILITY ALREADY IN OPERATION

The converse of the above requirement would be that no certificate is required for any non-substantial addition to a facility already in operation. Therefore, if the Piqua project can be deemed a non-substantial addition, no certificate is necessary. "Substantial addition is defined in Ohio Administrative Rule #4906-1-02 reads as follows:

- (U) "Substantial addition" in the case of an electric generating plant or a gas transmission line, is any modification of a utility facility not operating under a certificate, which modification in itself constitutes a major utility facility or a substantial environmental or social impact. In general the following examples apply to this definition:
- (1) Electric generating plant
 - (a) Addition of a generating unit of fifty MW or greater to an existing plant; or
 - (b) Addition of a fifty MW or greater generating unit which is designed to operate in conjunction with an existing unit to establish a combined cycle unit.
 - (2) Gas transmission line:
 - (a) The rerouting of a gas transmission line of greater than one-half mile in length of rerouted transmission line;
 - (b) The addition of a pumping station and or associated facilities to an existing transmission line; or
 - (c) The replacement of an existing transmission line with a new transmission line in the existing right-of-way, which replacement increases the size of the right-of-way corridor.
 - (3) Substantial environmental impact:
 - (a) An adverse, measurable change in the Ohio EPA's air quality index, for a twenty-four-hour period, within a radius of the plant equal to or greater than five miles, such change being attributable to the operation of the facility;
 - (b) An adverse, measurable change outside the mixing zone in one or more of the water quality parameters listed in paragraphs (C) (2) (c) to (g) of rule 4906-13-04 of the Administrative Code, such change being attributable to the operation of the facility (for construction impact, such change must occur for a period of time equal to or greater than four months);
 - (c) Defacing of natural topography without subsequent removal of construction debris, restoration of landscaping and vegetation, and minimization of the adverse effects of such operations.
 - (d) The loss of terrestrial and/or aquatic biota which endangers survival potential or causes irreversible biological displacement; or

- (c) Commitment of natural resources contrary to law, and extending beyond the expected useful life of the proposed facility.
- (4) Substantial social impact
- (a) Any action or installation which may endanger public health or safety;
- (b) Any action or installation which may create an economic loss to a community or the surrounding populace such as a decrease in property values, loss of jobs, decrease in business income, etc.; or
- (c) Any action which may detract from the cultural value and aesthetic quality of a scenic area, recreation area or other recognized landmarks (as defined by paragraph (F) (1) (b) of rule 4906-13-05 and paragraph (F) (1) (b) of rule 4906-15-05 of the Administrative Code)

Again, it is necessary to submit a letter of intent to the Power Siting Commission in order to elicit its determination as to whether the Piqua project constitutes a "substantial addition".

It is, therefore, my conclusion that, whether or not a certificate must ultimately be applied for, a "letter of intent" must be submitted. In fact, one of the stated purposes of this letter of intent is "to clarify jurisdictional questions with respect to replacements of existing facilities with like facilities, substantial additions or other jurisdictional questions." Ohio Administrative Rule #4906-5-01 (B) (3). A complete copy of the procedural rules are attached herewith and it only remains to be noted that Ohio Administrative Rule #4906-5-12 (A) provides that "an applicant considering construction of a major utility facility may confer with the Commission staff prior to submitting a Letter of Intent in order to obtain guidance concerning the suitability of a particular site." It is my recommendation that such a conference take place. The Power Siting Commission is located at the following address:

SENECA TOWERS
SUITE 716
361 E. BROAD STREET
P.O. BOX 1735
COLUMBUS, OHIO 43216

CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

5.2.3.

DATE: FEBRUARY 12, 1979
MEMO TO: HANSELMAN-ESKEW & ASSOCIATES
FROM: STEPHEN E. KLEIN
RE: BOUNDARIES OF CERTIFIED TERRITORIES OF ELECTRIC SUPPLIERS

In response to your request for information concerning statutory restrictions on the geographical territory which potentially could be served by the proposed District Heating & Cooling District, the only state laws conceivably applicable are Sections 4933.81 through 4933.90, R.C. (Certified Territories for Electric Suppliers).

The starting point in the analysis of these statutes is Section 4933.83 (A) which reads in pertinent part:

Except as otherwise provided in this section and Article XVIII of the Ohio Constitution, each electric supplier shall have the exclusive right to furnish electric service to all electric load centers located presently or in the future within its certified territory, and shall not furnish, make available, render, or extend its electric service for use in electric load centers located within the certified territory of another electric supplier....

The definition or "formula" for determining the "certified territory" within which each electric supplier has an exclusive right to furnish electric service is found in Section 4933.82 (A), R.C.

Except as otherwise provided in this section, the boundaries of the certified territory of each electric supplier shall be considered set as a line or lines substantially equidistant between its existing distribution lines and the nearest existing distribution lines of any other electric supplier in every direction, so that there is thereby certified to each electric supplier such land area as is located nearer to one of its existing distribution lines than to the nearest existing distribution line of any other electric supplier.

Assuming for the moment that "distribution lines" (electric lines having a design voltage below 35,000 volts phase to phase which are being or have been used primarily to provide electric service directly to consumers) would retain their function in the Piqua project such that they could feasibly demarcate the limits of the service territory, it would appear that these statutes are

applicable to the District Heating & Cooling Project. Nevertheless, appearances may be deceiving, even though, according to Section 4933.82 (F), R.C., "all portions of the state shall be included within certified territory established pursuant to this section."

For example the definition of "electric supplier" as used in the above-quoted statutes, expressly excludes a municipal corporation that provides electric service. Section 4933.81 (A), R.C. Therefore, if Piqua is a municipal corporation that provides electric service, Piqua is apparently not an "electric supplier".

Again, the term "electric service" is defined in Section 4933.81 (F), R. C. as "retail electric service furnished to a consumer for ultimate consumption." If the District Heating & Cooling System only supplies hot water, then the System would not be required to comply with these statutes which only seek to regulate electric service.

Moreover, Article XVIII of the Ohio Constitution is frequently cited as an exception to these statutes and this Article not only grants to municipalities like Piqua the authority to exercise all powers of local self-government (Section 3) but permits any municipality to own and operate within or without its corporate limits, any public utility (Section 4). Even more to the point, Section 6 of Article XVIII states that any municipality, owning or operating a public utility for the purpose of supplying the service or product thereof to the municipality or its inhabitants, may also sell and deliver to others... the surplus product of (the) utility...."

Reference to Article XVIII is contained not only in Section 4933.83 (A) R. C., quoted above, but also in Section 4933.83 (C), R.C.

Except as provided in division (B) of this section and Article XVIII of the Ohio Constitution, each electric supplier has the obligation and exclusive right to furnish electric service to electric load centers, wherever located, which it was serving on January 1, 1977, or which it had agreed to serve under lawful contracts in effect on or resulting from written bids submitted under bond prior to January 1, 1977, and no other electric supplier shall furnish, make available, or extend electric service to any such electric load centers.

The effect of annexation on "certified territories" is governed by Section 4933.84, R. C. which, despite its self-contradictory nature, probably exempts the Piqua project from statutory restriction

Annexation or incorporation by a municipal corporation or other unit of local government does not affect the right of an electric supplier to continue or extend electric service within its certified territory except insofar as that right is affected or modified by Article XVIII or any other article of the Ohio Constitution. Notwithstanding this section or any other provision of law, the right of a municipal corporation to furnish service to such portion of the corporation as has been annexed to the corporation since the time maps have been drawn in accordance with section 4933.82 of the Revised Code shall not be abridged.

Finally, as if to clarify a municipal utility's complete freedom from control by Sections 4933.81 through 4933.90, R. C., Section 4933.87, R. C. states unequivocally, that:

Nothing contained in sections 4933.81 to 4933.90 of the Revised Code shall be construed to affect the right of municipal corporations to generate, transmit, distribute, or sell electric energy. The rights and powers of municipal corporations as they exist on or after the effective date of this section to acquire, construct, own, lease, or operate in any manner a public utility or to supply the service or product by means of a rate ordinance adopted under section 743.26 of the Revised Code or under Section 4, Article XVIII, Ohio Constitution in any portion of the state is not affected by sections 4933.81 to 4933.90 of the Revised Code.

From the above analysis, it would seem that municipal power plants are totally exempt from this statutory attempt to fix the boundaries of service areas, due to the many exceptions quoted above. Yet such a conclusion means that the "exceptions swallow up the rule" because if the boundaries of municipal utilities remain unregulated, those investor-owned utilities who have common boundaries with the municipal utilities would, to that extent, be unregulated as well and subject to unrestricted encroachment. Such a result would nullify the express intent of Section 4933.82 (F) that "all portions of the state shall be included within certified territory established pursuant to this section."

In summation, it is my conclusion and you are so advised that Sections 4933.81 through 4933.90 of the Revised Code is not applicable to the District Heating and Cooling Project for the following reasons:

1. The District Heating & Cooling System does not fit the definition of an "electric supplier";
2. The District Heating & Cooling System does not provide "electric service" as that term is defined;
3. The formulation of boundaries according to "distribution lines" has no practical application to the District Heating & Cooling System;
4. The application of these statutes to municipal utilities would violate Article XVIII of the Ohio Constitution.

CAVEAT: Since these statutes have been in effect only six months, they have not yet received any judicial interpretation. In addition, if the intent of these statutes is to achieve a comprehensive division of all service areas in the state, such intent is substantially violated by excluding municipal utilities from its provisions. I strongly suggest that before any action is taken which runs counter to the provisions of these statutes, this matter should be brought to the attention of the P.U.C.O., perhaps at the time of our meeting with the Power Siting Commission.

CITY OF PIQUA

5.2.4.

219 WEST WATER STREET · PIQUA, OHIO 45356

MEMORANDUM ON RIGHTS OF MUNICIPAL RESIDENTS TO DEMAND UTILITY SERVICE FROM A CITY-OWNED UTILITY

TO: Hanselman/Eskew and Associates
FROM: Stephen E. Klein, Project Attorney
DATE: May 25, 1979

In reply to your request for my opinion regarding possible rights of municipal residents to demand service from a municipally-owned utility, please be advised as follows:

Section 4 of Article 18 of the Ohio Constitution states in part that "Any municipality may . . . operate within or without its corporate limits, any public utility the products or service of which is or is to be supplied to the municipality or its inhabitants . . ."

Interpreting this constitutional provision, the Ohio Supreme Court has, in Pfau v. City of Cincinnati, 142 O. St. 101, 50 N.E. 2d 172 (1943), broadly enunciated municipal independence from legislative restraints in the operation of public utilities. In that case, the court concluded that the "Legislature is without power to impose restrictions or limitations upon . . ." the rights conferred upon municipalities in Section 4. In any, statutes only control the operations of non-charter municipalities---Piqua is a charter city.

In State ex. rel. Indian Hill Acres, Inc. v. Kellogg, 149 O. St. 461, 79 N.E. 2d 319 (1948), the Ohio Supreme Court concluded that a municipality was not required to supply service to all of the public who demanded it just because it was disposing of utility service outside of its limits. Rather, a municipality was thought to have the discretion to decide through its legislative body whether or not it was in the best interests of the inhabitants of the municipality to provide this service. Thus, council could conclude that it was advisable to suspend any extension of extraterritorial service in order to supply service to inhabitants; it could even decide, without being discriminatory, that it was in the best interests of the municipality to make exceptions to the suspension of service for hardship cases and for those potential users who petitioned for annexation of their property to the municipality.

It is significant to note that the constitutional provision which permits a city to own and operate a public utility supplying service to its inhabitants does not require that all a city's inhabitants be served. In fact, the only constitutional restriction touching this issue at all, limits the supply of service (rather than the contrary) by restricting the amount of service supplied to non-inhabitants to less than fifty percent of the amount of service supplied to inhabitants of the city. (Art. XVIII Sec. 6, Ohio Const.)

Therefore, it is my opinion, and you are so advised, that neither constitutional nor statutory restrictions exist which would fetter the sound judgment of the City of Piqua by mandating public utility service to all inhabitants without qualification.

Stephen E. Klein
Attorney at Law

SEK/km

5.2.5.

MEMORANDUM ON POSSIBLE LEGAL RECOURSE BY OTHER PUBLIC UTILITIES
IN RESPONSE TO CO-GENERATION

TO: HANSELMAN-ESKEW & ASSOCIATES

FROM: STEPHEN E. KLEIN, ATTORNEY

DATE: MARCH 9, 1979

In response to your request for my opinion as to the potential liability of the District Heating & Cooling System for depriving competing public utilities of consumers, please be advised as follows:

At the outset, it should be stated that, given the amorphous character of tortious claims, a lawsuit can always be fashioned out of a set of facts when enough money or economic hardship is involved. Obviously, if one of the consequences of a successful District Heating and Cooling System is to obtain customers who had been users of alternate energy suppliers, those energy suppliers will be motivated to discourage further reduction in the number of their consumers and they may adopt a legal recourse for this purpose. Nevertheless, it is my opinion and you are so advised that, in all probability, no successful cause of action can be framed under the circumstances which could prevent or hinder competition between the District Heating and Cooling System and other utilities for customers.

My conclusion is based in part, upon the examination of the more traditional forms of tort claims such as "Inteference with Contractual Relations," "Inteference with Prospective Advantage," etc. See Prosser, Torts, 4th Ed. at 927 et. seq. Clearly, these tradional types of actions are inapplicable here because no "unfair competition" is evident. Rather, the contrary is true, which brings up the second possible claim theoretically available to local suppliers of alternate energy forms: franchise infringement.

Competition in the marketplace is only objectionable in the realm of public franchises wherein virtual monopolies are tolerated in order to lower the cost and raise the efficiency of certain products and services, such as electric and gas service.

In the abstract, it could be alleged that suppliers of energy for heating purposes should not be competitive because such a condition violates the franchise principal. Yet, in fact, a supplier of gas or electricity for heating purposes holds a franchise for gas or electric service rather than for heat. Therefore, so long as the proposed District Heating & Cooling System supplies only hot water to consumers, not gas, there can be no franchise infringement. If alternate forms of energy for heating purposes are more economical, the public weal mandates the availability of those energy forms.

Moreover, the District Heating & Cooling System would have available to it the municipal condemnation power which permits condemnation of existing facilities. Village of Blue Ash v City of Cincinnati, 173 O. St. 345, 182 NE 2d. 557 (1962). Even more important is the principal enunciated by the state constitution that municipalities are not required to condemn existing utilities as a condition to establishing their own. Vabel, Municipal Home Rule in Ohio, 1428-1429. Clearly, such license to create a competing municipally-owned utility within the district of a privately-owned but franchised utility demonstrates the conclusion that any existing energy supplier cannot prevent the growth of the proposed District Heating & Cooling System.

CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

5.2.6.

MEMORANDUM ON THE CITY'S AUTHORITY TO PROCEED WITH THE IMPLEMENTATION OF THE PROPOSED DISTRICT AND HEATING AND COOLING SYSTEM

TO: Hanselman/Eskew and Associates
FROM: Stephen E. Klein, Project Attorney
DATE: May 25, 1979

In reply to your request for my opinion on the authority of the City of Piqua to proceed with implementing the proposed district heating and cooling system, please be advised as follows:

The City of Piqua derives its authority to "acquire, construct, own, lease and operate within or without its corporate limits, any public utility" directly from the Ohio Constitution (Art. XVIII, Section 4).

The Ohio Supreme Court has declared that this provision of the constitution is self-executing and not subject to restrictions imposed by the state legislature. Swank v. Village of Shiloh, 166 O.St. 415, 143 N.E. 2d 586; Pfau v. Cincinnati, 142 O.St. 101, 50 N.E. 2d 172.

As succinctly stated in Vaubel, Municipal Home Rule in Ohio, 1399, 1400:

In theory, then, municipal power to acquire and operate public utilities is the most expansive of the Home Rule powers because it is more free from state control than any other Home Rule power. It is not subject to a variance limitation as is local
"CITY OF OPPORTUNITY"

self-government power in the case of non-charter municipalities.

It is not subject to the direct limitations of Section 6, Article XIII, and Section 13, Article XVIII, as are the municipal powers of taxation and incurring debt. In the latter regard, the issuance of municipal revenue bonds for the acquisition of public utilities, under provisions of Section 12, Article XVIII, have been found not to constitute debt; therefore, they do not come within state debt controlling powers. However, utility acquisition bonds issued under Section 4, Article XVIII, which pledge the general credit of a municipality do constitute debt, and these come within state control.

This absence of either express or implied constitutional limitations upon municipal utility power has led the courts to hold repeatedly that the state cannot deprive, lessen, limit, curtail, modify, condition, restrict, interfere with, burden or circumvent municipal constitutional power. Even though the state can "implement" municipal power, the state cannot "regulate" it, because regulation has been found to constitute a forbidden limitation. Only on rare occasions have contrary or qualifying views been expressed, and then without persuasive force.

Therefore, it is my opinion and you are so advised, that the City of Piqua possesses an authority, free of constitutional or statutory restrictions, to implement the proposed district heating and cooling system.

Stephen E. Klein
Attorney at Law

5.3 FINANCIAL ASSESSMENT

Assessing the financial capacity of the Piqua community to undertake the district heating and cooling project requires consideration of:

- 1) the city's current financial status
- 2) the financing mechanisms and instruments available to the community for implementation and
- 3) an assessment of methods available to finance end-user retrofits.

Section 5.3.1 assesses the current financial status of the City of Piqua and discusses the City's key financing method i.e., bond financing. Section 5.3.2 identifies and evaluates end-user retrofit financing capabilities/resources.

The Demonstration Team dismisses by observation certain financing schemes and debt instruments which are more appropriately considered by investor held utilities. Federal and State law provides cities (and consequently the Piqua Municipal Power System) with financing methods which are not available to investor held utilities i.e. tax exempt revenue bonds and tax exempt general obligation bonds. The sale of stock or corporate securities is not an option available to the City of Piqua. Section 5.2 evaluates alternative "innovative ownership schemes" and finds them lacking appropriateness or substantial financial advantages.

5.3.1 FINANCIAL STATUS AND BONDED INDEBTEDNESS

The responsibilities for the major financial functions of the City are divided among the Manager, the Director of Finance and the Commission. Preparation of the budget is the responsibility of the city manager. Appropriations fall exclusively within the domain of the city commission.

The Director of Finance is the fiscal officer of the City and also its chief accounting officer. The Director is to keep the books of the City and exhibit accurate statements of all monies received and expended and of all taxes and assessments. At the end of each fiscal year, or more often if requested by the Commission, the Director is to examine the accounts of all officers and departments of the City. The Director is not to allow the amount set aside for any appropriation to be overdrawn, or the amount appropriated for any one item of expense to be drawn upon for any other purpose, or a voucher to be paid unless sufficient funds are in the treasury of the City to the credit of the fund upon which such voucher is drawn. The Director is charged with the responsibility of receiving and dispersing all funds of the City and maintaining custody thereof.

Other important financial functions are:

- 1) General recommendations and planning by the Manager.
- 2) Budget preparation by the Manager with the assistance of the Director of Finance.
- 3) Express approval of all budgeting and appropriations of monies by the City Commission.
- 4) Examination of accounts by the Bureau of Inspection and Supervision of Public Offices, discussed under the next caption.
- 5) Assessment of real property by the County Auditor, who is an elected official, subject to supervision by the State Commissioner of Tax Equalization.
- 6) Assessment of public utility property and tangible personal property by the State Tax Commissioner.

The City maintains its accounts, appropriations and other fiscal records on a cash basis in accordance with the procedures established and prescribed by the Bureau of Inspection and Supervision of Public Offices in the office of the Ohio Auditor of State. The Bureau is charged by Ohio law with the responsibility of inspecting and supervising the accounts and records of the

City, as well as each taxing subdivision and most public agencies and institutions in Ohio. The most recent examination of the City's accounts and records by the Bureau was completed through March 31, 1977, and has been received by the City. No material findings or items for adjustment were made.

Assessed Valuation--Set forth below is the assessed valuation, for the most recent five years, of property within the City subject to ad valorem taxes levied by the City.

<u>Tax Collection Year</u>	<u>Real Property (Other than Public Utility) (a)</u>	<u>Public Utility Real Property and Tangible Personal Property (b)</u>	<u>Tangible Personal Property (Other than Public Utility) (c)</u>	<u>Total Assessed Valuation</u>
1975	\$50,587,890	\$4,239,780	\$26,526,800	\$ 81,354,470
1976	51,505,790	3,780,360	20,728,000	86,014,150
1977	52,051,680	3,775,930	30,992,370	86,819,980
1978	68,709,620	3,829,480	31,566,250	105,105,350
1979	69,789,190	3,598,010	36,322,060	109,709,260

Source: County Auditor

- a) Real property taxes collected in a calendar year are levied in the preceding calendar year on assessed values as of January 1 of that preceding year.
- b) Public utility real and tangible personal property taxes collected in a calendar year are levied in the preceding calendar year on assessed values determined as of December 31 of the second year preceding the tax collection year.
- c) Tangible personal property taxes collected in a calendar year are levied in the same calendar year, on assessed values during and at the close of the most recent fiscal year of the taxpayer (ending on or before March 31 of said calendar year) at tax rates determined in the preceding year.

The City's present land area is 5.35 square miles. Percent of assessed valuation by major land use category is illustrated on the following page.

