ANL-78-XX-92

THE COMMUNITY SYSTEMS PROGRAM

ITS GOALS AND ACCOMPLISHMENTS

1978

ICES
INTEGRATED COMMUNITY ENERGY SYSTEMS

ARGONNE NATIONAL LABORATORY

COMMUNITY SYSTEMS PROGRAM

MASTER

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ARGONNE NATIONAL LABORATORY COMMUNITY SYSTEMS PROGRAM: ITS GOALS AND ACCOMPLISHMENTS 1978

Prepared for:

U.S. Department of Energy
Building and Community Systems Division

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

FOREWORD

The Community Systems Program of the Division of Buildings and Community Systems, Office of Energy Conservation, of the United States Department of Energy (DOE), is concerned with conserving energy and scarce fuels through new methods of satisfying the energy needs of American Communities. These programs are designed to develop innovative ways of combining current, emerging, and advanced technologies into Integrated Community Energy Systems (ICES) that could furnish any, or all, of the energy-using services of a community. The key goals of the Community System Program then, are to identify, evaluate, develop, demonstrate, and deploy energy systems and community designs that will optimally meet the needs of various communities.

The overall Community Systems effort is divided into three main areas: (a) Integrated Systems, (b) Community Planning & Design, and (c) Implementation Mechanisms. The *Integrated Systems* work is intended to develop the technology component and subsystem data base, system analysis methodology, and evaluations of various system conceptual designs which will help those interested in applying integrated systems to communities. Also included in this program is an active participation in demonstrations of ICES. The *Community Planning & Design* effort is designed to develop concepts, tools, and methodologies that relate urban form and energy utilization. This may then be used to optimize the design and operation of community energy systems. *Implementation Mechanisms* activities will provide data and develop strategies to accelerate the acceptance and implementation of community energy systems and energy-conserving community designs.

ARGONNE NATIONAL LABORATORY

COMMUNITY SYSTEMS PROGRAM

1 OVERVIEW

1.1 GOAL OF THE COMMUNITY SYSTEMS PROGRAM

The goal of the Community Systems Program at Argonne National Laboratory is to promote energy conservation at the community level in ways that satisfy human needs while consuming the minimum non-renewable energy resources. To achieve this goal, the Community Systems Program has taken an overall view of the community and its energy-related activities that include an integration of technological (e.g., community energy supply systems) and non-technological (e.g., community design and dominant institutions) aspects. This holistic approach and the goal of the Community Systems Program are symbolized in the four E's of the above logo, namely:

- to conserve Energy;
- to preserve the Environment; and
- to achieve Economy
- in the design and operation of human settlements (Ekistics).

The term "Integrated Community Energy Systems" (ICES) is defined to embody the philosophy, goals, and concepts of the Community Systems Program, and the interdependent goals of ICES planning are shown in Fig. 1.1

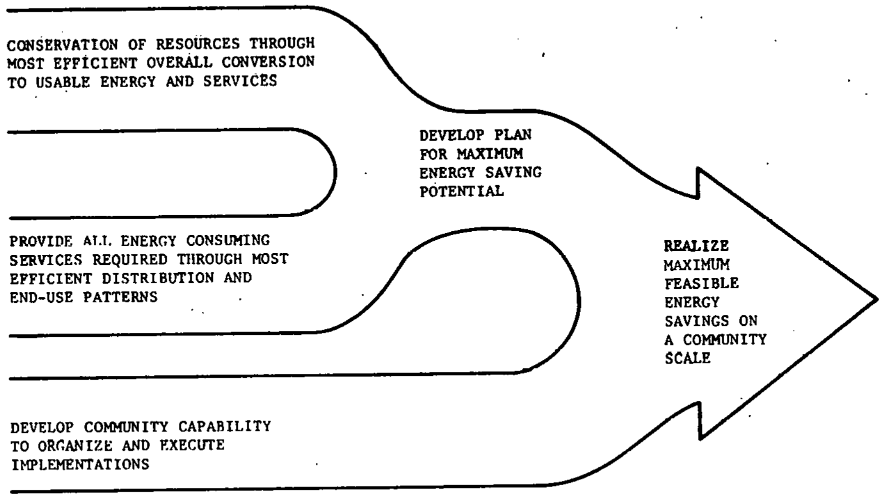

Fig. 1.1 The Interdependent Goals of Integrated Community Systems Planning

1.2 CONCEPT OF INTEGRATED COMMUNITY ENERGY SYSTEMS

The concept of Integrated Community Energy Systems (ICES), as defined in the overall Community Systems Program, includes a broad spectrum of technologies that meets energy service requirements in a manner that maximizes use of the input energy resources. This is accomplished through cogeneration and energy cascading principles in which production of the various energy services involved is technically integrated to minimize energy waste. The process of cogeneration of electricity as a byproduct of heat is illustrated in Fig. 1.2.

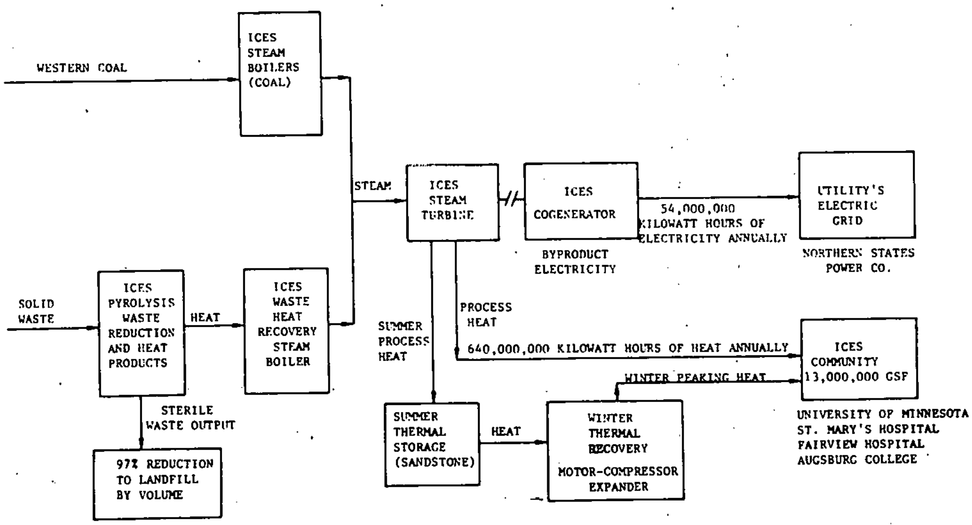

Fig. 1.2 Grid-Connected ICES: Electricity as a Byproduct of Heat

1.2.1 Grid-Connected ICES

A Grid-Connected ICES uses a central cogeneration plant and distribution system to provide heating, cooling, and electrical energy services. Moreover, the system is:

- controlled in parallel with the electric utility,
- designed to allow unrestricted electricity interchanges with the utility grid, and
- governed by an identifiable system of cost allocation and changes for the electrical and thermal products.

Figure 1.3 Illustrates the Grid-Connected ICES concept.