<u>Category</u>	<u>Percent Of Assessed Valuation</u>
Residential	74.36%
Commercial	15.86%
Industrial	9.40%
Agricultural	.38%

The seven largest ad valorem property tax payers with respect to property located in the City, based on assessed valuation of taxable real property in the City for the 1978 collection year, are:

<u>Name of Taxpayer</u>	<u>Nature of Business</u>	<u>Assessed Valuation*</u>
French Oil Mill Machinery Co.	Extraction machinery	\$2,223,110
Aerovent, Inc.	Industrial air handling equipment	2,215,950
Hartzell Propeller, Inc.	Propeller manufacturing	2,017,020
Orr Felt Company	Paper makers and felt products	1,835,170
Medalist-Allen A. Company	Clothing manufacturing	1,833,150
Champion International Corp.	Paper products manufacturing	1,708,500
Wayne Corporation (Miller-Meteor Div.)	Hearses	1,484,520

* Source: County Auditor

There are also two public, investor owned, utilities located in the City which have substantial assessed valuations: (i) Ohio Bell Telephone Company, a telephone utility with an assessed valuation of \$2,015,190 and (ii) Dayton Power and Light Company, an electric and natural gas utility with an assessed valuation of \$1,576,670.

Pursuant to statutory requirements of a sexennial reappraisal, the County Auditor adjusted the true value of taxable real property to reflect then current fair market values in 1977. These adjustments were reflected in the 1977

duplicate (collection year 1978) and in the ad valorem taxes distributed to the City in 1978. Pursuant to law, the assessment ratio has been fixed at 35% of true value under existing rules of the Ohio Commissioner of Tax Equalization. The County Auditor is required to adjust (but without individual appraisal of properties except in the sexennial reappraisal) taxable real property value triennially to reflect true values. Thus, taxable real property is to be assessed at not more than 35% of its true value, except that taxable real property devoted exclusively to agricultural use is to be assessed at not more than 35% of its current agricultural use value as determined by the County Auditor in accordance with rules adopted by the Commissioner for such purpose.

The Ohio General Assembly has from time to time exercised its power to revise the Ohio laws applicable to the determination of assessed valuation of property subject to ad valorem taxation and the amount of tax proceeds produced by ad valorem taxes levied on such property. It is anticipated that the General Assembly will continue to make such revisions.

The following are the rates for the years indicated, in mills per \$1.00 of assessed valuation, at which the City and the overlapping taxing subdivisions levied ad valorem property taxes.

Collection Year	Tax Table A Overlapping Tax Rates					Effective Total Rate *
	City	County	Piqua City School District	Jt. Voc. School District	Total	
1975	5.40	4.90	27.90	2.90	41.10	Not Applicable
1976	5.40	7.50	28.00	2.60	43.50	Not Applicable
1977	5.50	7.50	31.60	2.60	47.20	Not Available
1978	5.60	7.50	31.30	2.40	46.80	37.57
1979	5.50	7.50	30.10	2.40	45.50	36.14

Source: County Auditor

* Under statutory procedures, the amount realized by each taxing subdivision from real property taxation (other than amounts realized from taxes levied at a rate required to produce a specified amount, such as for debt

service charges or emergency school levies, and taxes levied inside the ten-mill limitation or any applicable charter tax rate limitation) is limited to the amount realized from real property taxes in the preceding year plus: (i) any new taxes (other than renewals) approved by the electorate but calculated to produce an amount equal to what would have been realized if levied in the preceding year and (ii) amounts realized from new and existing taxes on the assessed valuation of real property added to the tax duplicate since the preceding year. As noted, only the City's one mill hospital levy is subject to these restrictions. All real property taxes are further reduced by an additional 10% (see "Collection of Ad Valorem Taxes and Special Assessments" herein for discussion of reimbursement by the State for such 10% reduction). The "Effective Total Rate" column reflects the aggregate of the foregoing reductions for the City and the overlapping taxing subdivisions and therefore the effective rate at which real property taxes are levied.

The following are the rates, in mills per \$1.00 assessed valuation, at which the City levied ad valorem property taxes for the indicated general categories of purposes and for the years indicated:

TAX TABLE B

City Tax Rates

Inside the Ten Mill Limitation

<u>Collection Year</u>	<u>Operating</u>	<u>Police and Fire Pension</u>	<u>Debt Retirement</u>	<u>Total</u>
1975	3.70	.60	-0-	4.30
1976	3.70	.60	-0-	4.30
1977	3.70	.60	-0-	4.30
1978	3.70	.60	-0-	4.30
1979	3.70	.60	-0-	4.30

Voted Tax Rates

<u>Collection Year</u>	<u>Operating</u>	<u>Debt Retirement</u>	<u>Hospital</u>	<u>Total Voted</u>
1975	-0-	.20	.90	1.20
1976	-0-	.20	.90	1.20
1977(a)	-0-	.20	1.00	1.30
1978	-0-	.20	1.00	1.20
1979	-0-	.20	1.00	1.20

(a) In 1977, a voted .10 mill tax for operating purposes of the Miami Conservancy District was also levied.

The voted tax levies for "Debt Retirement" continue for the life of the bonds authorized by the electors, in annual amounts sufficient to pay debt service on such bonds as the same becomes due.

THE MUNICIPAL INCOME TAX--In 1966 the electors of the City authorized the Commission to levy a .7% income tax, renewable on an annual basis. The tax was increased to 1% on a continuing basis in 1972. The municipal income tax is collected and administered by the Director of Finance.

The income tax, which is levied on both corporate income and employee wages and salaries, is in effect at the rate of 1.0% for a continuing period of time. The proceeds of the income tax, after payment of the expenses of collection thereof, have been allocated by the Commission for the current year as follows: 44% to the general fund, 28% to the Street Construction Fund, 21% to the Safety Forces and 7.0% to the Park Fund.

The annual collections of the City income tax for the last five calendar years and the amount estimated for the current year were and are:

<u>Year</u>	<u>Amount</u>	<u>Tax Rate (%)</u>	<u>Resident Credit (%)*</u>	<u>Estimated Delinquency</u>
1974	\$ 977,173	1.0%	100%	\$3,900
1975	1,029,427	1.0%	100%	4,100
1976	1,081,352	1.0%	100%	4,300
1977	1,148,513	1.0%	100%	4,600
1978	1,256,577	1.0%	100%	5,000
1979 (estimated)	1,338,953	1.0%	100%	5,379

* Residents permitted, as credit against City income tax payment, the stated percentage of income tax they paid as employees in another municipal corporation.

OTHER INCOME--Piqua also realizes income from other sources such as fees, fines, Local Government Fund and General Revenue Sharing. Piqua Municipal Power System rates and revenues are discussed in other sections of the analysis.

CITY DEBT AND OTHER LONG TERM OBLIGATIONS-- The following describes statutory and constitutional debt and ad valorem property tax limitations applying to the City, and presently outstanding and projected bond and note indebtedness of the City. As further discussed and described below, the Notes are partially

exempt debt with approximately one-half of the principal amount subject to both of the direct debt limitations, and are subject to the indirect debt (and related property tax) limitation. The water rate increase is expected to result in all debt for the water utility being exempt from direct debt limitations.

STATUTORY DIRECT DEBT LIMITATIONS---The Revised Code provides that the net principal amount of both voted and unvoted debt of the City that is not "exempt debt" (discussed below) may not exceed 10-1/2% of the total value of all property in the City as listed and assessed for taxation, and that the net principal amount of its unvoted non-exempt debt may not exceed 5-1/2% of such value. These two limitations, referred to as the "direct debt limitations", may be amended from time to time by the General Assembly.

The City's ability to incur unvoted debt (whether or not exempt from the direct debt limitations) is also restricted by the indirect debt limitation (discussed under the caption "Indirect Debt and Unvoted Property Tax Limitations"). In the case of unvoted non-exempt debt both the direct and indirect debt limitations apply.

The Revised Code provides that various types of debt that the City may issue are exempt from the direct debt limitations ("exempt debt"). Exempt debt includes, among others: general obligation debt issued for municipal utility (water, sewage disposal, sewerage, electric, gas), off-street parking, hospital, and garbage and refuse collection or disposal improvements, to the extent that such debt is "self-supporting" (that is, revenues from the category of facilities are sufficient to pay applicable operating and maintenance expenses and all related debt service and other requirements); bonds issued in anticipation of the collection of special assessments; revenue bonds; notes issued in anticipation of the collection of current revenues (which under Ohio law have a maximum six months maturity) or in anticipation of the proceeds of a specific tax levy; notes issued for certain emergency purposes; bonds issued to pay non-contractual final judgments; and unvoted general obligation bonds, to the extent that debt service thereon will be met from

lawfully available municipal income taxes to be applied thereto, issued pursuant to ordinances containing covenants of the City to appropriate annually from such municipal income taxes amounts necessary to meet the highest annual debt service payments (the City has no such income tax supported debt outstanding). To the extent that bonds which may be issued would be exempt debt, notes issued in anticipation of such bonds also would be exempt debt.

In calculating the debt subject to the direct debt limitations, the amount of money in the City's Bond Retirement Fund allocable to the principal amount of non-exempt debt is deducted from gross non-exempt debt.

Without consideration of money in the City's Bond Retirement Fund, and based on the currently applicable assessed valuation:

a) The total voted and unvoted debt of the City that could be issued, subject to the 10-1/2% limitation applicable to total non-exempt debt is \$11,519,472. The total City debt (including an allocated portion of \$1,323,000 of the Notes) subject to such limitation is \$1,512,900, leaving a borrowing capacity of \$10,006,572 within the 10-1/2% limitation for combined voted and unvoted non-exempt debt.

b) The total City unvoted non-exempt debt that could be issued subject to the 5-1/2% limitation is \$6,034,009. The total City debt subject to such limitation (including an allocated portion of \$1,323,000 of the Notes) is \$1,464,900, leaving a borrowing capacity of \$4,569,109 within the 5-1/2% limitation for unvoted non-exempt debt.

DEBT CURRENTLY OUTSTANDING--The following tables list the City's outstanding debt represented by bonds and notes as of April 1, 1979.

Principal Amounts of Debt Outstanding;
Leeway for Additional Debt Within Direct Debt Limitations

A. Total debt including the Notes but excluding the outstanding notes being funded with the Notes:			\$ 6,805,919
B. Exempt debt:			
<u>Category</u>	<u>Outstanding Principal Amount</u>		
Special Assessment	\$ 266,919		
Sewer General Obligation	455,000		
Parking General Obligation	39,100		
Water General Obligation (including \$1,377,000 of the Notes)	1,527,000		
Mortgage Revenue (Electric and Sewer)	3,005,000		
Total exempt debt:			\$ 5,293,019
C. Total non-exempt debt (A minus B):			\$ 1,512,900
D. 5-1/2% unvoted debt limitation (5-1/2% of assessed valuation):			\$ 6,034,009
E. Total limited tax non-exempt bonds and notes outstanding:			
Bonds outstanding	\$ - 0 -		
Notes outstanding (including \$1,323,000 of the Notes)	\$1,464,900		\$ 1,464,900
F. Debt leeway within 5-1/2% unvoted debt limitation, but subject to indirect debt limitation (D minus E):			\$ 4,569,109(a)
G. 10-1/2% direct debt limitation on voted and unvoted debt (10-1/2% of assessed valuation):			\$11,519,472
H. Total non-exempt bonds and notes outstanding:			
Bonds outstanding	\$ 48,000		
Notes outstanding (including \$1,323,000 of the Notes)	\$1,464,900		\$ 1,512,900
I. Debt leeway within 10-1/2% direct debt limitation (G minus H):			\$10,006,572(a)
(a) Leeway determined without reference to applicable moneys in the City's Bond Retirement Fund.			

Various City and Overlapping

General Obligation Debt Allocations

	<u>Amount</u>	<u>Per Capita (b)</u>	<u>% of City's Current Assessed Valuation</u>
Net City Non-exempt GO Debt (a)	\$1,512,900	\$ 74.54	1.38%
Total City GO Debt (exempt and non-exempt)	\$6,805,919	\$335.34	6.20%
Total Overlapping GO Debt (c)	\$8,059,764	\$397.13	7.35%

(a) Total City debt, less exempt debt.

(b) Based on 1976 population estimates for the City (Bureau of Census, "Population Estimates and Projections").

(c) Includes, in addition to total City GO debt, allocations of total GO debt of overlapping debt issuing subdivisions, based on assessed valuation of territory of such other subdivisions within City (% figures are percent of total debt of other subdivisions so allocated to City), as follows: \$649,359 of County debt (19.28%); and \$604,486 of Piqua City School District debt (73.36%).

Source of assessed valuation and GO debt figures for overlapping subdivisions:
County Auditor

The City is not and has never been in default on any of its debt obligations.

INDIRECT DEBT AND UNVOTED PROPERTY TAX LIMITATIONS--Voted general obligation bonds, and voted general obligation bonds in anticipation of which notes are issued, may be issued by the City pursuant to a majority vote of the electors of the City. Ad valorem taxes, without limitation as to amount or rate, to pay debt service on such voted bonds are authorized by the electors at the same time the issuance of the bonds is authorized. Voted obligations may also be issued by certain overlapping subdivisions.

General obligation bonds (such as the Bonds) and notes issued in anticipation thereof (such as the Notes) may also be issued by the City (and by certain overlapping subdivisions) without a vote of the electors. Such unvoted bonds and bond anticipation notes cannot be issued by the City unless the tax required to be imposed on taxable property in the City for the payment of

debt service on (a) such bonds (or the bonds in anticipation of which notes are issued), and (b) all outstanding unvoted general obligation bonds (including bonds in anticipation of which notes are issued) of the combination of overlapping taxing subdivision including the City resulting in the highest tax required for such debt service, in any one year is ten mills or less per \$1.00 of assessed valuation. This indirect debt limitation, the product of what is commonly referred to as the "ten mill limitation", is imposed by a combination of the provision of Article XII, Sections 2 and 11 of the Ohio Constitution and Section 5705.02 of the Ohio Revised Code.

The ten mill limitation is the maximum aggregate millage for all purposes that may be levied on any single piece of property by all overlapping taxing subdivisions without a vote of the electors. The ten mills which may be levied without a vote of the electors is allocated among certain overlapping taxing subdivisions in the County, including the City, pursuant to a statutory formula. Of the entire ten mills, 10 mills is in fact currently being levied, in accordance with the formula, by the combination of the City and taxing subdivisions overlapping the City. The current allocation of the ten mills is as follows: 4.3 mills City, 2.4 County, 3.3 School District. Such allocation has remained constant for at least the last five years.

This "inside" millage allocated to each overlapping taxing subdivision is required by present Ohio law to be used first for the payment of debt service on unvoted general obligation debt of the subdivision, unless provision has been made for its payment from other sources, and the balance for other purposes of the subdivision. To the extent this "inside" millage is required for debt service of a taxing subdivision (which may exceed the formula allocation to that subdivision), the amount that would otherwise be available to that subdivision or to other such overlapping subdivisions for general fund purposes is reduced.

Revenue bonds and notes and mortgage revenue bonds are not included in debt subject to the ten mill limitation since they are not general obligations of the City, and neither the general revenue nor the faith and credit of the City is pledged for their payment.

The ten mill limitation applies to all unvoted general obligation debt even if debt service on some of such debt is expected to be paid in fact from special assessments, utility earnings or other sources, such as is the case with the Bonds as discussed above under "Source of Payment for the Notes and the Bonds".

The total millage theoretically required by the City and by the County of Miami (the only overlapping taxing subdivision which has issued unvoted debt) for their outstanding unvoted bonds (including bonds in anticipation of which notes are outstanding) of such subdivision is 5.124 mills for 1980, the year of the highest potential debt service. There thus remains 4.876 mills within the ten mill limitation which has yet to be allocated to debt service by either the City or the County, and which is available to the City or other overlapping subdivision in connection with the issuance of additional unvoted general obligation debt.

LONG TERM FINANCIAL OBLIGATIONS OTHER THAN BONDS AND NOTES--The City has no long term financial obligations, other than the bonds and notes described above.

FUTURE FINANCINGS--At this time the City has definite plans to undertake three new capital improvement projects for which it plans to borrow moneys. These three require the borrowing of approximately \$12,800,000 of additional moneys although the type of financing to be used is not decided in all cases. The most immediate of the three is the installation of a bag house pollution control equipment at the Piqua Municipal Power System plant at an estimated cost of \$3,000,000 which, it is now contemplated, will be financed through the issuance of mortgage revenue bonds. The second and third capital improvement projects include improvements to the City's sewage collection and treatment system and water treatment plant, respectively.

The City also plans to issue an aggregate of \$181,000 in general obligation bonds or notes in anticipation of such bonds during the next twelve months to retire notes already outstanding. Of such principal amount, all will be unvoted debt payable primarily from utility and parking revenues and income tax proceeds.

CONCLUSIONS--The primary method of financing the district heating retrofit (in plant work and installation of the distribution system) will be through the issuance of mortgage revenue bonds--self liquidating debt. General Obligation Bonds should be considered as their use relates to:

- the district heating project's broad, longterm impact on general community economic viability
- general investment in the city's future
- easing the initial years front-end burden.

5.3.2 END-USER FINANCIAL ALTERNATIVES

The retrofit of the individual structures will depend upon the ability of the structure owner to assemble the capital required to accomplish the retrofit. Many sources of capital are available, and it is expected that the vast majority of retrofits will be performed relying upon traditional sources of money.

The residential survey indicated that slightly over 45% of the home owners would use cash-on-hand or savings to finance an energy saving improvement of five hundred dollars or more.* It is assumed that for actual financing, this estimate should be lowered due to consumers' imperfect knowledge of cost of retrofit and imperfect knowledge of the future market conditions. For these reasons, a conservative estimate would be that approximately 15% will retrofit using cash or savings; the remaining 85% will require financing of one form or another.

Several bankers and loan officers in Piqua were presented with this scenario, and all agreed that financing retrofits would present no problems to their institutions. In fact, they expressed a willingness to participate in lending funds for short-terms (⁺ five years) at interest rates around 11%. The bankers stated that loans of this type could generally be processed as signature loans and would not require mortgages to be written as in a home improvement loan. Home improvement loans will also be available.

Although lending institutions have expressed interest in lending money and support the project, it is fully understood that the local lenders will not be able to make loans in support of the full 85% of the retrofits due to household/business financial conditions. For this reason, other sources of financing have been analyzed as alternatives to end-users. The following indicates sources of capital either available or potentially available to aid in financing end-user systems.

* Please refer to Appendix for financing methods at the Zone level.

- a) Tax Credits/Incentives--systems designed to reduce the cost of retrofit to end-users by lessening the tax burden on the users, include property tax abatements, energy credits, local income tax credits, state and federal tax credits. These systems provide incentives to retrofit, not financing for retrofit, and would be most attractive to persons generally in middle income groups. The reader should refer to section 5.2.8, Project Taxes for additional information on this subject.
- b) Low Interest Loans for Residential Retrofit--there are several ways of generating capital for retrofit loans at an interest rate lower than 11%. The primary condition for generating a loan pool for purposes such as district heating is to reduce cost of money the private sector must pay over that of the public sector. Therefore, a public agency is generally the direct or indirect source for lower interest loans. The City of Piqua can take the initiative in assembling low interest loan financing. The FHA, Community Improvement Loan program is a source example. The program below has authorization, however, the Demonstration Team is having some difficulty determining the current level of funding.

**14.108 MAJOR HOME IMPROVEMENT LOAN
INSURANCE-HOUSING OUTSIDE URBAN
RENEWAL AREAS**

(203(k))

FEDERAL AGENCY: HOUSING PRODUCTION AND MORTGAGE CREDIT/FHA, DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

AUTHORIZATION: National Housing Act, Section 203(k); Public Law 73-479; 12 U.S.C. 1709, 1715(b).

OBJECTIVES: To help families repair or improve existing residential structures outside urban renewal areas.

TYPES OF ASSISTANCE: Guaranteed/Insured Loans.

USES AND USE RESTRICTIONS: HUD insures lenders against loss on loans. These loans may be used to finance the alteration, repair, or improvement of existing one to four-family housing not within urban renewal areas. The housing must be at least 10 years old, unless the loan is primarily to make major structural improvements. The maximum insurable loan on a single-family structure is \$12,000 or \$17,400 in areas where cost levels so require.

- c) Low Interest Loans for Commercial Retrofit-- Financing retrofits in commercial structures encounters many of the same issues that face residential users; however, a business will have financing advantages related to the tax structure (investment credits, depreciation, and assignability of costs). The commercial users have many of the same sources of capital available and many may in fact have established lines of credit.

Additionally, the Small Business Administration has low interest loan money (5-6%) for eligible firms.

59.012 SMALL BUSINESS LOANS

(Regular Business Loans--7(a) Loans)

FEDERAL AGENCY: SMALL BUSINESS ADMINISTRATION

AUTHORIZATION: Small Business Act, as amended, Section 7(a); Public Law 85-536, as amended; 72 Stat. 387; 15 U.S.C. 636(a).

OBJECTIVES: To aid small businesses which have difficulty obtaining financing in the commercial marketplace.

TYPES OF ASSISTANCE: Guaranteed/Insured Loans; Direct Loans.

USES AND USE RESTRICTIONS: To construct, expand, or convert facilities; to purchase building equipment, or materials; for working capital. Excludes gambling establishments, communications media, nonprofit enterprises, speculators in property, lending or investment enterprises, and financing of real property held for sale or investment; also excludes funds to indiscriminately relocate the business. Funds must not otherwise be available on reasonable terms, nor used to pay off a loan to an unsecured creditor who is in a position to sustain loss.

ELIGIBILITY REQUIREMENTS:

Applicant Eligibility: A small business which is independently owned and operated and is not dominant in its field. Generally for manufacturers, average employment not in excess of 250, wholesalers, annual sales not over \$9,500,000; and retail and service concerns, revenues not over \$2,000,000. (See Uses and Use Restrictions above.)

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Statement of personal history, personal financial statement, company financial statements, summary of collateral.

59.022 EMERGENCY ENERGY SHORTAGE ECONOMIC INJURY LOANS

(EES LOANS)

FEDERAL AGENCY: SMALL BUSINESS ADMINISTRATION

AUTHORIZATION: Small Business Act, as amended, Section 7(b)(8); Public Law 93-386, 87 Stat. 1024.

OBJECTIVES: To assist small business concerns seriously and adversely affected by a shortage of fuel, electrical energy, energy-producing resources, or by a shortage of raw or processed materials resulting from such shortages.

TYPES OF ASSISTANCE: Direct Loans; Guaranteed/Insured Loans

USES AND USE RESTRICTIONS: May be used for working capital, to pay financial obligations the concern would have been able to

meet had it not suffered the energy shortage. Provide refinancing of short term (and in some instances long term) debt, and to convert its operation to a different fuel source. Excludes speculation, nonprofit enterprises, change of ownership, real property for sale or investment, agricultural activity, financing. No funds for upgrading, relocation, or construction.

ELIGIBILITY REQUIREMENTS:

Applicant Eligibility: Small business must be independently owned and operated, not dominant in its field; and meet SBA size standards. Except for Vietnam-era veterans, business must have been in operation for the preceding 3 years. Repayment ability must be demonstrated and evidence of substantial economic injury must be provided.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Statement of personal history; personal financial statement, company financial statements for current as well as past years, summary of collateral.

**59.013 STATE AND LOCAL DEVELOPMENT
COMPANY LOANS**

(501 and 502 Loans)

FEDERAL AGENCY: SMALL BUSINESS ADMINISTRATION

AUTHORIZATION: Small Business Investment Act of 1958, as amended, Title V, Public Law 85-699; 15 U.S.C. 696.

OBJECTIVES: To make Federal funds available to State and local development companies to provide long-term financing to small business concerns located in their areas. Both State and local development companies are corporations chartered for the purpose of promoting economic growth within specific areas.

TYPES OF ASSISTANCE: Direct Loans; Guaranteed/Insured Loans.

USES AND USE RESTRICTIONS: Loans to State development companies are to assist small businesses with equity capital, and long-term financing. Loans to local development companies are for the purchase of land, buildings, machinery, and equipment or for constructing, expanding, or modernizing buildings. Loans are not available to local development companies to provide small businesses with working capital or for refinancing purposes. Loans to State development companies may not exceed 20 years and loans to local development companies may not exceed 25 years.

ELIGIBILITY REQUIREMENTS:

Applicant Eligibility: A State development company must be incorporated under a special State law with authority to assist small businesses throughout the State. Loans are available to local development companies which are incorporated under general State corporation statute, either on a profit, or nonprofit basis, for the purpose of promoting economic growth in a particular community within the State.

Beneficiary Eligibility: Potential beneficiaries are small businesses independently owned and operated for a profit and not dominant in their fields. More specific criteria defining a small business are established by the Small Business Administration. Loans are not available to assist a charitable institution, newspaper, magazine, radio or television broadcasting company, or similar type enterprise.

Credentials/Documentation: The application should include, among other things, a copy of the development company's charter, bylaws, list of stockholders or membership, and all prescribed financial data.

- d) Basic Grants or Matching Grants for Retrofit-- this alternative relies on federal transfer payments to aid low income households in retrofitting. The City of Piqua currently operates a housing rehabilitation grant program using Department of Housing and Urban Development Block Grant (CDBG) funds for repair/rehabilitation of housing in Piqua. The City currently funds energy related rehabilitation with these monies. Conversations with HUD officials indicate a willingness to participate in a retrofit undertaking that would be of benefit to low and moderate income households. Other federal programs are also available for grants to households for energy improvements, and are being pursued as they apply to Piqua.

The above briefly discusses retrofit financing and describes some financing mechanisms and alternatives. It is not meant to be an inclusive description but to highlight some of the more straightforward financial alternatives that are potentially available and will mesh with the District Heating and Cooling Retrofit System.

5.4 ENVIRONMENTAL IMPACT

INTRODUCTION

During the last 15 years there has been increasing concern within the United States for protection of all aspects of the environment. This concern has resulted in the passage of numerous Federal laws and the subsequent development of implementing regulations to protect various aspects of the environment. These laws cover such diverse areas as air quality, water quality, noise control, archaeological and historic preservation, and protection of endangered species of plants and wildlife. The most significant of the Federal laws and Executive Orders affecting the environment are listed below:

1. The Archeological and Historic Preservation Act of 1974;
2. The Clean Air Act;
3. The Coastal Zone Management Act of 1972;
4. The Endangered Species Act of 1973;
5. The Federal Water Pollution Control Act, as amended;
6. The Fish and Wildlife Coordination Act of 1958;
7. The Flood Disaster Protection Act of 1973;
8. The Marine Protection Research and Sanctuaries Act of 1972;
9. The National Environmental Policy Act of 1969;
10. The National Historic Preservation Act of 1966; Executive Order 11593 ("Protection and Enhancement of Cultural Environment," May 13, 1971): and 36 CFR Part 800 ("Procedures for the Protection of Historic and Cultural Property," January 25, 1974);
11. The Rivers and Harbors Act of 1899;
12. The Safe Drinking Water Act of 1974;
13. The Solid Waste Disposal Act;
14. The Water Resources Planning Act of 1965;
15. The Wild and Scenic Rivers Act of 1968;
16. Executive Order 11296 ("Evaluation of Flood Hazards in locating Federally Owned or Financed Buildings, Roads, and Other Facilities, and in Disposing of Federal Lands and Properties," August 10, 1966);
17. Federal Insecticide, Fungicide, and Rodenticide Act as amended;
18. The Noise Control Act of 1972.

Some of the laws noted above are concerned with one specific area of the environment, while others have a much broader area of concern. One of the most significant laws is the National Environmental Policy Act of 1969 which requires all Federal agencies to prepare detailed Environmental Impact Statements on major Federal actions that significantly affect the quality of the human environment. The National Environmental Policy Act requires that agencies include in their decision making process an appropriate and careful consideration of all environmental aspects of proposed actions, an explanation of potential environmental effects of proposed actions and their alternatives for public understanding, a discussion of ways to avoid or minimize adverse effects of proposed actions, and a discussion of how to restore or enhance environmental quality as much as possible. Facilities such as district heating and cooling may likely be subjected to an environmental impact analysis to determine whether or not significant environmental impacts will result either directly or indirectly from the proposed project.

In the event that Federal funds are either directly or indirectly involved in the district heating project, the National Environmental Policy Act clearance procedures will apply. There are essentially two methods of environmental clearance provided for in most Federal assistance projects. These are:

- 1) An Environmental Assessment Statement (EAS) -- which includes a summary analysis of the environmental consequences of the project and concludes with a "Statement of No Significant Effect on the Environment". The EAS procedure is used where it is generally obvious that no environmental impacts will result; and that the finding can be made without extensive environmental analysis/evaluation.
- 2) An Environmental Impact Statement (EIS) -- which is employed when it is not possible to file a Notice of Significant Effect on the Environment. The EIS is a much more involved, complex, costly and time consuming analysis of both temporary and long-term environmental impacts which may result from the project. Today, the environmental impact statement considers a full range of consequences which extend well beyond the impacts on the physical environment to

include the social, human, and economic "environment". It is not impossible that before district heating and cooling can be implemented on a large scale that an Urban Impact Statement will also be required.

In addition to the above, the State of Ohio has adopted power siting regulations, and has constituted the Ohio Power Siting Commission which generally reviews plans for power plant construction and the extension of distribution lines/pipes. Section 5.1 of this institutional analysis details the relationship of the City of Piqua to the Ohio Power Siting Commission. In summary, the finding has been made that the City of Piqua's District Heating Project would become subject to the Ohio Power Siting Commission only in the event that the overall capacity of the plant is increased (that the overall production capacity of the plant would go above 60 MW). Attached to the Opinion of Consul is a letter to this effect. It is obvious that the Ohio Power Siting Commission would not become involved in the initial stages of the project implementation even related to the distribution system.

Although this feasibility analysis does not assume direct or indirect Federal financing, it is appropriate that the City of Piqua identify and evaluate the potential of environmental impact analysis on the district heating and cooling project in that:

- 1) it is not inconceivable that a finding could be made that current assistance in planning constitutes Federal involvement;
- 2) that environmental impact legislation could be modified to include projects not financed by the Federal Government; and
- 3) most importantly, regardless of whether or not Federal financial assistance is part of the project, the City and its citizens will want to fully consider the physical and human consequences of the project as it relates to them and their children's everyday lives.

Because the City will want to consider the full range of project impacts; and in that the National Environment Policy Act requirements constitute a comprehensive approach to executing environmental analysis, it is appropriate that this feasibility analysis evaluates the project on a preliminary basis pursuant to the NEPA guidelines.

Utilizing guidelines contained in the National Environmental Policy Act and subsequently promulgated regulations, the EIS analysis is reviewed by appropriate Federal agencies and State agencies and interested citizens or organizations. The draft is then submitted to the President's Council on Environmental Quality. If significant environmental impacts will result from the proposed project, then a full Environmental Impact Statement must be developed along with the related reviews and public hearings required.

Some of the major points which must be addressed in the preparation of an environmental impact appraisal are as follows:

1. Brief description of project;
2. Probable impact of the project on physical, social and economic environment;
3. Any probable adverse environmental effects which cannot be avoided;
4. Alternatives considered with evaluation of each;
5. Relationships between local short-term uses of man's environment/resources, and maintenance and enhancement of long-term productivity;
6. Steps to minimize damage to the physical and human environment;
7. Any irreversible and irretrievable commitment of resources;
8. Public objections to the project, if any, and their resolution; and
9. Agencies consulted about the project.

The potential environmental impacts of a district heating project can be divided into two broad categories. These categories are:

1. The environmental impacts of construction, and
2. The environmental impacts of operation.

The next two sections will address the environmental impacts in each of these categories which may result from the project as they relate to the Study Area.

5.4.1 TEMPORARY IMPACTS OF CONSTRUCTION

The environmental impacts of constructing a district heating system can be further divided into those temporary impacts that exist only during the construction phases and the permanent impacts of the project's construction and location for both the plant and the distribution system. The temporary environmental impacts caused by construction activities are as follows:

1. Noise and dust generated by construction activities;
2. Removal of vegetation and pavement causing soil erosion and siltation during construction;
3. Possible disturbance and silting from river crossing;
4. Disruption of normal traffic patterns caused by construction in streets;
5. Potential for broken gas and water mains and sewer lines;
6. Disruption in the community especially in the central business district; and
7. Temporary inconveniences for businesses and residences while individual connections are being made.

Most of the temporary impacts are the nuisance conditions that are usually associated with construction operations. Most of the impacts can be minimized by the proper planning and execution of various construction activities. For instance, the impact of noise in a residential neighborhood can be minimized by limiting the contractor's operations to normal daytime hours when many people are away from home at work or school. Since essentially all of the distribution and return system will be constructed in existing streets and rights-of-way, some disruption of normal traffic patterns is unavoidable. However, by proper planning of construction operations, the actual time that a street must be closed can be minimized. Maximum use of alleys will also minimize street disruption.

One of the most significant potential impacts during construction operations is the potential breaking of gas mains, water mains, and existing sewer lines while constructing the HP-ICES distribution and return system. In particular, a broken gas main or sewer line could create a significant environmental hazard. A broken gas main can create either an immediate or delayed explosion of disastrous proportions. A broken sewer line can result in the discharge of raw and untreated sewage to nearby drainage ditches, creeks and streams, and create serious public health hazards and water pollution problems. For those reasons, it is important that the initial design carefully locate existing water and gas mains and sewer lines. In addition, it is important that the contractor take certain precautions during construction in the event that all such facilities are not properly and adequately located on the construction plans.

Disruption in the central business district can be minimized by installing main trunk lines behind Main Street and where possible using Miami Conservancy District river corridor land. Again, maximum use of alleys will minimize disruption of normal merchant and customer activity. Proper planning of required river crossings will minimize impact on the Great Miami River as it moves through the City. Where possible the distribution lines can be hung from existing bridges. This of course will necessitate additional permits.

Since most of the power plant construction will take place indoors, little or no impact will result. Trucks carrying equipment and supplies will require access to the plant from I-75 along Route 25-A. This road is currently being widened to four lanes and is bordered by vacant land and industrial uses.

5.4.2 PERMANENT IMPACTS OF CONSTRUCTION

The principal impacts of construction operations that are of a permanent nature are the following:

1. Construction materials required for construction;
2. Energy utilized in the construction process;
3. Land occupied by proposed plant and district heating system;
4. Disruption of previously undisturbed terrain.

The concrete, steel, and other materials required during construction are essentially irreversible and irretrievable commitments of these resources. That is, once they are used in the proposed construction, it is highly unlikely that they will ever be used again for any other purpose. The energy utilized during the construction process will be primarily gas, oil and diesel fuel that is required for the operation of trucks, bulldozers, ditch diggers, and other electrical tools and equipment used during power plant retrofit and construction of the district heating system.

The land on which the power plant is located will be committed to this use for a minimum of 42 years and probably for a much longer time. However, this commitment is not permanent, in that, if the power plant were to be abandoned in the distant future, the building could be torn down and the land could be utilized for other purposes. The low flow dam already exists and is not considered. The major land requirement will be associated with the central plant facility and related distribution system. Land required for the

distribution and return system will only be a narrow easement that is only 10 to 15 feet wide. The City already owns all of the easement for the distribution and return system (there may be a few exceptions). The presence of the distribution and return system will not prevent the land itself from being utilized for its present purposes (streets, alleys). However, in some cases there may be a restriction in building a structure or building within the permanent easement.

One of the major environmental impacts of construction operations is the disruption of previously undisturbed terrain. During construction of the distribution system, rights-of-way must be cleared of vegetation and smoothly graded so that construction equipment can move easily along the right-of-way while digging the trench for the hot water line. If the construction takes place in an area that has been previously undisturbed, then there is a danger that unique vegetation or wildlife habitat or previously undiscovered archaeological sites may be damaged or destroyed by the construction operations. In Piqua nearly all of the district heating distribution system construction is expected to be along existing streets, alleys and highways and therefore will not involve much construction in areas that have been previously undisturbed. The environmental impacts of construction that do occur in undisturbed terrain as the distribution system moves out from the center of town can be minimized by careful site selection and routing of mains to avoid unique vegetation, wildlife, or archaeological sites if and where they may occur.

5.4.3 ENVIRONMENTAL IMPACT OF OPERATION

One of the advantages which European proponents of district heating often refer to is that "district heating improves air quality". This is, and should be, the case in communities which significantly reduce the burning of high sulphur content fuels and solid fuels susceptible to incomplete combustion in the residential, commercial and small industrial sectors. These sectors typically burn fuels in a manner which creates environmental air pollution. Equipment used by the residential, commercial, and small industrial sectors may be of pre-emissions consideration design, subject to less stringent emissions standards due to their smaller size or they may be improperly operated and poorly maintained thus producing greater than designed emissions quantities.

There can be little doubt that the complex technologies and process of removing environmental air pollutants is better approached through central station equipment and consolidation of operating and maintenance expertise that is available at the central power plant. Even in areas which burn predominately low sulphur content oil, an improvement in air quality may be experienced through the meeting of thermal loads with coal burned at a central power plant. This can especially be true where cogeneration is utilized to reduce the quantity of primary fuel input required to meet thermal and electrical loads.

This section deals with the environmental impacts that would be caused by the conversion of the Piqua Municipal Power Plant to a plant capable of cogenerating electricity and thermal energy for the use of the City of Piqua. Significant differences exist between the European experience and what can be expected in the retrofit of American power plants for cogeneration of electrical and thermal energy.

5.4.4 OHIO ENVIRONMENTAL PROTECTION AGENCY AIR POLLUTION CONTROL STANDARDS

In 1972 and 1974 the Environmental Protection Agency of the State of Ohio adopted regulations setting forth the air quality control standards controlling the emission of particulate matter and sulphur oxide into the atmosphere. These regulations and subsequent amendments in 1977 provide the basis for regulation of Sulphur Dioxide, Suspended Particulate Matter, Nitrogen Oxides, Carbon Monoxide and photochemical oxidants. The most important factors governing the air quality in the planning areas are the concentration of sulphur dioxide and total suspended particulates.

SULPHUR DIOXIDE - Sulphur combines with oxygen in several ways. The most common union of these two elements is the colorless gas, sulphur dioxide (SO_2).

All the oxides of sulphur are potentially harmful to the environment and to humans because they are dehydrated forms of acids.

Sulphur dioxide is an irritant to the upper respiratory tract and, if carried to the lungs, can cause injury to delicate tissue. The maximum allowable concentration of sulphur dioxide in the air as set by the Ohio Ambient Air Quality Standards of 1973 is 260 ug/m^3 . In 1974, peaks of 81 were reached in both March and October and in 1975 the peak recorded value was 36 in October.

SULFUR DIOXIDE CONCENTRATIONS

----- 1975

— 1974

Fig 6-1

None of these approached the State Standard nor the Federal Standard of 365 ug/m^3 . More recent data from 1977 indicates these standards were not exceeded in the study area. Figure 6-1 is a graph of Sulphur Dioxide concentrations in the study area in 1974 and 1975.

SUSPENDED PARTICULATE MATTER - Suspended particulate matter is essentially airborne dirt. This pollution category actually includes airborne solid or liquid bodies having a diameter smaller than 100 microns. Thus, suspended particulate matter can consist of visible particles, fumes, soot, oil and grease.

This pollutant is a health hazard and can harm such bodily tissues as nose and throat linings and lungs by mere mechanical irritation.

Suspended particulates can be directly harmful if they carry poisonous or disease-producing substances. Some of the particulate matter can multiply the harm of irritant gases. Sulphur dioxide for instance, when absorbed on particulate matter and inhaled, will penetrate deep into the lungs and will cause considerably greater damage than if it was inhaled alone. The Ohio Standard for suspended particulates is 150 ug/m^3 for a twenty-four hour period while the Federal Standard is 260 ug/m^3 . The peak recorded value for 1974 was 244 ug/m^3 and for 1975 was 220 ug/m^3 . The State Standard was exceeded three times in 1974 and four times in 1975. The Federal Standard was not exceeded.

Recorded data from 1977 indicates an increase in suspended particulate matter over the 1975 levels. Graph 6-2 is a representation of 1974 and 1975 suspended particulate matter.

The cognizant agency evaluating the air quality in the Piqua area is the Regional Air Pollution Control Agency located in Dayton, Ohio. Figure 6-3 is a map of the area monitored and controlled by RAPCA.

Ohio State Regulation AC-3745-17 sets the air quality standards for suspended particulates and sulphur dioxide concentrations. The purpose of the regulations is to achieve acceptable ambient air quality per these standards throughout the State. However, if the existing air quality of the ambient air in any part of the area is equal to or better than the standards required by Regulation AC-3745-17-02, a non-degradation policy AC-3745-17-02 prevents significant and avoidable deterioration of this cleaner air even though the results might be within the limitations of AC-3745-17. The classification of regions based on existing pollutant concentrations indicates that the ambient

TOTAL SUSPENDED PARTICULATES

--- 1975

— 1974

Fig. 6-2

Fig. 6-3

REGIONAL SAMPLING SITES

FIGURE I

air in the Dayton Air Quality Control Region, which includes Piqua, exceeds the pollutant limitations of the regulation except for carbon monoxide; therefore, the non-degradation policy does not apply to Piqua.

Regulation AC-3745-17-04 limits the amount of visible air contaminants, or smoke, which may be emitted from the plant. Stack emissions cannot be darker than No.1 on the Ringelmann Chart or 20 percent opacity except for an aggregate of 3 minutes in any 60 minute period when No.3 on the Ringelmann Chart or 60 percent opacity will be tolerated.

Regulation AC-3745-17-08 restricts the emission of fugitive dust and gases which are defined as air contaminants emitted from any source other than a flue or a stack. Fugitive dust is generated by coal handling and storing procedures; however, this problem is currently circumvented with dust control facilities and proper handling procedures.

Regulation AC-3745-17-10 restricts emission of particulate matter, or fly ash, from fuel burning equipment. The allowable particulate emission is a function of the total heat input of all fuel input to a single fuel burning unit. The total heat input of all fuel burning units in the plant determine the maximum amount of particulate emissions. The emission restrictions increase in severity with total heat input.

The allowable particulate emission thus determined is also the maximum emission allowable from any single fuel burning unit. If Boiler No.3 is considered retired, the approximate total heat input, as defined, would be as follows:

<u>UNIT</u>	<u>HEAT INPUT</u> <u>10⁶ BTU PER HOUR</u>
Boiler No.4	216.0
Boiler No.5	216.0
Boiler No.6	<u>294.0</u>
Total Heat Input	726.0 x 10 ⁶ BTU per hour

The allowable rate of particulate emission under AC-3745-17-10 is in pounds of emission per million BTU (10⁶ BTU) per hour input and becomes more restrictive as total heat input increases as illustrated on Curve P-1, of Figure 6-4. Beyond 1000 x 10⁶ BTU per hour total heat input, the allowable emission remains at 0.1 pounds per 10⁶ BTU per hour input.

A summary of existing State of Ohio Ambient Air Quality Standards is given in Table 6-7.

TABLE 6-7
STATE OF OHIO
AMBIENT AIR QUALITY STANDARDS
(Federal Standards in Parentheses)

Pollutant	Concentration (g. h)	Remarks (i. j)
Suspended Particulates (a)	60 micrograms/m ³ (75 μ g/m ³ primary, 60 μ g/m ³ secondary)	Maximum annual geometric mean at any sampling site
	150 micrograms/m ³ (260 μ g/m ³ primary, 150 μ g/m ³ secondary)	Maximum 24-hour concentration not to be exceeded more than one time per year.
Sulfur Dioxide (b)	60 micrograms/m ³ (80 μ g/m ³ primary)	Maximum annual arithmetic mean concentration.
	260 micrograms/m ³ (365 μ g/m ³ primary)	Maximum 24-hour concentration not to be exceeded more than one time per year.
	(1,300 micrograms/m ³)	Maximum three-hour concentration not to be exceeded more than one time per year.
Carbon Monoxide (c)	9 parts per million (9 ppm primary)	Maximum eight-hour arithmetic mean concentration not to be exceeded more than once per year.
	(35 ppm primary)	Maximum one-hour concentration not to be exceeded more than one hour per year.
Nitrogen Oxides (e)	100 micrograms/m ³ (100 μ g/m ³ primary)	Annual arithmetic mean.
Photochemical Oxidants (f)	.06 parts per million (.08 ppm primary)	Maximum one-hour arithmetic mean not to be exceeded more than once per year.
	.04 parts per million	Maximum four-hour arithmetic mean not to be exceeded more than one consecutive four-hour period per year.
	.02 parts per million	Maximum 24-hour arithmetic mean not to be exceeded more than once per year.
Hydrocarbons Non-Methane (d)	126 micrograms/m ³ (160 μ g/m ³ primary)	Maximum three-hour arithmetic mean concentration between the hours of 6 a.m. and 9 p.m.
	331 micrograms/m ³	Maximum 24-hour arithmetic mean concentration not to be exceeded more than one day per year.

Regulation AC-3745-17-13 restricts the emission of sulphur dioxide resulting from the burning of fuel to produce heat or power.

The Dayton Air Quality Control Region is assigned Priority II with respect to sulphur oxide emissions (see Table 6-5); therefore, the Piqua Plant must conform to the degree of emission reduction specified by Curve P-1, Figure 6-6. The allowable sulphur dioxide emission under Curve P-1 is 1.0 pounds of emission per 10^6 BTU per hour total heat input.

To meet the 1.0 pounds emission standard using 12,000 BTU per pound coal without sulphur removal equipment requires coal with a sulphur content of approximately 0.6% or below. Piqua currently burns "low sulphur" coal to meet the sulphur dioxide standard. Coals normally burned prior to the regulations contained between 2% and 3% sulphur.

5.4.5 STATUS OF THE PIQUA MUNICIPAL POWER PLANT

The Piqua Municipal Power Plant is a product of 1930's and 1940's technology. The boilers used for the production of steam utilize a travelling grate stoker system to burn No.2 coal. Since current pollution abatement standards were not in existence during the design and construction of the boiler equipment, the devices originally installed within the plant to limit emissions of air pollution substances are minimal. In fact, the only device originally installed on the boilers which contributes to limiting air pollution is a mechanical dust collector. Recent legislation requires that the existing boilers at the Piqua Municipal Power Plant which are still in operation be retrofitted to meet current air pollution standards. Future fuel burning equipment which utilizes coal will also be required to meet air pollution standards in effect at that time.

On June 16, 1975, the City signed a Consent and Abatement Order with OEPA in which the City indicated it would take action to comply with OEPA environmental regulations in the operation of the City-owned electric plant. Particulate emissions from the steam plant exceed allowable amounts; however, the plant is at the present time, in compliance with regulations regarding sulphur emissions and is not required to install sulphur removal equipment. The Consent and Abatement Order, which is included into the Appendix to this report, in essence, requires the City to either install particulate control devices, or shut down the electric plant.

5.4.6 ACTIONS BEING UNDERTAKEN BY THE PIQUA MUNICIPAL POWER PLANT

Work is currently under way to retrofit Boilers No. 4, 5, and 6 to install bag-type dust collectors which will bring the plant into compliance with particulate emission standards. Numerous delays by the City in deciding to install dust collection devices have occurred since the Consent and Abatement Order, due to plant management changes and other more pressing matters. The delay may have, in fact, helped the retrofit of the plant since the original considerations anticipated that electrostatic precipitators would be installed for particulate removal.

Electrostatic precipitators are classed as cold-side precipitators or as hot-side precipitators, depending on whether it is installed after the air heater and economizer to handle flue gas temperatures of about 300°F or installed before the economizer and air heater and handles flue gas temperatures up to 800°F. The hot precipitator is larger and more expensive to purchase and install than the cold type; and is used when low sulphur coals are to be burned. As the sulphur content of coal diminishes, so does the efficiency of the cold precipitator; and, the 99% efficiency of particulate removal necessary to meet the emission standard cannot be achieved. The precipitator efficiency with low sulphur fuels recovers with high flue gas temperature and the installation of a hot precipitator is necessary to meet the standard.

Since sulphur emission standards are met with low sulphur coal, it would have been necessary to install a hot precipitator for particulate removal.

There are inherent problems with the Piqua Plant and plant site which contribute to the complexity and cost of providing air pollution control facilities discussed.

The layout of the power plant does not lend itself to easy access to the gas outlet of the boiler which must be connected to the pollution control equipment, since the rear of the boilers to which pollution control devices must be connected are down the center of the power plant building. Locating equipment such as precipitators at, or over, the rear of each boiler would not be practical. Locating equipment east of the plant on supports designed with railroad clearance to allow coal movement requires duct work from the boiler to the equipment and back to the stack.

In the final analysis, the bag-type dust collector was selected and installation will be accomplished on the east side of the plant. It is doubtful that the 1975 bag-house technology would have been chosen if the original compliance schedule had been met.

5.4.7 STATUS OF PIQUA MUNICIPAL POWER PLANT ACTIONS

Meetings were held during the months of March and April between the Ohio Attorney General's office, the Environmental Protection Agency, and the Regional Air Pollution Control Agency. The City clearly indicated its intention to comply with applicable clean air standards in a timely fashion; and at the same time relate the installation of the bag-type dust collectors to the implementation of the power plant retrofit for district heating. It is now apparent that both Federal and State officials will allow the City sufficient time to accomplish the analysis and to complete installation of the bag-house technology.

Specifications for the construction/implementation of the bag houses is complete. The base estimate for complete construction is 3.5 million dollars. Bids are due on July 13, 1979, and the City anticipates award of a contract within 45 days following the closing date. The City does not anticipate additional litigation regarding this matter.

5.5 DECISIONS NECESSARY FOR IMPLEMENTATION

Throughout sections 1.3.1 and 5.0 a complete discussion of the commercialization/project decision making process is presented. During Phase I the Demonstration Team expended substantial resources and man hours securing involvement by various actors/"decision makers". As a result of this effort all roles have been identified and characterized; and critical decisions related to project implementation have been identified pursuant to level, timing, findings and impact.

Although many actors, organizations, interest groups and offices have been involved and will continue to participate, for purposes of the District Heating Project many are characterized as "Advisory". These actors' support is important especially as they relate to market penetration and customer hook-ups. To that extent their concurrence is institutionally important and helpful but not legally necessary. Participants in this group include Power Advisory Committee, Public Utilities Commission of Ohio, Ohio Department of Energy, U.S. Department of Housing and Urban Development, Area-Wide A-95 Agency, Piqua Manufacturer's Association, Downtown Merchants Association, and the Chamber of Commerce.

Another set of organizations or actors exercise a higher level of authority over project implementation. This group of "decision makers" legally has purvient over specific elements(s) which could result in modifications or changes to the District Heating Project. However, their authority can generally control or prevent implementation. The following outline characterizes these organizations, bodies and offices.

1. Miami Conservancy District

- a. Source of Authority = Ohio Revised Code
- b. Role = Flood Prevention along the Great Miami River
- c. Issues = Will installation of segment of distribution system on their land affect flood control? Will installation of line violate integrity of levee?
- d. Findings and Information = Negative findings pursuant to questions above. Will require permit, review of plans and construction drawings.

- e) Status = Meetings to date indicate no general opposition. Preliminary approval expected by June 1, 1980. Final permit issued upon submission/review of construction drawings.

2. Ohio Power Siting Commission

- a) Source of Authority = Ohio Revised Code
- b) Role = Environmental review/certification of new power plants and power plant capacity expansion.
- c) Issues = Environmental consideration related to above responsibility.
- e) Status = Only applicable to Piqua District Heating Project upon addition of 30 MW unit in 1986 or later.

3. USEPA and Ohio EPA

- a) Source of Authority = NEPA and Ohio Revised Code
- b) Role = Adopt and enforce air quality standards
- c) Issue = Piqua Power Plant's compliance/non-compliance with applicable air quality standards
- d) Findings and Information = Positive findings related to above issue. Signed construction contracts by May, 1980 for installation of bag houses which have been approved.
- e) Status = Bids received below cost estimates. Contract execution expected by January, 1980.

4. Donaldson, Lufkin and Jenrette (Underwriter)

- a) Source of Authority = Institutional/Financial Markets
- b) Role = Underwrite revenue bond sales. Development, preparation, sale and execution of debt instruments.
- c) Issues = Project feasibility, bond repayment, coverage.
- d) Findings and Information = Positive findings related to above. Require feasibility analysis, market confirmation, City of Piqua/PMPS concurrence.
- e) Preliminary approval/concurrence July, 1980.

5. Miami County - Ohio Department of Transportation (ODOT)

- a) Source of Authority = Miami County - Ohio Constitution and Ohio Revised Code. ODOT - Ohio Revised Code.
- b) Role = Authority over county and state road network surrounding and passing through the City of Piqua.
- c) Issues = Will installation of segments of piping system crossing roads disrupt traffic to a significant degree? What constraints are placed on additional loadings on bridges, using county and state highway right-of-ways, etc.?
- d) Findings and Information = Negative findings pursuant to questions above. Will require permits from Miami County Engineer and State, review of plans and construction drawings.
- e) Status = Meetings to date, indicate no general opposition. Preliminary approval expected by July 1, 1980 following submission/review of plans.

The key decision making authority rests with the PMPS--the Piqua City Commission. The commission's interest and ability to control decisions extends to nearly all project elements including distribution system plans, market penetration, financing and operation. A complete discussion of their role and authority is presented in chapters 1 and 5 of this report. The product resulting from the Phase II Scope of Work will provide answers to questions raised by the commission during Phase I and will enable the City to complete decisions at the close of Phase II regarding the structure and form of implementing the District Heating Project. All other actors including the City Manager, Power Systems Director, Finance Director, Bond Council, Hanselman-Eskew and Associates, and the Georgia Tech Engineering Experiment Station serve as support to the City Commission as part of the Demonstration Team.

6.0 ECONOMIC ANALYSIS

The following outline discusses the components considered in determining the amount of financing (and consequently the total revenues and debt service load needed) required to carry the district heating project over the study period. These costs and charges are inputs to the Donaldson, Lufkin & Jenrette Municipal Bond model or are calculated within the model.

CONSTRUCTION COST--considers all elements related to the power plant and distribution system construction specifically included are:

- materials
- labor
- contingences
- sub contracts
- overhead
- profit
- engineering & consultating fees
- permits

Construction Cost Estimate spread sheets are contained in the Appendix.

SITE ACQUISITION--no additional land is required to carry out the Piqua district heating project as currently structured.

FINANCING FEES AND CHARGES--are costs related to the development, preparation, sale and execution of the required debt instruments.

- bond council
 - . fees
 - . expenses
- financial consultants
 - . fees
 - . expenses
- underwriter
 - . average takedown
 - . underwriter's fee
 - . expenses and travel
 - . management
 - . prospections, preparation and printing

- . bond rating
- . advertising
- . bond printing, signatures and fiscal agent
- . underwriter's council
- . underwriter's financial/feasibility consultant
- . closing dinner

INTEREST--both interest charges and interest proceeds are considered.

- actual interest rate or bond yield
 - capitalized interest
 - interest receivable
- (construction and all reserve funds)

FUNDS AND OTHER "ACCOUNTS"--must be included as required by the underwriter, securities ratio/agencies and investors

- debt service reserve fund
- coverage ratio

PIQUA DISTRICT HEATING FINANCING

Three alternative power plant retrofit schemes and attendant thermal energy distribution systems were proposed at the onset of this analysis. However, it was recognized early in the investigation that any one of the individual retrofit options was not viable alone. The alternative retrofit options combined in a phased expansion of the thermal system will provide sufficient available energy. Therefore, the multi-phase inplant and distribution system construction results in a series of capital requirements that must be met over a several year period.

Although a portion of distribution system construction occurs in each of the 20 years, the financing of several years of work is packaged in one sale along with the most related power plant retrofit/construction phase. This portion delivers cogenerated thermal energy to customers in January, 1983. Project construction is timed or phased according to the following schedule:

Project Capital Cost Summary by Phase of Construction 5/79

Year	Project Phase (* indicates power plant year element operational)	Power Plant Costs	Distribution System Costs	Total Costs	Date of Bond Issue (Jan)
1981	Phase I - Base and Unit 5--				
92	Turbine-Gen. \$, Peaking				
* 83	Boiler Mod. Initial D.H.S. Construct. Distrib. System	966,336	7,957,360	8,923,696	1981
84	Phase II-Add 30 MW Unit--				
85	Power Plant Construction Incremental D.H.S. Expan.				
* 86	Distribution Syst. Expan.	29,720,977	18,938,320	48,659,297	1984
87	Phase II' -				
88					
89					
90		- 0 -	9,357,410	9,357,410	1988
91	Phase III-Modify Unit 6 for Cogeneration--Turbine Gen.\$				
92	Incremental D.H.S. Expan.				
* 93	Distribution Syst. Expan.	416,517	13,138,870	13,555,387	1991
94	Phase IV - Retrofit Unit 4				
95	with Cogeneration Turbine--				
* 96	Turbine - Gen. \$				
97	Incremental D.H.S. Expan.				
98	Distribution Syst. Expan.				
99					
2000		4,001,470	17,356,110	21,357,580	1994
	TOTAL	34,205,300	66,193,070	101,853,370	

Additional parameters and assumptions must be set in order to structure the debt instruments. The table on the following page presents the financing inputs. In each case A-rated serial bonds with 25 year maturities are assumed. Donaldson, Lufkin and Jenrette's (DLJ) Municipal Bond Model is then used to calculate annualized capital cost for each bond issue. Below is a summary of the key results which are then inputted to the subsequent present value analysis and sensitivity analysis.

<u>Phase</u>	<u>Total Issue</u>	<u>Maximum Annual Debt Service</u>
1	\$10,610,000	\$922,837
2	\$54,150,000	\$4,694,350
2'	\$10,660,000	\$911,650
3	\$19,370,000	\$1,654,212
4	\$14,340,000	\$1,225,855
Total	\$109,130,000	

Base Case	\$30,305,000	\$2,633,987

The cumulative debt service pay out schedule results in relatively low debt service during the initial or "start-up" years and builds to relatively higher debt service payments over time with the highest payments \$9,408,905 occurring between 1996 and 2008. The curve below illustrates the cumulative debt service load through 2021 which extends well beyond the "project study period".

CUMULATIVE DEBT SERVICE

MUNICIPAL BOND MODEL INPUTS

<u>Phase</u>	<u>Date Operational</u>	<u>Interest Rate%</u>	<u>Date Issue</u>	<u>Construction Period</u>	<u>Annual Draw</u>	<u>Maturity (Years)</u>	<u>DSRF Rate%</u>	<u>CIF Rate%</u>	<u>CF Rate%</u>	<u>Unfinanced Portion</u>
1	1983	6.75	1981	2 years	50%	25	8.5	7	7	0
2	1986	6.75	1984	4 "	25%	25	8.5	7	7	0
2'	1990	6.75	1988	3 "	33.3%	25	8.5	7	7	0
3	1993	6.75	1991	3 "	33.3%	25	8.5	7	7	0
4	1996	6.75	1994	7 "	16.66%	25	8.5	7	7	0

Base Case -- 20 MW Turbine Generator

*	1993	6.75	1991	2 "	50%	25	8.5	7	7	0
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DSRF = Debt Service Reserve Fund

CIF = Capitalized Interest Fund

CF = Construction Fund

The Donaldson, Lufkin and Jenrette, Municipal Debt Analysis Model spread sheets reproduced on the following pages present in detail the results of this financing method. In addition, the spread sheets for financing the base case (20 MW condensing turbine, boiler, and related work) construction in 1993 are included.

Advantages include relatively low front-end costs which allow the district heating project to pace the market for thermal energy. However, the rapid rise in cost/debt service relatively early during the project period may present financial obstacles. A cursory evaluation of this debt service schedule appears to suggest deferring/spreading the cost of the Phase 2 distribution system expansion to later years where the increases in natural gas prices really take effect. The dashed line on the graph below illustrates this point, which will be further investigated/optimized in the phase II of this project.

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUKIN & JENNETTE
Piqua Municipal Power System
RATE - 6.75% MATURITY - 25 YEARS

SERIES 1981
ISSUE SUMMARY

DELIVERY DATE: 1/ 1/81

INTEREST ACCRUED FROM: 1/ 1/81

ESTIMATED COSTS OF CONSTRUCTION.....	68,923,696.00
LESS: CONSTRUCTION FUND EARNINGS @ 7.000%.....	708,732.70
CAPITALIZED INTEREST FUND EARNINGS @ 7.000%.....	125,330.62
DEBT SERVICE RESERVE FUND EARNINGS @ 8.500%.....	156,882.37
CONSTRUCTION FINANCING REQUIREMENT	67,932,750.30
ADD: CAPITALIZED INTEREST FROM 1/ 1/81 TO 1/ 1/83.....	61,432,350.00
DEBT SERVICE RESERVE FUND (1.00 TIMES MAXIMUM ANNUAL DEBT SERVICE).....	922,837.50
BOND DISCOUNT (3.000%).....	310,300.00
ADDITIONAL EXPENSES (0.000%).....	0.00
REMAINDER DUE TO \$0.000 ROUNDING.....	3,762.20
TOTAL REQUIRED REVENUE BONDS	610,610,000.00
AVERAGE LIFE.....	16.76 YEARS
AVERAGE COUPON.....	6.750%
NET INTEREST COST.....	6.929%
TRUE INTEREST COST.....	7.074%

NOTE: NET AND TRUE INTEREST COSTS GIVE EFFECT TO BOND DISCOUNT
OF \$310,300.00.

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUKIN & JENNETTE
Piqua Municipal Power System
RATE - 6.75% MATURITY - 25 YEARS

CONSTRUCTION FUND FLOW OF FUNDS

EARNINGS ACCRUED FROM: 1/ 1/81

TARGET DATE OF CONSTRUCTION COMPLETION: 1/ 1/83

PERIOD BEGINS	BEGINNING BALANCE CONSTRUCTION FUND	PERCENTAGE DRAWDOWN	AMOUNT OF DRAWDOWN	BALANCE REMAINING INVESTED	CONSTRUCTION FUND EARNINGS END OF PERIOD	CAPITALIZED INTEREST EARNINGS END OF PERIOD	DEBT SERVICE RESERVE EARNINGS END OF PERIOD
1/ 1/81	7,936,512			7,936,512	277,777	50,132	39,220
7/ 1/81	8,393,643	25.00	2,230,923	6,072,719	212,545	37,599	39,220
1/ 1/82	8,362,084	25.00	2,230,923	4,131,160	144,590	25,066	39,220
7/ 1/82	4,340,037	25.00	2,230,923	2,109,113	73,818	12,533	39,220
1/ 1/83	2,234,686	25.00	2,230,923	3,762			
TOTAL			8,923,695		708,732	125,330	156,882

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUFKIN & JENNETTE
PLOUA MUNICIPAL POWER SYSTEM
RATE - 6.75% MATURITY - 25 YEARS

PROPOSED NEW ISSUE

DELIVERY DATE: 1/ 1/81

INTEREST ACCRUED FROM: 1/ 1/81

DATE	COUPON RATE	PRINCIPAL	INTEREST	TOTAL DEBT SERVICE
1/ 1/82			716,175.00	716,175.00
1/ 1/83			716,175.00	716,175.00
1/ 1/84	6.750	205,000.00	716,175.00	921,175.00
1/ 1/85	6.750	220,000.00	702,337.50	922,337.50
1/ 1/86	6.750	235,000.00	687,487.50	922,487.50
1/ 1/87	6.750	250,000.00	671,625.00	921,625.00
1/ 1/88	6.750	265,000.00	654,750.00	919,750.00
1/ 1/89	6.750	280,000.00	636,862.50	921,862.50
1/ 1/90	6.750	305,000.00	617,625.00	922,625.00
1/ 1/91	6.750	325,000.00	597,037.50	922,037.50
1/ 1/92	6.750	345,000.00	575,100.00	920,100.00
1/ 1/93	6.750	370,000.00	551,812.50	921,812.50
1/ 1/94	6.750	395,000.00	526,837.50	921,837.50
1/ 1/95	6.750	420,000.00	500,175.00	920,175.00
1/ 1/96	6.750	450,000.00	471,825.00	921,825.00
1/ 1/97	6.750	480,000.00	441,450.00	921,450.00
1/ 1/98	6.750	510,000.00	409,050.00	919,050.00
1/ 1/99	6.750	545,000.00	374,625.00	919,625.00
1/ 1/ 0	6.750	585,000.00	337,837.50	922,837.50
1/ 1/ 1	6.750	620,000.00	298,350.00	918,350.00
1/ 1/ 2	6.750	665,000.00	256,500.00	921,500.00
1/ 1/ 3	6.750	710,000.00	211,612.50	921,612.50
1/ 1/ 4	6.750	755,000.00	163,687.50	918,687.50
1/ 1/ 5	6.750	810,000.00	112,725.00	922,725.00
1/ 1/ 6	6.750	860,000.00	58,050.00	918,050.00

TOTAL 10,610,000.00 12,005,887.50 22,615,887.50

ACCRUED FROM 1/ 1/81

NET COST 12,005,887.50

AVERAGE COUPON 6.750
BOND YEARS 177,865,000
AVERAGE LIFE 16.764

REQUIRED REVENUES

DATE	PRINCIPAL DEBT SERVICE	PROPOSED DEBT SERVICE	TOTAL DEBT SERVICE	CAPITALIZED INTEREST	NET DEBT SERVICE	REQUIRED REVENUES	SURPLUS	COVEN
1/ 1/82		716,174	716,174	716,174				
1/ 1/83		716,174	716,174	716,174				
1/ 1/84		921,174	921,174		921,174	1,151,468	230,293	1.25
1/ 1/85		922,337	922,337		922,337	1,152,921	230,584	1.25
1/ 1/86		922,487	922,487		922,487	1,153,109	230,621	1.25
1/ 1/87		921,624	921,624		921,624	1,152,031	230,406	1.25
1/ 1/88		919,749	919,749		919,749	1,149,687	229,937	1.25
1/ 1/89		921,862	921,862		921,862	1,152,328	230,465	1.25
1/ 1/90		922,624	922,624		922,624	1,153,281	230,656	1.25
1/ 1/91		922,037	922,037		922,037	1,152,546	230,509	1.25
1/ 1/92		920,099	920,099		920,099	1,150,124	230,024	1.25
1/ 1/93		921,812	921,812		921,812	1,152,265	230,453	1.25
1/ 1/94		921,837	921,837		921,837	1,152,296	230,459	1.25
1/ 1/95		920,174	920,174		920,174	1,150,218	230,043	1.25
1/ 1/96		921,824	921,824		921,824	1,152,281	230,456	1.25
1/ 1/97		921,449	921,449		921,449	1,151,812	230,362	1.25
1/ 1/98		919,049	919,049		919,049	1,148,812	229,762	1.25
1/ 1/99		919,624	919,624		919,624	1,149,531	229,906	1.25
1/ 1/ 0		922,837	922,837		922,837	1,153,546	230,709	1.25
1/ 1/ 1		918,349	918,349		918,349	1,147,937	229,587	1.25
1/ 1/ 2		921,499	921,499		921,499	1,151,874	230,374	1.25
1/ 1/ 3		921,612	921,612		921,612	1,152,015	230,463	1.25
1/ 1/ 4		918,687	918,687		918,687	1,148,359	229,671	1.25
1/ 1/ 5		922,724	922,724		922,724	1,153,406	230,681	1.25
1/ 1/ 6		918,049	918,049		918,049	1,147,562	229,512	1.25
TOTAL		22,615,887	22,615,887	1,432,349	21,183,537	26,479,421	5,295,884	

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUTKIN & JENNETTE
PIQUA MUNICIPAL POWER SYSTEM
RATE - 6.75% & MATURITY 25 YEARS

SERIES 1984
ISSUE SUMMARY

DELIVERY DATE: 1/ 1/84

INTEREST ACCRUE FROM: 1/ 1/84

ESTIMATED COSTS OF CONSTRUCTION.....	\$48,659,297.00
LESS: CONSTRUCTION FUND EARNINGS @ 7.000%.....	6,009,041.19
CAPITALIZED INTEREST FUND EARNINGS @ 7.000%.....	638,229.37
DEBT SERVICE RESERVE FUND EARNINGS @ 8.500%.....	1,596,079.00
CONSTRUCTION FINANCING REQUIREMENT	\$40,415,947.44
ADD: CAPITALIZED INTEREST FROM 1/ 1/84 TO 1/ 1/85.....	\$7,294,050.00
DEBT SERVICE RESERVE FUND (1.00 TIMES MAXIMUM ANNUAL DEBT SERVICE).....	4,694,350.00
BOND DISCOUNT (3.000%).....	1,620,900.00
ADDITIONAL EXPENSES (0.000%).....	0.00
REMAINDER DUE TO \$5,000 ROUNDING.....	4,752.56
TOTAL REQUIRED REVENUE BONDS	\$54,030,000.00
AVERAGE LIFE.....	16.77 YEARS
AVERAGE COUPON.....	6.750%
NET INTEREST COST.....	6.929%
TRUE INTEREST COST.....	7.074%

NOTE: NET AND TRUE INTEREST COSTS GIVE EFFECT TO BOND DISCOUNT
OF \$1,620,900.00.

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUTKIN & JENNETTE
PIQUA MUNICIPAL POWER SYSTEM
RATE - 6.75% & MATURITY 25 YEARS

CONSTRUCTION FUND FLOW OF FUNDS

EARNINGS ACCRUE FROM: 1/ 1/84

TARGET DATE OF CONSTRUCTION COMPLETION: 1/ 1/88

PERIOD ENDING	BEGINNING BALANCE CONSTRUCTION FUND	PERCENTAGE DRAWDOWN	AMOUNT OF DRAWDOWN	BALANCE REMAINING INVESTED	CONSTRUCTION FUND EARNINGS END OF PERIOD	CAPITALIZED INTEREST EARNINGS END OF PERIOD	DEBT SERVICE RESERVE EARNINGS END OF PERIOD
1/ 1/84	40,420,700			40,420,700	1,414,724	255,291	199,509
7/ 1/84	42,290,226	15.00	7,290,894	34,991,331	1,224,696	191,468	199,509
1/ 1/85	36,607,006	15.00	7,298,894	29,308,112	1,025,793	127,645	199,509
7/ 1/85	30,661,051	15.00	7,298,894	23,362,157	817,675	63,822	199,509
1/ 1/86	24,443,165	15.00	7,298,894	17,144,271	600,049		199,509
7/ 1/86	17,943,830	10.00	4,865,929	13,077,900	457,726		199,509
1/ 1/87	13,735,117	10.00	4,865,929	8,869,207	310,422		199,509
7/ 1/87	9,379,139	10.00	4,865,929	4,513,210	157,962		199,509
1/ 1/88	4,870,662	10.00	4,865,929	4,752			
TOTAL			48,659,296		6,009,041	638,229	1,596,078

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUFKIN & JENNETTE
PLOUHA MUNICIPAL POWER SYSTEM
RATE - 6.75% & MATURITY 25 YEARS

PROPOSED NEW ISSUE

DELIVERY DATE: 1/ 1/84

INTEREST ACCRUED FROM: 1/ 1/84

DATE	COUPON RATE	PRINCIPAL	INTEREST	TOTAL DEBT SERVICE
1/ 1/85			3,647,025.00	3,647,025.00
1/ 1/86			3,647,025.00	3,647,025.00
1/ 1/87	6.750	1,045,000.00	3,647,025.00	4,692,025.00
1/ 1/88	6.750	1,115,000.00	3,576,487.50	4,691,487.50
1/ 1/89	6.750	1,190,000.00	3,501,225.00	4,691,225.00
1/ 1/90	6.750	1,270,000.00	3,420,900.00	4,690,900.00
1/ 1/91	6.750	1,355,000.00	3,335,175.00	4,690,175.00
1/ 1/92	6.750	1,450,000.00	3,243,712.50	4,693,712.50
1/ 1/93	6.750	1,545,000.00	3,145,837.50	4,690,837.50
1/ 1/94	6.750	1,650,000.00	3,041,550.00	4,691,550.00
1/ 1/95	6.750	1,760,000.00	2,930,175.00	4,690,175.00
1/ 1/96	6.750	1,880,000.00	2,811,375.00	4,691,375.00
1/ 1/97	6.750	2,005,000.00	2,684,475.00	4,689,475.00
1/ 1/98	6.750	2,145,000.00	2,549,137.50	4,694,137.50
1/ 1/99	6.750	2,290,000.00	2,404,350.00	4,694,350.00
1/ 1/ 0	6.750	2,440,000.00	2,249,775.00	4,689,775.00
1/ 1/ 1	6.750	2,605,000.00	2,085,075.00	4,690,075.00
1/ 1/ 2	6.750	2,780,000.00	1,909,237.50	4,689,237.50
1/ 1/ 3	6.750	2,970,000.00	1,721,587.50	4,691,587.50
1/ 1/ 4	6.750	3,170,000.00	1,521,112.50	4,691,112.50
1/ 1/ 5	6.750	3,385,000.00	1,307,137.50	4,692,137.50
1/ 1/ 6	6.750	3,615,000.00	1,078,650.00	4,693,650.00
1/ 1/ 7	6.750	3,855,000.00	834,637.50	4,689,637.50
1/ 1/ 8	6.750	4,115,000.00	574,425.00	4,689,425.00
1/ 1/ 9	6.750	4,395,000.00	296,662.50	4,691,662.50
TOTAL		54,030,000.00	61,163,775.00	115,193,775.00

ACCURED FROM 1/ 1/84

NET COST

61,163,775.00

AVERAGE COUPON
BOND YEARS
AVERAGE LIFE

6.750
Y06,130.000
16.771

REQUIRED REVENUES

DATE	PRIOR DEBT SERVICE	PROPOSED DEBT SERVICE	TOTAL DEBT SERVICE	CAPITALIZED INTEREST	NET DEBT SERVICE	REQUIRED REVENUES	SURPLUS	COVE
1/ 1/85		3,647,024	3,647,024	3,647,024				
1/ 1/86		3,647,024	3,647,024	3,647,024				
1/ 1/87		4,692,024	4,692,024		4,692,024	5,865,031	1,173,006	1.2
1/ 1/88		4,691,487	4,691,487		4,691,487	5,864,359	1,172,871	1.2
1/ 1/89		4,691,224	4,691,224		4,691,224	5,864,031	1,172,806	1.2
1/ 1/90		4,690,899	4,690,899		4,690,899	5,863,624	1,172,724	1.2
1/ 1/91		4,690,174	4,690,174		4,690,174	5,862,718	1,172,543	1.2
1/ 1/92		4,693,712	4,693,712		4,693,712	5,867,140	1,173,428	1.2
1/ 1/93		4,690,837	4,690,837		4,690,837	5,863,546	1,172,709	1.2
1/ 1/94		4,691,549	4,691,549		4,691,549	5,864,437	1,172,887	1.2
1/ 1/95		4,690,174	4,690,174		4,690,174	5,862,718	1,172,543	1.2
1/ 1/96		4,691,374	4,691,374		4,691,374	5,864,218	1,172,843	1.2
1/ 1/97		4,689,474	4,689,474		4,689,474	5,861,843	1,172,368	1.2
1/ 1/98		4,694,137	4,694,137		4,694,137	5,867,671	1,173,534	1.2
1/ 1/99		4,694,349	4,694,349		4,694,349	5,867,937	1,173,587	1.2
1/ 1/ 0		4,689,774	4,689,774		4,689,774	5,862,218	1,172,443	1.2
1/ 1/ 1		4,690,074	4,690,074		4,690,074	5,862,593	1,172,510	1.2
1/ 1/ 2		4,689,237	4,689,237		4,689,237	5,861,546	1,172,309	1.2
1/ 1/ 3		4,691,587	4,691,587		4,691,587	5,864,484	1,172,896	1.2
1/ 1/ 4		4,691,112	4,691,112		4,691,112	5,863,890	1,172,778	1.2
1/ 1/ 5		4,692,137	4,692,137		4,692,137	5,865,171	1,173,034	1.2
1/ 1/ 6		4,693,649	4,693,649		4,693,649	5,867,062	1,173,412	1.2
1/ 1/ 7		4,689,637	4,689,637		4,689,637	5,862,046	1,172,409	1.2
1/ 1/ 8		4,689,424	4,689,424		4,689,424	5,861,781	1,172,356	1.2
1/ 1/ 9		4,691,662	4,691,662		4,691,662	5,864,578	1,172,915	1.2
TOTAL		115,193,774	115,193,774	72,244,019	107,899,724	134,874,656	26,974,931	

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUFFIN & JENNETTE

PIQUA MUNICIPAL POWER SYSTEM
RATE 6.75 & MATURITY 25 YEARS

SERIES 1988

ISSUE SUMMARY

DELIVERY DATE: 1/ 1/88

INTEREST ACCRUED FROM: 1/ 1/88

ESTIMATED COSTS OF CONSTRUCTION.....	69,357,410.00
LESS: CONSTRUCTION FUND EARNINGS @ 7.000%.....	1,013,429.38
CAPITALIZED INTEREST FUND EARNINGS @ 7.000%.....	125,921.25
DEBT SERVICE RESERVE FUND EARNINGS @ 8.500%.....	232,470.75
CONSTRUCTION FINANCING REQUIREMENT	67,985,500.62
ADD: CAPITALIZED INTEREST FROM 1/ 1/88 TO 1/ 1/90.....	61,439,100.00
DEBT SERVICE RESERVE FUND (1.00 TIMES MAXIMUM ANNUAL DEBT SERVICE).....	911,650.00
BOND DISCOUNT (3.000%).....	319,800.00
ADDITIONAL EXPENSES (0.000%).....	0.00
REMAINDER DUE TO \$5,000 ROUNDING.....	1,989.89

TOTAL REQUIRED REVENUE BONDS 610,660,000.00

AVERAGE LIFE.....	16.51 YEARS
AVERAGE COUPON.....	6.750%
NET INTEREST COST.....	6.932%
TRUE INTEREST COST.....	7.079%

NOTE: NET AND TRUE INTEREST COSTS GIVE EFFECT TO BOND DISCOUNT
OF \$319,800.00.

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUFFIN & JENNETTE

PIQUA MUNICIPAL POWER SYSTEM
RATE 6.75 & MATURITY 25 YEARS

CONSTRUCTION FUND FLOW OF FUNDS

EARNINGS ACCRUED FROM: 1/ 1/88

TARGET DATE OF CONSTRUCTION COMPLETION: 1/ 1/91

PERIOD BEGIN	BEGINNING BALANCE CONSTRUCTION FUND	PERCENTAGE DRAWDOWN	AMOUNT OF DRAWDOWN	BALANCE REMAINING INVESTED	CONSTRUCTION FUND EARNINGS END OF PERIOD	CAPITALIZED INTEREST EARNINGS END OF PERIOD	DEBT SERVICE RESERVE EARNINGS END OF PERIOD
1/ 1/88	7,989,450			7,989,450	279,630	50,368	38,745
7/ 1/88	8,358,194	16.67	1,559,880	6,798,314	237,940	37,776	38,745
1/ 1/89	7,112,776	16.67	1,559,880	5,552,896	194,351	25,184	38,745
7/ 1/89	5,811,177	16.67	1,559,880	4,251,296	148,795	12,592	38,745
1/ 1/90	4,451,429	16.67	1,559,880	2,891,549	101,204		38,745
7/ 1/90	3,031,478	16.67	1,559,880	1,471,618	51,506		38,745
1/ 1/91	1,561,870	16.67	1,559,880	1,989			
TOTAL			9,359,281		1,013,429	125,921	232,470

MUNICIPAL DEBT ANALYSIS
DUNN, LUTKIN & JENNETTE

PIDUA MUNICIPAL POWER SYSTEM
RATE 6.75 & MATURITY 25 YEARS

PROPOSED NEW ISSUE

DELIVERY DATE: 1/ 1/88

INTEREST ACCRUED FROM: 1/ 1/88

DATE	COUPON RATE	PRINCIPAL	INTEREST	TOTAL DEBT SERVICE
1/ 1/89			719,550.00	719,550.00
1/ 1/90	6.750	190,000.00	719,550.00	909,550.00
1/ 1/91	6.750	200,000.00	706,725.00	906,725.00
1/ 1/92	6.750	215,000.00	693,225.00	908,225.00
1/ 1/93	6.750	230,000.00	670,712.50	900,712.50
1/ 1/94	6.750	245,000.00	648,187.50	908,187.50
1/ 1/95	6.750	265,000.00	626,650.00	911,650.00
1/ 1/96	6.750	280,000.00	608,762.50	908,762.50
1/ 1/97	6.750	300,000.00	589,862.50	909,862.50
1/ 1/98	6.750	320,000.00	569,612.50	909,612.50
1/ 1/99	6.750	340,000.00	548,012.50	908,012.50
1/ 1/ 0	6.750	365,000.00	525,062.50	910,062.50
1/ 1/ 1	6.750	390,000.00	500,425.00	910,425.00
1/ 1/ 2	6.750	415,000.00	474,100.00	909,100.00
1/ 1/ 3	6.750	445,000.00	446,087.50	911,087.50
1/ 1/ 4	6.750	475,000.00	416,050.00	911,050.00
1/ 1/ 5	6.750	505,000.00	384,987.50	908,987.50
1/ 1/ 6	6.750	540,000.00	352,900.00	909,900.00
1/ 1/ 7	6.750	575,000.00	319,450.00	908,450.00
1/ 1/ 8	6.750	615,000.00	284,637.50	909,637.50
1/ 1/ 9	6.750	655,000.00	248,125.00	908,125.00
1/ 1/10	6.750	700,000.00	208,912.50	908,912.50
1/ 1/11	6.750	745,000.00	168,662.50	906,662.50
1/ 1/12	6.750	800,000.00	118,375.00	911,375.00
1/ 1/13	6.750	850,000.00	57,375.00	907,375.00

TOTAL 10,660,000.00 11,880,000.00 22,540,000.00

ACCURED FROM 1/ 1/88

NET COST

11,000,000.00

AVERAGE COUPON
BOND YEARS
AVERAGE LIFE

6.750
175,000,000
16.510

REQUIRED REVENUES

DATE	PRIOR DEBT SERVICE	PROPOSED DEBT SERVICE	TOTAL DEBT SERVICE	CAPITALIZED INTEREST	NET DEBT SERVICE	REQUIRED REVENUES	SURPLUS	COVER
1/ 1/89		719,549	719,549	719,549				
1/ 1/90		909,549	909,549	719,549	189,999	237,499	47,499	1.25
1/ 1/91		906,724	906,724		906,724	1,133,406	226,681	1.25
1/ 1/92		908,224	908,224		908,224	1,135,201	227,056	1.25
1/ 1/93		908,712	908,712		908,712	1,135,090	227,178	1.25
1/ 1/94		908,187	908,187		908,187	1,135,234	227,046	1.25
1/ 1/95		911,649	911,649		911,649	1,139,562	227,912	1.25
1/ 1/96		908,762	908,762		908,762	1,135,953	227,190	1.25
1/ 1/97		909,862	909,862		909,862	1,137,378	227,465	1.25
1/ 1/98		909,612	909,612		909,612	1,137,015	227,403	1.25
1/ 1/99		908,012	908,012		908,012	1,135,015	227,003	1.25
1/ 1/ 0		910,062	910,062		910,062	1,137,578	227,515	1.25
1/ 1/ 1		910,424	910,424		910,424	1,138,031	227,604	1.25
1/ 1/ 2		909,099	909,099		909,099	1,136,374	227,274	1.25
1/ 1/ 3		911,087	911,087		911,087	1,138,859	227,771	1.25
1/ 1/ 4		911,049	911,049		911,049	1,138,812	227,762	1.25
1/ 1/ 5		908,987	908,987		908,987	1,136,234	227,246	1.25
1/ 1/ 6		909,899	909,899		909,899	1,137,374	227,474	1.25
1/ 1/ 7		908,449	908,449		908,449	1,135,562	227,112	1.25
1/ 1/ 8		909,637	909,637		909,637	1,137,046	227,409	1.25
1/ 1/ 9		908,124	908,124		908,124	1,135,156	227,031	1.25
1/ 1/10		908,912	908,912		908,912	1,136,140	227,229	1.25
1/ 1/11		906,662	906,662		906,662	1,133,528	226,865	1.25
1/ 1/12		911,374	911,374		911,374	1,139,218	227,843	1.25
1/ 1/13		907,374	907,374		907,374	1,134,218	226,843	1.25
TOTAL		22,539,999	22,539,999	1,439,099	21,100,899	26,376,124	5,275,224	

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUKIN & JENNETTE
FIDUCIARY MUNICIPAL POWER SYSTEM
RATE - 6.75% & MATURITY 25 YEARS
SERIES 1991
ISSUE SUMMARY

DELIVERY DATE: 1/ 1/91

INTEREST ACCRUED FROM: 1/ 1/91

ESTIMATED COSTS OF CONSTRUCTION.....	\$13,555,387.00
LESS: CONSTRUCTION FUND EARNINGS @ 7.000%.....	1,480,300.29
CAPITALIZED INTEREST FUND EARNINGS @ 7.000%.....	50,817.37
DEBT SERVICE RESERVE FUND EARNINGS @ 8.500%.....	312,598.12
CONSTRUCTION FINANCING REQUIREMENT.....	\$11,711,671.22
ADD: CAPITALIZED INTEREST FROM 1/ 1/91 TO 1/ 1/92.....	\$967,950.00
DEBT SERVICE RESERVE FUND (1.00 TIMES MAXIMUM ANNUAL DEBT SERVICE).....	1,225,875.00
BOND DISCOUNT (3.000%).....	430,200.00
ADDITIONAL EXPENSES (0.000%).....	0.00
REMAINDER DUE TO \$5,000 ROUNDING.....	1,592.71
TOTAL REQUIRED REVENUE BONDS.....	\$14,340,000.00
AVERAGE LIFE.....	16.51 YEARS
AVERAGE COUPON.....	6.750%
NET INTEREST COST.....	6.932%
TRUE INTEREST COST.....	7.079%

NOTE: NET AND TRUE INTEREST COSTS GIVE EFFECT TO BOND DISCOUNT OF \$430,200.00.

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUKIN & JENNETTE
FIDUCIARY MUNICIPAL POWER SYSTEM
RATE - 6.75% & MATURITY 25 YEARS
CONSTRUCTION FUND FLOW OF FUNDS

EARNINGS ACCRUED FROM: 1/ 1/91

TARGET DATE OF CONSTRUCTION COMPLETION: 1/ 1/94

PERIOD BEGINS	BEGINNING BALANCE CONSTRUCTION FUND	PERCENTAGE DRAWDOWN	AMOUNT OF DRAWDOWN	BALANCE REMAINING INVESTED	CONSTRUCTION FUND EARNINGS END OF PERIOD	CAPITALIZED INTEREST EARNINGS END OF PERIOD	DEBT SERVICE RESERVE EARNINGS END OF PERIOD
1/ 1/91	11,715,975			11,715,975	410,059	33,878	52,099
7/ 1/91	12,212,012	16.67	2,259,683	9,952,329	348,131	16,939	52,099
1/ 1/92	10,369,699	16.67	2,259,683	8,110,016	283,850		52,099
7/ 1/92	8,445,966	16.67	2,259,683	6,186,283	216,519		52,099
1/ 1/93	6,454,903	16.67	2,259,683	4,195,220	146,832		52,099
7/ 1/93	4,394,152	16.67	2,259,683	2,134,469	74,706		52,099
1/ 1/94	2,261,275	16.67	2,259,683	1,592			
TOTAL			13,558,098		1,480,300	50,817	312,598

FIJIRA MUNICIPAL POWER SYSTEM
RATE - 6.75% & MATURITY 25 YEARS

PROPOSED NEW ISSUE

DELIVERY DATE: 1/ 1/91

INTEREST ACCRUED FROM: 1/ 1/91

DATE	COUPON RATE	PRINCIPAL	INTEREST	TOTAL DEBT SERVICE
1/ 1/92			967,950.00	967,950.00
1/ 1/93	6.750	255,000.00	967,950.00	1,222,950.00
1/ 1/94	6.750	270,000.00	950,737.50	1,220,737.50
1/ 1/95	6.750	290,000.00	932,512.50	1,222,512.50
1/ 1/96	6.750	310,000.00	912,937.50	1,222,937.50
1/ 1/97	6.750	330,000.00	892,012.50	1,222,012.50
1/ 1/98	6.750	355,000.00	869,737.50	1,224,737.50
1/ 1/99	6.750	375,000.00	845,775.00	1,220,775.00
1/ 1/ 0	6.750	405,000.00	820,462.50	1,225,462.50
1/ 1/ 1	6.750	430,000.00	793,125.00	1,223,125.00
1/ 1/ 2	6.750	460,000.00	764,100.00	1,224,100.00
1/ 1/ 3	6.750	490,000.00	733,050.00	1,223,050.00
1/ 1/ 4	6.750	525,000.00	699,975.00	1,224,975.00
1/ 1/ 5	6.750	560,000.00	664,537.50	1,224,537.50
1/ 1/ 6	6.750	595,000.00	626,737.50	1,221,737.50
1/ 1/ 7	6.750	635,000.00	586,575.00	1,221,575.00
1/ 1/ 8	6.750	680,000.00	543,712.50	1,223,712.50
1/ 1/ 9	6.750	725,000.00	497,812.50	1,222,812.50
1/ 1/10	6.750	775,000.00	448,875.00	1,223,875.00
1/ 1/11	6.750	825,000.00	396,562.50	1,221,562.50
1/ 1/12	6.750	885,000.00	340,875.00	1,225,875.00
1/ 1/13	6.750	940,000.00	281,137.50	1,221,137.50
1/ 1/14	6.750	1,005,000.00	217,687.50	1,222,687.50
1/ 1/15	6.750	1,075,000.00	149,850.00	1,224,850.00
1/ 1/16	6.750	1,145,000.00	77,287.50	1,222,287.50
TOTAL		14,340,000.00	15,981,975.00	30,321,975.00

ACCURED FROM 1/ 1/91

NET COST

15,981,975.00

AVERAGE COUPON
BOND YEARS
AVERAGE LIFE

6.750
236,775.000
16.511

REQUIRED REVENUES

DATE	PRIOR DEBT SERVICE	PROPOSED DEBT SERVICE	TOTAL DEBT SERVICE	CAPITALIZED INTEREST	NET DEBT SERVICE	REQUIRED REVENUES	SURPLUS	COVER
1/ 1/92		967,949	967,949	967,949				
1/ 1/93		1,222,949	1,222,949		1,222,949	1,528,687	305,737	1.21
1/ 1/94		1,220,737	1,220,737		1,220,737	1,525,921	305,184	1.21
1/ 1/95		1,222,512	1,222,512		1,222,512	1,528,140	305,628	1.21
1/ 1/96		1,222,937	1,222,937		1,222,937	1,528,671	305,734	1.21
1/ 1/97		1,222,012	1,222,012		1,222,012	1,527,515	305,503	1.21
1/ 1/98		1,224,737	1,224,737		1,224,737	1,530,921	306,184	1.21
1/ 1/99		1,220,774	1,220,774		1,220,774	1,525,968	305,193	1.21
1/ 1/ 0		1,225,462	1,225,462		1,225,462	1,531,828	306,365	1.21
1/ 1/ 1		1,223,124	1,223,124		1,223,124	1,528,906	305,781	1.21
1/ 1/ 2		1,224,099	1,224,099		1,224,099	1,530,124	306,024	1.21
1/ 1/ 3		1,223,049	1,223,049		1,223,049	1,528,812	305,762	1.21
1/ 1/ 4		1,224,974	1,224,974		1,224,974	1,531,218	306,243	1.21
1/ 1/ 5		1,224,537	1,224,537		1,224,537	1,530,671	306,134	1.21
1/ 1/ 6		1,221,737	1,221,737		1,221,737	1,527,171	305,434	1.21
1/ 1/ 7		1,221,574	1,221,574		1,221,574	1,526,968	305,393	1.21
1/ 1/ 8		1,223,712	1,223,712		1,223,712	1,529,640	305,928	1.21
1/ 1/ 9		1,222,812	1,222,812		1,222,812	1,528,515	305,703	1.21
1/ 1/10		1,223,874	1,223,874		1,223,874	1,529,843	305,968	1.21
1/ 1/11		1,221,562	1,221,562		1,221,562	1,526,953	305,390	1.21
1/ 1/12		1,225,874	1,225,874		1,225,874	1,532,343	306,468	1.21
1/ 1/13		1,221,137	1,221,137		1,221,137	1,526,421	305,284	1.21
1/ 1/14		1,222,687	1,222,687		1,222,687	1,528,359	305,671	1.21
1/ 1/15		1,224,849	1,224,849		1,224,849	1,531,062	306,212	1.21
1/ 1/16		1,222,287	1,222,287		1,222,287	1,527,859	305,571	1.21
TOTAL		30,321,974	30,321,974	967,949	29,354,024	36,692,531	7,338,506	

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUPKIN & JENNETTE
Piqua Municipal Power System
RATE 6.75 % MATURITY 25 YEARS
SERIES 1994

ISSUE SUMMARY

DELIVERY DATE: 1/ 1/94

INTEREST ACCRUED FROM: 1/ 1/94

ESTIMATED COSTS OF CONSTRUCTION.....	\$21,357,580.00
LESS: CONSTRUCTION FUND EARNINGS @ 7.000%.....	4,478,710.65
CAPITALIZED INTEREST FUND EARNINGS @ 7.000%.....	68,642.44
DEBT SERVICE RESERVE FUND EARNINGS @ 8.500%.....	984,256.44
CONSTRUCTION FINANCING REQUIREMENT.....	\$15,825,970.48
ADD: CAPITALIZED INTEREST FROM 1/ 1/94 TO 1/ 1/95.....	\$1,307,475.00
DEBT SERVICE RESERVE FUND (1.00 TIMES MAXIMUM ANNUAL DEBT SERVICE).....	1,654,212.50
BOND DISCOUNT (3.000%).....	581,100.00
ADDITIONAL EXPENSES (0.000%).....	0.00
REMAINDER DUE TO \$5,000 ROUNDING.....	814.87

TOTAL REQUIRED REVENUE BONDS \$19,370,000.00

AVERAGE LIFE.....	16.50 YEARS
AVERAGE COUPON.....	6.750%
NET INTEREST COST.....	6.932%
TRUE INTEREST COST.....	7.079%

NOTE: NET AND TRUE INTEREST COSTS GIVE EFFECT TO BOND DISCOUNT
OF \$581,100.00.

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUPKIN & JENNETTE
Piqua Municipal Power System
RATE 6.75 % MATURITY 25 YEARS

CONSTRUCTION FUND FLOW OF FUNDS

EARNINGS ACCRUED FROM: 1/ 1/94

TARGET DATE OF CONSTRUCTION COMPLETION: 1/ 1/98

PERIOD BEGINS	BEGINNING BALANCE CONSTRUCTION FUND	PERCENTAGE DRAWDOWN	AMOUNT OF DRAWDOWN	BALANCE REMAINING INVESTED	CONSTRUCTION FUND EARNINGS END OF PERIOD	CAPITALIZED INTEREST EARNINGS END OF PERIOD	DEBT SERVICE RESERVE EARNINGS END OF PERIOD
1/ 1/94	15,827,212	7.14	1,525,571	15,827,212	553,952	45,761	70,304
7/ 1/94	16,497,230	7.14	1,525,571	14,971,658	524,008	22,880	70,304
1/ 1/95	15,586,851	7.14	1,525,571	14,063,279	492,214		70,304
7/ 1/95	14,625,798	7.14	1,525,571	13,100,226	458,507		70,304
1/ 1/96	13,629,038	7.14	1,525,571	12,103,456	423,621		70,304
7/ 1/96	12,597,391	7.14	1,525,571	11,071,819	387,513		70,304
1/ 1/97	11,529,637	7.14	1,525,571	10,004,065	350,142		70,304
7/ 1/97	10,424,512	7.14	1,525,571	8,898,940	311,462		70,304
1/ 1/98	9,280,707	7.14	1,525,571	7,755,135	271,429		70,304
7/ 1/98	8,096,858	7.14	1,525,571	6,571,296	229,995		70,304
1/ 1/99	6,871,596	7.14	1,525,571	5,346,024	187,110		70,304
7/ 1/99	5,603,439	7.14	1,525,571	4,077,867	142,725		70,304
1/ 1/00	4,290,896	7.14	1,525,571	2,765,324	96,786		70,304
7/ 1/00	2,932,415	7.14	1,525,571	1,466,843	49,239		70,304
1/ 1/01	1,526,386	7.14	1,525,571	814			
TOTAL			21,358,007		4,478,710	68,642	984,256

MUNICIPAL BOND ANALYSIS
DONALDSON, LUFKIN & JENNETTE
PIQUA MUNICIPAL POWER SYSTEM
RATE 6.75 & MATURITY 25 YEARS

PROPOSED NEW ISSUE

DELIVERY DATE: 1/ 1/94

INTEREST ACCRUED FROM: 1/ 1/94

DATE	COUPON RATE	PRINCIPAL	INTEREST	TOTAL DEBT SERVICE
1/ 1/95			1,307,475.00	1,307,475.00
1/ 1/95	6.750	345,000.00	1,307,475.00	1,652,475.00
1/ 1/97	6.750	370,000.00	1,284,187.50	1,654,187.50
1/ 1/98	6.750	395,000.00	1,259,212.50	1,654,212.50
1/ 1/99	6.750	420,000.00	1,232,550.00	1,652,550.00
1/ 1/ 0	6.750	445,000.00	1,204,200.00	1,649,200.00
1/ 1/ 1	6.750	480,000.00	1,174,162.50	1,654,162.50
1/ 1/ 2	6.750	510,000.00	1,141,762.50	1,651,762.50
1/ 1/ 3	6.750	545,000.00	1,107,337.50	1,652,337.50
1/ 1/ 4	6.750	580,000.00	1,070,550.00	1,650,550.00
1/ 1/ 5	6.750	620,000.00	1,031,400.00	1,651,400.00
1/ 1/ 6	6.750	660,000.00	989,550.00	1,649,550.00
1/ 1/ 7	6.750	705,000.00	945,000.00	1,650,000.00
1/ 1/ 8	6.750	755,000.00	897,412.50	1,652,412.50
1/ 1/ 9	6.750	805,000.00	846,450.00	1,651,450.00
1/ 1/10	6.750	860,000.00	792,112.50	1,652,112.50
1/ 1/11	6.750	920,000.00	734,062.50	1,654,062.50
1/ 1/12	6.750	980,000.00	671,762.50	1,651,762.50
1/ 1/13	6.750	1,045,000.00	605,812.50	1,650,812.50
1/ 1/14	6.750	1,115,000.00	535,275.00	1,650,275.00
1/ 1/15	6.750	1,190,000.00	460,012.50	1,650,012.50
1/ 1/16	6.750	1,270,000.00	379,687.50	1,649,687.50
1/ 1/17	6.750	1,360,000.00	293,962.50	1,653,962.50
1/ 1/18	6.750	1,450,000.00	202,162.50	1,652,162.50
1/ 1/19	6.750	1,545,000.00	104,287.50	1,649,287.50
TOTAL		19,370,000.00	21,578,062.50	40,948,062.50

ACCRUED FROM 1/ 1/94

NET COST 21,578,062.50
AVERAGE COUPON 6.750
BOND YEARS 319,675.000
AVERAGE LIFE 16.504

REQUIRED REVENUES

DATE	PRIOR DEBT SERVICE	PROPOSED DEBT SERVICE	TOTAL DEBT SERVICE	CAPITALIZED INTEREST	NET DEBT SERVICE	REQUIRED REVENUES	SURPLUS	COVER
1/ 1/95		1,307,474	1,307,474	1,307,474				
1/ 1/96		1,652,474	1,652,474		1,652,474	2,065,593	413,118	1.25
1/ 1/97		1,654,187	1,654,187		1,654,187	2,067,734	413,546	1.25
1/ 1/98		1,654,212	1,654,212		1,654,212	2,067,765	413,553	1.25
1/ 1/99		1,652,549	1,652,549		1,652,549	2,065,687	413,137	1.25
1/ 1/ 0		1,649,199	1,649,199		1,649,199	2,061,499	412,299	1.25
1/ 1/ 1		1,654,162	1,654,162		1,654,162	2,067,703	413,540	1.25
1/ 1/ 2		1,651,762	1,651,762		1,651,762	2,064,703	412,940	1.25
1/ 1/ 3		1,652,337	1,652,337		1,652,337	2,065,421	413,084	1.25
1/ 1/ 4		1,650,549	1,650,549		1,650,549	2,063,187	412,637	1.25
1/ 1/ 5		1,651,399	1,651,399		1,651,399	2,064,249	412,849	1.25
1/ 1/ 6		1,649,549	1,649,549		1,649,549	2,061,937	412,387	1.25
1/ 1/ 7		1,649,999	1,649,999		1,649,999	2,062,499	412,499	1.25
1/ 1/ 8		1,652,412	1,652,412		1,652,412	2,065,515	413,103	1.25
1/ 1/ 9		1,651,449	1,651,449		1,651,449	2,064,312	412,862	1.25
1/ 1/10		1,652,112	1,652,112		1,652,112	2,065,140	413,028	1.25
1/ 1/11		1,654,062	1,654,062		1,654,062	2,067,570	413,515	1.25
1/ 1/12		1,651,962	1,651,962		1,651,962	2,064,953	412,990	1.25
1/ 1/13		1,650,812	1,650,812		1,650,812	2,063,515	412,703	1.25
1/ 1/14		1,650,274	1,650,274		1,650,274	2,063,843	412,568	1.25
1/ 1/15		1,650,012	1,650,012		1,650,012	2,062,515	412,503	1.25
1/ 1/16		1,649,687	1,649,687		1,649,687	2,062,109	412,421	1.25
1/ 1/17		1,653,962	1,653,962		1,653,962	2,067,453	413,490	1.25
1/ 1/18		1,652,162	1,652,162		1,652,162	2,065,203	413,040	1.25
1/ 1/19		1,649,287	1,649,287		1,649,287	2,061,609	412,321	1.25
TOTAL		40,948,062	40,948,062	1,307,474	39,640,587	49,550,734	9,910,146	

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUFKIN & JENNETTE

PIQUA MUNICIPAL POWER SYSTEM
RATE 6.75% & MATURITY 25 YEARS

SERIES 1991

ISSUE SUMMARY

DELIVERY DATE: 1/ 1/91

INTEREST ACCRUED FROM: 1/ 1/91

ESTIMATED COSTS OF CONSTRUCTION.....	\$25,500,000.00
LESS: CONSTRUCTION FUND EARNINGS @ 7.000%.....	2,023,971.05
CAPITALIZED INTEREST FUND EARNINGS @ 7.000%.....	357,977.81
DEBT SERVICE RESERVE FUND EARNINGS @ 8.500%.....	447,777.87

CONSTRUCTION FINANCING REQUIREMENT \$22,670,273.26

ADD: CAPITALIZED INTEREST FROM 1/ 1/91 TO 1/ 1/93.....	\$4,091,175.00
DEBT SERVICE RESERVE FUND (1.00 TIMES MAXIMUM ANNUAL DEBT SERVICE).....	2,633,987.50
BOND DISCOUNT (3.000%).....	909,150.00
ADDITIONAL EXPENSES (0.000%).....	0.00
REMAINDER DUE TO \$5,000 ROUNDING.....	414.24

TOTAL REQUIRED REVENUE BONDS \$30,305,000.00

AVERAGE LIFE..... 16.77 YEARS

AVERAGE COUPON..... 6.750%

NET INTEREST COST..... 6.929%

TRUE INTEREST COST..... 7.074%

NOTE: NET AND TRUE INTEREST COSTS GIVE EFFECT TO BOND DISCOUNT
OF \$909,150.00.

MUNICIPAL DEBT ANALYSIS
DONALDSON, LUFKIN & JENNETTE

PIQUA MUNICIPAL POWER SYSTEM
RATE 6.75% & MATURITY 25 YEARS

CONSTRUCTION FUND FLOW OF FUNDS

EARNINGS ACCRUED FROM: 1/ 1/91

TARGET DATE OF CONSTRUCTION COMPLETION: 1/ 1/93

PERIOD BEGINS	BEGINNING BALANCE CONSTRUCTION FUND	PERCENTAGE DRAWDOWN	AMOUNT OF DRAWDOWN	BALANCE REMAINING INVESTED	CONSTRUCTION FUND EARNINGS END OF PERIOD	CAPITALIZED INTEREST EARNINGS END OF PERIOD	DEBT SERVICE RESERVE EARNINGS END OF PERIOD
1/ 1/91	22,670,687			22,670,687	793,474	143,191	111,944
7/ 1/91	23,719,297	25.00	6,375,000	17,344,297	607,050	107,393	111,944
1/ 1/92	10,170,685	25.00	6,375,000	11,795,685	412,848	71,595	111,944
7/ 1/92	12,392,074	25.00	6,375,000	6,017,074	210,597	35,797	111,944
1/ 1/93	6,375,414	25.00	6,375,000	414			
TOTAL			25,500,000		2,023,971	357,977	447,777

DONALDSON, LUPKIN & JENNETTE
FINRA MUNICIPAL POWER SYSTEM
RATE 6.75% & MATURITY 25 YEARS

PROPOSED NEW ISSUE

DELIVERY DATE: 1/ 1/91

INTEREST ACCRUED FROM: 1/ 1/91

DATE	COUPON RATE	PRINCIPAL	INTEREST	TOTAL DEBT SERVICE
1/ 1/92			2,045,587.50	2,045,587.50
1/ 1/93			2,045,587.50	2,045,587.50
1/ 1/94	6.750	585,000.00	2,045,587.50	2,630,587.50
1/ 1/95	6.750	625,000.00	2,006,100.00	2,631,100.00
1/ 1/96	6.750	670,000.00	1,963,912.50	2,633,912.50
1/ 1/97	6.750	710,000.00	1,918,687.50	2,628,687.50
1/ 1/98	6.750	760,000.00	1,870,762.50	2,630,762.50
1/ 1/99	6.750	810,000.00	1,819,462.50	2,629,462.50
1/ 1/ 0	6.750	865,000.00	1,764,787.50	2,629,787.50
1/ 1/ 1	6.750	925,000.00	1,706,400.00	2,631,400.00
1/ 1/ 2	6.750	990,000.00	1,643,962.50	2,633,962.50
1/ 1/ 3	6.750	1,055,000.00	1,577,137.50	2,632,137.50
1/ 1/ 4	6.750	1,125,000.00	1,505,925.00	2,630,925.00
1/ 1/ 5	6.750	1,200,000.00	1,429,987.50	2,629,987.50
1/ 1/ 6	6.750	1,285,000.00	1,348,987.50	2,633,987.50
1/ 1/ 7	6.750	1,370,000.00	1,262,250.00	2,632,250.00
1/ 1/ 8	6.750	1,460,000.00	1,169,775.00	2,629,775.00
1/ 1/ 9	6.750	1,550,000.00	1,071,225.00	2,631,225.00
1/ 1/10	6.750	1,625,000.00	965,925.00	2,630,925.00
1/ 1/11	6.750	1,780,000.00	853,537.50	2,633,537.50
1/ 1/12	6.750	1,900,000.00	733,387.50	2,633,387.50
1/ 1/13	6.750	2,025,000.00	605,137.50	2,630,137.50
1/ 1/14	6.750	2,165,000.00	468,450.00	2,633,450.00
1/ 1/15	6.750	2,310,000.00	322,312.50	2,632,312.50
1/ 1/16	6.750	2,465,000.00	166,387.50	2,631,387.50
TOTAL		30,305,000.00	34,311,262.50	64,616,262.50

ACCURED FROM 1/ 1/91

NET COST 34,311,262.50

AVERAGE COUPON 6.750
BOND YEARS 508,315.000
AVERAGE LIFE 16.773

REQUIRED REVENUES

DATE	PRION DEBT SERVICE	PROPOSED DEBT SERVICE	TOTAL DEBT SERVICE	CAPITALIZED INTEREST	NET DEBT SERVICE	REQUIRED REVENUES	SURPLUS	COVER
1/ 1/92		2,045,587	2,045,587	2,045,587				
1/ 1/93		2,045,587	2,045,587	2,045,587				
1/ 1/94		2,630,587	2,630,587		2,630,587	3,288,234	657,646	1.25
1/ 1/95		2,631,099	2,631,099		2,631,099	3,288,874	657,774	1.25
1/ 1/96		2,633,912	2,633,912		2,633,912	3,292,390	658,478	1.25
1/ 1/97		2,628,687	2,628,687		2,628,687	3,285,859	657,171	1.25
1/ 1/98		2,630,762	2,630,762		2,630,762	3,288,453	657,690	1.25
1/ 1/99		2,629,462	2,629,462		2,629,462	3,286,828	657,365	1.25
1/ 1/ 0		2,629,787	2,629,787		2,629,787	3,287,234	657,446	1.25
1/ 1/ 1		2,631,399	2,631,399		2,631,399	3,289,249	657,849	1.25
1/ 1/ 2		2,633,962	2,633,962		2,633,962	3,292,453	658,490	1.25
1/ 1/ 3		2,632,137	2,632,137		2,632,137	3,290,171	658,034	1.25
1/ 1/ 4		2,630,924	2,630,924		2,630,924	3,288,656	657,731	1.25
1/ 1/ 5		2,629,987	2,629,987		2,629,987	3,287,484	657,496	1.25
1/ 1/ 6		2,633,987	2,633,987		2,633,987	3,292,484	658,496	1.25
1/ 1/ 7		2,632,249	2,632,249		2,632,249	3,290,312	658,062	1.25
1/ 1/ 8		2,629,774	2,629,774		2,629,774	3,287,218	657,443	1.25
1/ 1/ 9		2,631,224	2,631,224		2,631,224	3,289,031	657,806	1.25
1/ 1/10		2,630,924	2,630,924		2,630,924	3,288,656	657,731	1.25
1/ 1/11		2,633,537	2,633,537		2,633,537	3,291,921	658,384	1.25
1/ 1/12		2,633,387	2,633,387		2,633,387	3,291,734	658,346	1.25
1/ 1/13		2,630,137	2,630,137		2,630,137	3,287,671	657,534	1.25
1/ 1/14		2,633,449	2,633,449		2,633,449	3,291,812	658,362	1.25
1/ 1/15		2,632,312	2,632,312		2,632,312	3,290,390	658,078	1.25
1/ 1/16		2,631,387	2,631,387		2,631,387	3,289,234	657,846	1.25
TOTAL		64,616,262	64,616,262	4,091,174	60,525,087	75,656,359	15,131,271	

PRESENT VALUE AND SENSITIVITY ANALYSIS

Several alternative methods are available for assessing the economic feasibility of the district heating system. In Piqua's case however, discounted net present value analysis is the most appropriate given the phased construction/investment over a twenty year period. Further, this method allows the internalization of all costs to the community not merely those related to the cash flow of the PMPS. The net present value method of capital budgeting determines the net benefit (or cost) of an investment when time is a factor. Future net benefits are discounted back to the present at an assumed interest/discount rate which recognizes time by reflecting the "rate of time preference" i.e., one dollar's worth of benefits today is worth more than one dollar's worth of benefits one year from now.

For purposes of analyzing the Piqua District Heating System net benefit is defined as:

Net benefit from District Heating system is the present discounted value over the horizon of the total cost of the District Heating system compared to the conventional heating system. The net benefit is positive if the net cost is negative.

Net benefit from District Electrical System is the present discounted value over the horizon of the total cost of the District Electrical system compared to the conventional electrical system. The net benefit is positive if the net cost is negative.

Total net benefit of the District Heating System.

Obviously, in order to calculate net benefit all costs must be quantified. Previous chapters of this analysis are devoted to this task. In summary, total costs are the sum of fixed costs, non-fuel semi-fixed and variable costs, and fuel costs. In order to complete the set of inputs, several assumptions must be made.

- a) Discount Rate--determining the correct rate for discounting investments has been one of the most controversial topics in both the public and private financial markets. It is also important in terms of its impact on the level and type of expenditures which will be employed to carry the investment. For these reasons, this study chooses not to apply one discount rate in the economic analysis, but rather a range, varying from the city's cost borrowing to the federal borrowing rate to a forecasted long-range private market rate--(6.75% to 11.75%). The City's borrowing rate (6.75%) is most appropriate in that the project assumes revenue bonds (opportunity cost low-zero) and the project will be publically owned.
- b) Base Inflation Rate--is assumed to be 8% over the project period. Although this is significantly higher, the historical data and the demonstration team's understanding of macro economic adjustments supports this disturbing probability.
- c) Fuel Differential Escalation Rates--are difficult to predict for specific scarce fuels of a twenty year period. Therefore, the project's sensibility to varying differential rates is tested. The range generally applied is 3% to 13%.

The pages immediately following present a complete outline of the net present value model and related inputs which is used in the evaluation of the Piqua District Heating Project.

Net Present Value/Sensitivity Model

I. Benefit Analysis

THNT

A. Net benefit from District Thermal system is the present discounted value over the horizon of the total cost of the District Thermal system compared to the conventional Heating system. The net benefit is positive if the net cost is negative.

ELNT

B. Net benefit from District Electrical System is the present discounted value over the horizon of the total cost of the District Electrical system compared to the conventional Electrical system. The net benefit is positive if the net cost is negative.

TNET

=THNT+ELNT

C. Sum of the net benefit from the District Thermal System and the District Electrical System.

II. Definition of Total Costs

CAP+ANNUAL+
FUELCST

Total costs are the sum of fixed costs, non-fuel semi-fixed and variable costs, and fuel costs.

III. A Fixed Costs

BLDG1

1. Conventional Heating System

DEBBLDG1

The cost of new capital and the replacement of existing user buildings, houses and equipment-both financed and unfinanced.

BLDG2

2. District Thermal System

The cost of new capital and the replacement of existing user buildings, houses, and equipment-both financed and unfinanced.

DEBT2

(=THF+PPF)

Debt service on the financed portion of the thermal distribution system and the thermal component of the power plant.

UFC2

(=THU+PPU)

Unfinanced expense of the thermal distribution system and the thermal component of the power plant.

REPL2

(=THR+PPR)

Depreciation or replacement costs on the thermal distribution system and the thermal component of the power plant.

DEBT3

UFC3

REPL3

3. Conventional Electric System

The cost of the expansion modification and replacement of the electric power plant; including debt service of financed portion, unfinanced expenditures and depreciation.

DEBT4

UFC4

REPL4

4. District Electric System

The cost of the expansion, modification and replacement of the electric power plant in the district system; including debt service of financed portion, unfinanced expenditures and depreciation.

III. B Semi-Fixed and Variable Costs (Not Fuel)

1. Conventional Heating System

The operation and maintenance of heating equipment in user buildings and houses.

BLDGFL

(= FUEL (1,1) +

FUEL (1,2)+FUEL

(1,3)

This is functionally related to the fuel consumption of residential, commercial, and industrial heating fuel.

2. District Thermal System

The operation and maintenance of thermal equipment in user buildings and houses.

The operation and maintenance of the thermal distribution system.

Semi-fixed costs of the electric power plant thermal component, i.e. overhead staff, administrative expenses, operating staff, custodial expenses, insurance, etc.

Variable (non-fuel) costs of the electric power plant thermal component.

THERMAL

(=THERM (2,1)+

THERM (2,2)+THERM

(2,3)+FUEL(2,1)+

FUEL(2,2)+FUEL(2,3)

These are all functionally related to thermal output which is residential, commercial and industrial thermal energy plus residential, commercial and industrial heating fuel.

3. Conventional Electric System

Semi-fixed costs of the electric power plant; i.e. overhead staff, administrative expenses, operating staff, custodial expenses, insurance, etc.

Variable (non-fuel) costs of the electric power plant.

ELCTRIC1

(=ELEC(1,1)+ELEC
(1,2)+ELEC(1,3)

These are each functionally related to residential, commercial and industrial electricity.

4. District Electric System

Semi-fixed costs of the electric power plant electric component; i.e. overhead staff, administrative expenses, operating staff, custodial expenses, insurance, etc.

Variable (non-fuel) costs of the electric power plant electrical component.

ELCTRIC2

(=ELEC(2,1)+ELEC
(2,2)+ELEC(2,3)

These are each functionally related to residential, commercial and industrial electricity.

III. C Fuel Costs-Types of Fuel

- Type 1. Residential Heating Fuel
- Type 2. Commercial Heating Fuel
- Type 3. Industrial Heating Fuel
- Type 4. Purchased Dayton Power and Light Electricity
- Type 5. Coal Input to Power Plant
- Type 6. Fuel Oil Input to Power Plant

III. D Fuel Costs-Prices of Fuels

- PRICE 1=
- $FCOST_1 [EFO_1^{**T-1} * FO_1 + ENG_1^{**T-1} * FNG_1]$
1. Residential Heating fuel - The price per unit has a differential escalation rate calculated according to the fuel oil to natural gas mix of use.
- PRICE 2=
- $FCOST_2 [EFO_2^{**T-1} * FO_2 + ENG_2^{**T-1} * FNG_2]$
2. Commercial Heating Fuel - The price per unit has a differential escalation rate calculated according to the fuel oil to natural gas mix of use.

- PRICE 3 = $FCOST3[EF03^{**T-1} * F03 + ENG3^{**T-1} * FNG3]$ 3. Industrial Heating Fuel - The price per unit has a differential escalation rate calculated according to the fuel oil to natural gas mix of use.
- PRICE 4 = $FCOST4 * EF04^{**T-1}$ 4. Purchased Dayton Power and Light Electricity has its own differential escalation rate.
- PRICE 5 = $FCOST5 * EF04^{**T-1}$ 5. The coal input is assumed to have the same differential escalation rate as the purchased electricity.
- PRICE 6 = $FCOST6 * EF04^{**T-1}$ 6. The fuel oil input is assumed to have the same differential escalation rate as the purchased electricity.

III. Fuel Costs- Calculation

Fuel Costs for each system are the sum of the fuel costs (i.e. fuel use times price) for the fuels used in that system.

- FUEL (1,1)
FUEL (1,2)
FUEL (1,3) 1. Conventional Heating system - Uses residential heating fuel, commercial heating fuel and industrial heating fuel.
- FUEL (2,1)
FUEL (2,2)
FUEL (2,3)
FUEL (2,5)
FUEL (2,6) 2. District Thermal System - Uses residential heating fuel, commercial heating fuel, industrial heating fuel, coal input and fuel oil input.
- FUEL (3,4)
FUEL (3,5)
FUEL (3,6) 3. Conventional Electric System - Uses purchased electricity, and input and fuel oil input.
- FUEL (4,4)
FUEL (4,5)
FUEL (4,6) 4. District Electric System - Uses purchased electricity, coal input and fuel oil input.

DATA INPUTS

I. Capital Costs (\$1980 Input by Year)

A. Conventional Plan

BLDG(1)
DEBBLDG(1)	1. User buildings and houses - The cost of new capital and the replacement of existing equipment
	a. Unfinanced Portion
	b. Debt Service of Financed Portion
DEBT(3)
UFC (3)
REPL(3)	2. Electric Power Plant - Current capital costs, expansion, modification and replacement.
	a. Debt Service of Financed Portion
	b. Unfinanced Portion
	c. Depreciation

B. District Plan

BLDG(2)
DEBBLDG(2)	1. User Buildings and Houses - The cost of retrofitting houses to district heat and replacement of equipment
	a. Unfinanced portion
	b. Debt Service on Financed portion
THF
THU
THR	2. Thermal Energy Distribution System
	a. Debt Service on Financed Portion
	b. Unfinanced Portion
	c. Depreciation - "replacement"
PPF
PPU
PPR	3. Electric Power Plant Thermal Component
	a. Debt Service on Financed Portion
	b. Unfinanced Portion
	c. Depreciation - "replacement"
DEBT(4)
UFC(4)
REPL(4)	Electric Power Plant Electrical Component
	a. Debt Service of Financed Portion
	b. Unfinanced Portion
	c. Depreciation - "replacement"

II. Annual Costs (\$1980 Input)

A. Conventional Plan

IA = 1

1. User Buildings and Houses

The operation and maintenance of heating equipment.

IA = 2

2. Electric Power Plant

a. Semi-fixed utility costs, (e.g. overhead staff, administrative expenses, operating staff, custodial expenses, insurance, etc.)

IA = 3

b. Variable utility costs (other than energy) in the production of electricity

B. District Plan

IA = 4

1. User Buildings and Houses

The operation and maintenance of thermal equipment.

IA = 5

2. Thermal Distribution System

The operation and maintenance of equipment and system

IA = 6

3. Electric Power Plant Thermal Component

IA = 7

a. Semi-fixed costs

b. Variable costs

IA = 8

Electric Power Plant Electrical Component

IA = 9

a. Semi-fixed costs

b. Variable costs

IA is the program identifier for the category of annual costs. These costs are expressed as multi-period linear functions. In each period annual costs are equal to $A + B * \text{Consumption} * E^{t-1}$ where E is a correction for inflation and differential escalation of that category. A, B and E are given for each period for each annual cost category.

III. FUEL CONSUMPTION BY YEAR

A. Conventional Plan

FUEL (1,1)	1. Residential Heating Fuel	Million BTU
FUEL (1,2)	2. Commercial Heating Fuel	Million BTU
FUEL (1,3)	3. Industrial Heating Fuel	Million BTU

FUEL (3,4)	4. Dayton Power and Light Purchased Electricity	Million KWH
FUEL (3,5)	5. Coal for Utility	Million BTU
FUEL (3,6)	6. Fuel Oil for Utility	Million BTU
ELEC (1,1)	7. Residential Electricity	Million KWH
ELEC (1,2)	8. Commercial Electricity	Million KWH
ELEC (1,3)	9. Industrial Electricity	Million KWH

B. District Plan

FUEL (2,1)	1. Residential Heating Fuel	Million BTU
FUEL (2,2)	2. Commercial Heating Fuel	Million BTU
FUEL (2,3)	3. Industrial Heating Fuel	Million BTU
FUEL (4,4)	4. Dayton Power and Light Purchased Electricity	Million KWH
FUEL (2,5)	5. Coal for Utility - Thermal	Million BTU
FUEL (4,5)	6. Coal for Utility - Electricity	Million BTU
FUEL (2,6)	7. Fuel Oil for Utility - Thermal	Million BTU
FUEL (4,6)	8. Fuel Oil for Utility - Electricity	Million BTU
ELEC (2,1)	9. Residential Electricity	Million KWH
ELEC (2,2)	10. Commercial Electricity	Million KWH
ELEC (2,3)	11. Industrial Electricity	Million KWH
THERM (2,1)	12. Residential Thermal Energy	Million BTU
THERM (2,2)	13. Commercial Thermal Energy	Million BTU
THERM (2,3)	14. Industrial Thermal Energy	Million BTU

IV. FUEL COSTS \$1980

A. Price Per Unit

FCOST 1	1. Residential Heating Fuel	\$/MBTU
FCOST 2	2. Commercial Heating Fuel	\$/MBTU
FCOST 3	3. Industrial Heating Fuel	\$/MBTU
FCOST 4	4. Dayton Power and Light Purchased Electricity	\$/MKWH
FCOST 5	5. Coal Input to Power Plant	\$/MBTU
FCOST 6	6. Fuel Oil Input to Power Plant	\$/MBTU

B. Percent Input of Fuel Oil

F01	1. Residential Heating Fuel	%
F02	2. Commercial Heating Fuel	%

F03 3. Industrial Heating Fuel %

C. Percent Input of Natural Gas

FNG1 1. Residential Heating Fuel %

FNG2 2. Commercial Heating Fuel %

FNG3 3. Industrial Heating Fuel %

D. Differential Escalation Rates

EF01 1. Fuel Oil for Residential Heating %

EF02 2. Fuel Oil for Commercial Heating %

EF03 3. Fuel Oil for Industrial Heating %

EF04 4. Electricity (Dayton Power and Light) %

EF05 5. Coal %

EF06 6. Fuel Oil %

ENG1 7. Natural Gas for Residential Heating %

ENG2 8. Natural Gas for Commercial Heating %

ENG3 9. Natural Gas for Industrial Heating %

V. Other Data Inputs

DBRATIO 1. Interest rate adjustment factor for financing user building and equipment

DTRATIO 2. Interest rate adjustment factor for financing power plant and equipment

COL 3. Inflation Factor

DISC 4. Discount Factor

NET PRESENT VALUE/SENSITIVITY ANALYSIS RESULTS

The charts, tables and graphs found on the following pages present the analysis results in detail. It is important to note that the Demonstration Team has burdened the District Heating System with all conceivable costs throughout the entire study. Consequently, the results are of the most conservative nature.

Generally net benefit is sensitive to increases in the cost of (Differential Escalation Rate DER) natural gas and coal; and essentially insensitive to the DER of fuel oil. These results are expected in that natural gas is the primary fuel to be displaced; little fuel oil is used in the study area; and coal is the power plant's fuel. Illustrated by the graph below, the project is rather insensitive to variations in the discount rate. This "stability" is important given current economic uncertainties and a potential near term recession.

The economic calculations for the base case scenario (following page) show net benefits as negative in the initial years, becoming annually positive in 1991 (Table A) and cumulatively positive in 1999 (Table B). Throughout the 20 year project period there is an accumulative net total savings equivalent to 14 million in 1978 dollars. Tables C and D demonstrate the sensitivity of the findings annually and cumulatively positive when the escalation rate of natural gas is raised from 3 to 10%. Table E, employing the base case discount and inflation rates (6.75% and 8.0% respectively) presents cumulative net benefits of the District Heating System over the project period when scarce fuels are escalated at differential rates. Note that with coal held at a constant rate and fuel oil at 3%, the escalation of natural gas from 3 to 10% uses net benefits by 215 million 1978 dollars. Table F raises the discount rate to 10% keeping the remainder of the inputs the same as that in Table E, and indicates again the relative causal unsensitivity of the results. Phase 2 of this project attempts to further confirm the stability of the accumulated present worth net benefit through changes in assumptions of the net present value/sensitivity analysis, however the base case is assumed to represent a reasonable assessment, with a great deal of conservatism, of the forecasted condition.

ECONOMIC ANALYSIS OF THE PROPOSED PIQUA OHIO DISTRICT HEATING SYSTEM

BASE CASE REPORT

TABLE A

(ANNUAL COSTS IN THOUSANDS OF DOLLARS (UNDISCOUNTED))

YEAR	CONVENTIONAL COST		DISTRICT COST		NET COST		NET COST TOTAL
	THERMAL	ELECTRICAL	THERMAL	ELECTRICAL	THERMAL	ELECTRICAL	
1968	0.	57.3	0.	57.3	0.	0.	363.
1969	0.	57.3	0.	57.3	0.	0.	356.
1970	0.	57.3	0.	57.3	0.	0.	349.
1971	0.	57.3	0.	57.3	0.	0.	342.
1972	0.	57.3	0.	57.3	0.	0.	335.
1973	0.	57.3	0.	57.3	0.	0.	328.
1974	0.	57.3	0.	57.3	0.	0.	321.
1975	0.	57.3	0.	57.3	0.	0.	314.
1976	0.	57.3	0.	57.3	0.	0.	307.
1977	0.	57.3	0.	57.3	0.	0.	300.
1978	0.	57.3	0.	57.3	0.	0.	293.
1979	0.	57.3	0.	57.3	0.	0.	286.
1980	0.	57.3	0.	57.3	0.	0.	279.
1981	0.	57.3	0.	57.3	0.	0.	272.
1982	0.	57.3	0.	57.3	0.	0.	265.
1983	0.	57.3	0.	57.3	0.	0.	258.
1984	0.	57.3	0.	57.3	0.	0.	251.
1985	0.	57.3	0.	57.3	0.	0.	244.
1986	0.	57.3	0.	57.3	0.	0.	237.
1987	0.	57.3	0.	57.3	0.	0.	230.
1988	0.	57.3	0.	57.3	0.	0.	223.
1989	0.	57.3	0.	57.3	0.	0.	216.
1990	0.	57.3	0.	57.3	0.	0.	209.
1991	0.	57.3	0.	57.3	0.	0.	202.
1992	0.	57.3	0.	57.3	0.	0.	195.
1993	0.	57.3	0.	57.3	0.	0.	188.
1994	0.	57.3	0.	57.3	0.	0.	181.
1995	0.	57.3	0.	57.3	0.	0.	174.
1996	0.	57.3	0.	57.3	0.	0.	167.
1997	0.	57.3	0.	57.3	0.	0.	160.
1998	0.	57.3	0.	57.3	0.	0.	153.
1999	0.	57.3	0.	57.3	0.	0.	146.
2000	0.	57.3	0.	57.3	0.	0.	139.
2001	0.	57.3	0.	57.3	0.	0.	132.
2002	0.	57.3	0.	57.3	0.	0.	125.
2003	0.	57.3	0.	57.3	0.	0.	118.
2004	0.	57.3	0.	57.3	0.	0.	111.
2005	0.	57.3	0.	57.3	0.	0.	104.
2006	0.	57.3	0.	57.3	0.	0.	97.
2007	0.	57.3	0.	57.3	0.	0.	90.
2008	0.	57.3	0.	57.3	0.	0.	83.
2009	0.	57.3	0.	57.3	0.	0.	76.
2010	0.	57.3	0.	57.3	0.	0.	69.
2011	0.	57.3	0.	57.3	0.	0.	62.
2012	0.	57.3	0.	57.3	0.	0.	55.
2013	0.	57.3	0.	57.3	0.	0.	48.
2014	0.	57.3	0.	57.3	0.	0.	41.
2015	0.	57.3	0.	57.3	0.	0.	34.
2016	0.	57.3	0.	57.3	0.	0.	27.
2017	0.	57.3	0.	57.3	0.	0.	20.
2018	0.	57.3	0.	57.3	0.	0.	13.
2019	0.	57.3	0.	57.3	0.	0.	6.
2020	0.	57.3	0.	57.3	0.	0.	0.

ECONOMIC ANALYSIS OF THE PROPOSED PIQUA OHIO DISTRICT HEATING SYSTEM

BASE CASE REPORT

TABLE B

(CUMULATIVE DISCOUNTED COSTS IN THOUSANDS OF DOLLARS)

YEAR	CONVENTIONAL COST		DISTRICT COST		NET COST		NET COST TOTAL
	THERMAL	ELECTRICAL	THERMAL	ELECTRICAL	THERMAL	ELECTRICAL	
1968	0.	57.3	0.	57.3	0.	0.	363.
1969	0.	57.3	0.	57.3	0.	0.	726.
1970	0.	57.3	0.	57.3	0.	0.	1089.
1971	0.	57.3	0.	57.3	0.	0.	1452.
1972	0.	57.3	0.	57.3	0.	0.	1815.
1973	0.	57.3	0.	57.3	0.	0.	2178.
1974	0.	57.3	0.	57.3	0.	0.	2541.
1975	0.	57.3	0.	57.3	0.	0.	2904.
1976	0.	57.3	0.	57.3	0.	0.	3267.
1977	0.	57.3	0.	57.3	0.	0.	3630.
1978	0.	57.3	0.	57.3	0.	0.	3993.
1979	0.	57.3	0.	57.3	0.	0.	4356.
1980	0.	57.3	0.	57.3	0.	0.	4719.
1981	0.	57.3	0.	57.3	0.	0.	5082.
1982	0.	57.3	0.	57.3	0.	0.	5445.
1983	0.	57.3	0.	57.3	0.	0.	5808.
1984	0.	57.3	0.	57.3	0.	0.	6171.
1985	0.	57.3	0.	57.3	0.	0.	6534.
1986	0.	57.3	0.	57.3	0.	0.	6897.
1987	0.	57.3	0.	57.3	0.	0.	7260.
1988	0.	57.3	0.	57.3	0.	0.	7623.
1989	0.	57.3	0.	57.3	0.	0.	7986.
1990	0.	57.3	0.	57.3	0.	0.	8349.
1991	0.	57.3	0.	57.3	0.	0.	8712.
1992	0.	57.3	0.	57.3	0.	0.	9075.
1993	0.	57.3	0.	57.3	0.	0.	9438.
1994	0.	57.3	0.	57.3	0.	0.	9801.
1995	0.	57.3	0.	57.3	0.	0.	10164.
1996	0.	57.3	0.	57.3	0.	0.	10527.
1997	0.	57.3	0.	57.3	0.	0.	10890.
1998	0.	57.3	0.	57.3	0.	0.	11253.
1999	0.	57.3	0.	57.3	0.	0.	11616.
2000	0.	57.3	0.	57.3	0.	0.	11979.
2001	0.	57.3	0.	57.3	0.	0.	12342.
2002	0.	57.3	0.	57.3	0.	0.	12705.
2003	0.	57.3	0.	57.3	0.	0.	13068.
2004	0.	57.3	0.	57.3	0.	0.	13431.
2005	0.	57.3	0.	57.3	0.	0.	13794.
2006	0.	57.3	0.	57.3	0.	0.	14157.
2007	0.	57.3	0.	57.3	0.	0.	14520.
2008	0.	57.3	0.	57.3	0.	0.	14883.
2009	0.	57.3	0.	57.3	0.	0.	15246.
2010	0.	57.3	0.	57.3	0.	0.	15609.
2011	0.	57.3	0.	57.3	0.	0.	15972.
2012	0.	57.3	0.	57.3	0.	0.	16335.
2013	0.	57.3	0.	57.3	0.	0.	16698.
2014	0.	57.3	0.	57.3	0.	0.	17061.
2015	0.	57.3	0.	57.3	0.	0.	17424.
2016	0.	57.3	0.	57.3	0.	0.	17787.
2017	0.	57.3	0.	57.3	0.	0.	18150.
2018	0.	57.3	0.	57.3	0.	0.	18513.
2019	0.	57.3	0.	57.3	0.	0.	18876.
2020	0.	57.3	0.	57.3	0.	0.	19239.

***TOTAL NET PRESENT VALUE OF COSTS =

-13927.5***

INFLATION = 1.3%

FUEL OIL = 1.1134

NATURAL GAS = 1.1134

ECONOMIC ANALYSIS OF THE PROPOSED PIMA OHIO DISTRICT HEATING SYSTEM

*** SENSITIVITY ANALYSIS REPORT ***

TABLE C

(ANNUAL COSTS IN THOUSANDS OF DOLLARS (UNDISCOUNTED))

YEAR	CONVENTIONAL COST		DISTRICT COST		NET COST		NET COST TOTAL
	THERMAL	ELECTRICAL	THERMAL	ELECTRICAL	THERMAL	ELECTRICAL	
1981							
1982							
1983							
1984							
1985							
1986							
1987							
1988							
1989							
1990							
1991							
1992							
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2110							
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2112							
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2119							
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2160							
2161							
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2168							
2169							
2170							
2171							
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2200							
2201							
2202							
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2207							
2208							
2209							
2210							
2211							
2212							
2213							
2214							
2215							
2216							
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2220							
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2227							
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2229							
2230							
2231							
2232							
2233							
2234							
2235							
2236							
2237							
2238							
2239							
2240							
2241							
2242							
2243							
2244							
2245							
2246							
2247							
2248							
2249							
2250							
2251							
2252							
2253							
2254							
2255							
2256							
2257							
2258							
2259							
2260							
2261							
2262							
2263							
2264							
2265							
2266							

TABLE E

DISCOUNTED PRESENT VALUE NET BENEFITS

\$1000

Inflation 8%
Discount 6.75%
Escalation:
Fuel Oil 3%
Coal 0%

Inflation 8%
Discount 6.75%
Escalation:
Natural Gas 3%
Coal 0%

Inflation 8%
Discount 6.75%
Escalation:
Fuel Oil 3%
Natural Gas 3%

Escalation of
Natural Gas:

3%	13,928
4%	33,733
5%	56,405
6%	82,354
7%	112,046
8%	146,013
9%	184,858
10%	229,267
11%	280,018
12%	337,994
13%	404,195

Escalation of
Fuel Oil:

3%	13,928
4%	13,712
5%	13,409
6%	13,003
7%	12,472
8%	11,793
9%	10,939
10%	9,878
11%	8,575
12%	6,986
13%	5,065

Escalation of
Coal:

0%	13,928
1%	8,962
2%	3,294
3%	-3,176
4%	-10,563
5%	-18,995
6%	-28,622
7%	-39,609
8%	-52,149
9%	-66,458
10%	-82,781

TABLE F
DISCOUNTED PRESENT VALUE NET BENEFITS

\$1000

Inflation 8%
Discount 10%
Escalation:
Fuel Oil 3%
Coal 0%

Inflation 8%
Discount 10%
Escalation:
Natural Gas 3%
Coal 0%

Inflation 8%
Discount 10%
Escalation:
Fuel Oil 3%
Natural Gas 3%

Escalation of
Natural Gas:

3%	4,702
4%	17,405
5%	31,893
6%	48,416
7%	67,258
8%	88,742
9%	113,234
10%	141,149
11%	172,959
12%	209,196
13%	250,464

Escalation of
Fuel Oil:

3%	4,702
4%	4,668
5%	4,589
6%	4,456
7%	4,258
8%	3,980
9%	3,608
10%	3,123
11%	2,505
12%	1,729
13%	769

Escalation of
Coal:

0%	4,702
1%	1,445
2%	-2,256
3%	-6,462
4%	-11,244
5%	-16,681
6%	-22,863
7%	-29,894
8%	-37,888
9%	-46,978
10%	-57,314

7.0 Phase II Scope of Work

SCHEDULE OF WORK FOR PHASE II AND FUTURE PHASES

Objective

The objective of this phase of the project is to: (a) establish the Preliminary Feasibility and Conceptual Institutional Arrangements; (b) establish the technical feasibility of the most promising Demonstration Project uncovered in Phase 1; (c) establish the institutional arrangements and framework required to bring this alternative to demonstration; (d) conduct a technical feasibility analysis of the most technologically attractive Demonstration Project identified.

The aforementioned Phase 2 tasks are set forth below and the Contractor shall perform said tasks in accordance with its proposal to DOE to continue to Phase 2 as defined in this project Phase 1 Final Report, except as hereinafter modified.

Scope of Work for Phase 2

7.1 Task 1 Develop a Detailed Work Management Plan

- 7.1.1 Develop detailed Work Management Plan to accomplish objectives of Phase 2.
- 7.1.2 Provide a pert chart, a cost for each task, a milestone chart, a manpower resource requirement plan, a definition of the corporate and program organizational structure, and allocation of responsibility for performance of required tasks.

PHASE II -- PROJECT ORGANIZATION CHART

7.2 Task 2 Load and Service Area Assessment

- 7.2.1 Characterize service area by electric and thermal densities, and develop the thermal and electric diurnal, seasonal, and annual load duration curves for each.
- 7.2.2 Characterize service area in relation to degree-days heating, average heating season temperature, number of heating days, and design temperature.
- 7.2.3 Evaluate the City of Piqua's annual load growth relative to growth projections.
- 7.2.4 Re-evaluate operating projections, service requirements, and cost performance for confirmation or revision over the life of the project.
- 7.2.5 Reassess potential energy savings and scarce fuel savings (therms and BTU/yr) attributable to Demonstration Program for a typical annual operating cycle.
- 7.2.6 Develop a full scale district heating marketing program applicable within the service area. The marketing effort shall be targeted toward zones and customers (residential, commercial, industrial) identified in Phase 1. One result of this task is to secure firm, individual customer commitments of sufficient scale to support the anticipated interim construction capital investment.
- 7.2.7 Secure industrial, commercial, institutional, and residential sign-ups for district heating service on a case by case basis.
- 7.2.8 Plan for interim district heating service anticipated in latter stage of Phase 2. This shall include the planning and feasibility evaluation necessary to proceed with interim service to those customers using steam to hot water convertors connected to the existing steam distribution system.

7.3 Task 3 Technical Assessment

- 7.3.1 Based on Phase 1 results select optimum retrofit scheme based on expected growth and sensitivity to energy prices.
- 7.3.2 Characterize operating characteristics cost and the establishment of provisions for future growth.
- 7.3.3 Select distribution system development pace and power plant capital investment to optimize system feasibility through the matching of debt service loads and thermal and electrical demands.

- 7.3.4 Determine distribution system line sizes and insulation requirements. Provide outline specification for distribution piping and insulation. Estimate distribution heat losses (BTU/ft.² and total).
- 7.3.5 Survey proposed routing of main distribution lines for initial installation along center line of the pipe system. Determine right of ways, and locate underground utilities, identify interferences and property lines. Prepare a topographical map of initial distribution system route.
- 7.3.6 For determining capital cost, update the distribution system zone level costs from actual distribution system routing proposals and line size determination in the initial service area.
- 7.3.7 On the basis of the above, update information on soil conditions as related to corrosion, drainage, and acceptability to buried pipe.
- 7.3.8 Verify assumptions made with respect to boiler and turbine performance in Phase 1 through boiler performance and turbine rating studies to determine effects of retrofit. Establish modes of operation and establish control scheme of cogeneration plant with interfacing of existing plant control scheme.
- 7.3.9 Conduct and document an investigation of domestic and foreign products in order to assure potential customers and installers of the availability and cost of district heating equipment.
- 7.3.10 Develop end-user outline specifications for use by domestic manufacturers to estimate cost of producing district heating equipment. Assemble a work book on piping materials, heat exchangers, water heaters, controls and meters.
- 7.3.11 Provide comprehensive heat and material balance along with flowsheet for retrofitted plant.
- 7.3.12 Provide summarized tabulation of salient features of plant description and operating parameters.

7.4 Task 4 Economic Assessment

- 7.4.1 Finalize thermal and electric rate structure. Quantify and qualify the detailed operating and debt-service costs within context of formulating thermal and electric rate structure for customers within the Piqua community. Rate structure shall include cost impacts for end-user retrofit.

7.4.2 Survey representative buildings in initial service areas to determine the extent of retrofit required including the costs and barriers of retrofit. Compare representative utility bills for these buildings relative to projected thermal energy cost by district heating.

7.4.3 Prepare a comprehensive summary of fuel and electricity price projections applicable to the district heating area based on the best information available from reliable sources. Place particular emphasis on the price of scarce fuel (natural gas and oil where applicable). Select probable price projection ranges acceptable to the decision makers who will be responsible for the decision to proceed with construction.

7.4.4 Based on the selected price projection ranges, analyze the economics of the District Heating System using a methodology familiar to the decision makers. Also, provide two proforma income statements and balance sheets in normal accounting format for each alternative considered. These should reflect the most attractive and least attractive economics within the probable price projection ranges for fuel and electricity. Support all assumptions with appropriate data and include sufficient documentation of computer programs employed to permit a numerical check of results.

7.5 Task 5 Institutional Assessment

7.5.1 Identify any additional legal questions and possible resolution not addressed in Phase 1. These questions shall focus upon the preparation of necessary/required opinions and instruments in support of such activities as the design-build RFP/contract, customer hook-up forms, Bond Prospectus, ancillary easements, right of way agreements, and operation of district heating.

7.5.2 Determine by in-house study the possible impact on gas rates for remaining users in Piqua as a consequence of displacing gas and depriving the local gas distributor of customers as a result of implementing district heating. Determine impact on local gas distributor in regard to lost revenue.

7.5.3 Analyze environmental impact of converting the primary heating fuel of Piqua from natural gas to coal. Assess and quantify the microclimatic effects, long term degradation of environmental air quality, and impact of current air pollution abatement plans on the project. Identify any corrective actions required to meet foreseeable pollution standards and include in the plans for system implementation.

- 7.5.4 Analyze and evaluate both the technical and economic issues related to the installation of air quality control equipment. Prepare preliminary plans based upon the analysis.
- 7.5.5 Develop a local code which will provide standards for end-user connections to the district heating system. Develop technical specifications, identify permit procedures, and prepare outline procedures for district heating installation inspection.

7.6 Task 6 Staffing Requirements

- 7.6.1 Develop scope of work for a Design/Build team member participation in all phases of Phase 2.
- 7.6.2 Solicit proposal for Design/Build Team. The Design/Build Team shall participate with the project team in developing construction time schedules, construction cost estimates, preliminary schematic plans and be prepared to proceed with future phases of the project.
- 7.6.3 Identify, qualify, and characterize the manpower skills and knowledge required for the continued developmental (market) operation and maintenance of the district heating system. In addition to ability to assess and evaluate site specific customer retrofits, economic justifications, and the commitment of appropriate equipment, the staff shall be capable of developing applicable operating procedures, policies for a uniform accounting system, meter readings, and collections.

7.7 Task 7 Finance Arrangement

- 7.7.1 Appropriate work product from both Phase 1 and 2 shall be reorganized and assembled within an Engineering/Financial Feasibility Analysis for utilization by both the City's bond counsel and underwriters for inclusion in the Bond Prospectus.

7.8 Task 8 Inspection of Operational District Heating System

- 7.8.1 As part of the technology survey, three members of the Project Team shall inspect several operating district heating plants in certain Scandinavian countries selected on the basis of similarity to the Piqua demonstration plant. The purpose of the inspection is to obtain information to augment the current state-of-the-art in the United States since technology transfer of operational procedures including problems associated with community scale cogeneration district heating plants has not been fully disseminated.

- 7.8.2 Foreign manufacturers of district heating equipment shall be contacted and their manufacturing capability assessed. The end-product of this Task shall be the garnering of critical, first-hand knowledge of district heating systems' design and operating practices; thereby optimizing the buildability and ultimate viability of the Piqua District Heating System.

7.9 Task 9 Proposal for Implementation

- 7.9.1 Based upon the work accomplished in Phase 2, prepare a detailed implementation plan for the remainder of the demonstration program. At a minimum, the multiphase program should include:

Description of the Demonstration Project including the preferred retrofit scheme and thermal distribution network.

Demonstration Master Schedule

Detailed Task Schedule for subsequent phases with PERT Charts for each subsequent phase.

PHASE II COST PROPOSAL

	<u>Est. Cost (\$)</u>
Georgia Institute of Technology	95,345
Hanselman-Eskew and Associates	276,000
Design/Build Firm to be selected	29,000
KWH/Thermal Rate Analysis; Emission Control Analysis	41,875
Power Plant Performance Tests	55,000
Contingencies	73,125
 Total Estimated Cost	 570,345
Less City of Piqua Cost Sharing (28.4%)	162,345
Total	408,000

CITY OF PIQUA

219 WEST WATER STREET - PIQUA, OHIO 45356

September 18, 1979

U.S. Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

Attention: Mr. Charles Frazier

Gentlemen:

The Piqua, Ohio Demonstration Team, which is comprised of the City of Piqua, Hanselman-Eskew and Associates and the Georgia Tech Engineering Experiment Station has completed Phase I of the study designed to assess the feasibility of district heating in Piqua, Ohio through power plant retrofit. This initial phase does not reveal any technical, legal, institutional or economic obstacles to the successful implementation of district heating. Subsequent phases of the project will rigorously examine the economic, technical and financial aspects to insure the most beneficial and cost effective implementation process.

The City of Piqua, as well as the entire Demonstration Team is eager to continue work on this program and recognize the valuable contributions and savings to be realized through the successful implementation of District Heating in Piqua and are therefore prepared to commit themselves to this goal.

Sincerely,

James Henderson
Mayor

JH/ms

David Wade
Project Leader, Georgia Tech
Engineering Experiment Station

William C. Hanselman
Project Manager

William C. Eskew
Project Leader - Hanselman-Eskew
and Associates

Wallick Construction Co.

P. O. BOX 1023 • COLUMBUS, OHIO 43216
TELEPHONE (AREA 614) 464-4640

Offices at 150 E. Mound Street

September 19, 1979

Mr. William Escue
5060 Wadsworth Road
Dayton, Ohio 45414

Re: Piqua Hot Water Heat

Dear Mr. Escue:

Please be advised that Wallick Construction Co. as the developer of and the designer of Piqua Manor of Piqua, Ohio, have elected to design the project in such a manner to take full advantage to the proposed hot water heat to be provided through the proposed system to be installed by the City of Piqua.

Although the project may be completed prior to the time that the system is actually installed by the City, it will be temporarily using alternate fuels until such time as it can tie its design system into the Piqua Hot Water System.

I trust this is the information you desire. If there is any other way we can help you in this respect, please do not hesitate to contact us.

Very truly yours,

WALLICK CONSTRUCTION CO.

Sanford Goldston
Executive Vice President

ihj

cc: Mr. Alan F. Scott
Mr. Jack L. Wallick

piqua

memorial

hospital

624 PARK AVE. PIQUA, OHIO 45356

May 25, 1979

Mr. Frank Patrizio, Jr.
City Manager
Municipal Building
Piqua, Ohio 45356

Attention: Mr. William Eskew

Dear Sir:

This letter is to formally announce our intention to participate in the proposed District Heating Project. Piqua Memorial Hospital will utilize the service provided that the cost of energy is the same as or lower than we are now experiencing; that approvals, as may be needed from various planning authorities, are received; that adequate funds are available to cover any capital related costs involved in the Hospital's conversion.

Yours very truly,

R. W. Sorrell, Sr.
Administrator

RWS:dm

Piqua City School District

419 Coldwell Street, Piqua, Ohio 45356
Telephone 513-773-4321

June 6, 1979

SUPERINTENDENT
Duane Bachman

ASSISTANT SUPERINTENDENT
M.D. Pedroff, Ph.D.

ADMINISTRATIVE ASSISTANT
Richard Pearson

BOARD OF EDUCATION
William B. McNeil, President
William C. Alexander, Vice President
James Gover
William Paron
Cornelia Tinkler
Victoria Cruchet, Clerk

Mr. Frank Patrizio
City Manager
City of Piqua
Piqua, Ohio

Dear Frank:

Please let this letter express our interest in forced hot water heat if, in fact, such a source of energy would become available. If the cost of such heat is competitive and if this type of energy is more reliable than the current utility used in the Piqua City School system, we would definitely be interested.

We understand that this is a possibility and we hope that this letter will correctly express an interest in such energy if and when it becomes available.

Thank you very much.

Sincerely,

Duane Bachman, Superintendent
Piqua City Schools

DB:rh

Attention: Mr. Eskew

PIQUA DAILY CALL

NEWSPAPER OF PIQUA, OHIO

ASH AND SPRING STREETS, PIQUA, OHIO 45356 • AREA CODE 513 773-2721

May 31, 1979

Mr. William Eskew
Hanselman & Eskew Associates
City of Piqua
City Building
W. Water Street
Piqua, Ohio 45356

Dear Mr. Eskew,

As you know, this newspaper has been an avid supporter of the Department of Energy-Georgia Tech-City of Piqua study project seeking to determine the feasibility of cogeneration for the immediate city area.

We would be interested in obtaining copies of the final conclusions of the study for use in planning future energy strategy at the newspaper.

As you know from research already done, we operate in a three-story building with an abundance of glass stemming from its turn-of-the-century construction when windows were vital to air flow and light. Now, of course, it makes for an inefficient building vis-a-vis energy conservation.

The heating system is an old one and while functioning well now, we know it is going to be replaced sometime within the next 10 years. We would consider conversion to a system such as the one under consideration if it could be shown to be cost-effective.

Please realize a decision of this magnitude would be made at our home office in Chicago, however with proper justification, I would have no hesitation in pushing for cogeneration given proper documentation.

Please keep me advised as to the status of your study and provide us with the results as soon as they are available. We hope it proves feasible and that the city moves ahead with implementation.

Best personal regards,

Richard B. Holland
Editor-General Manager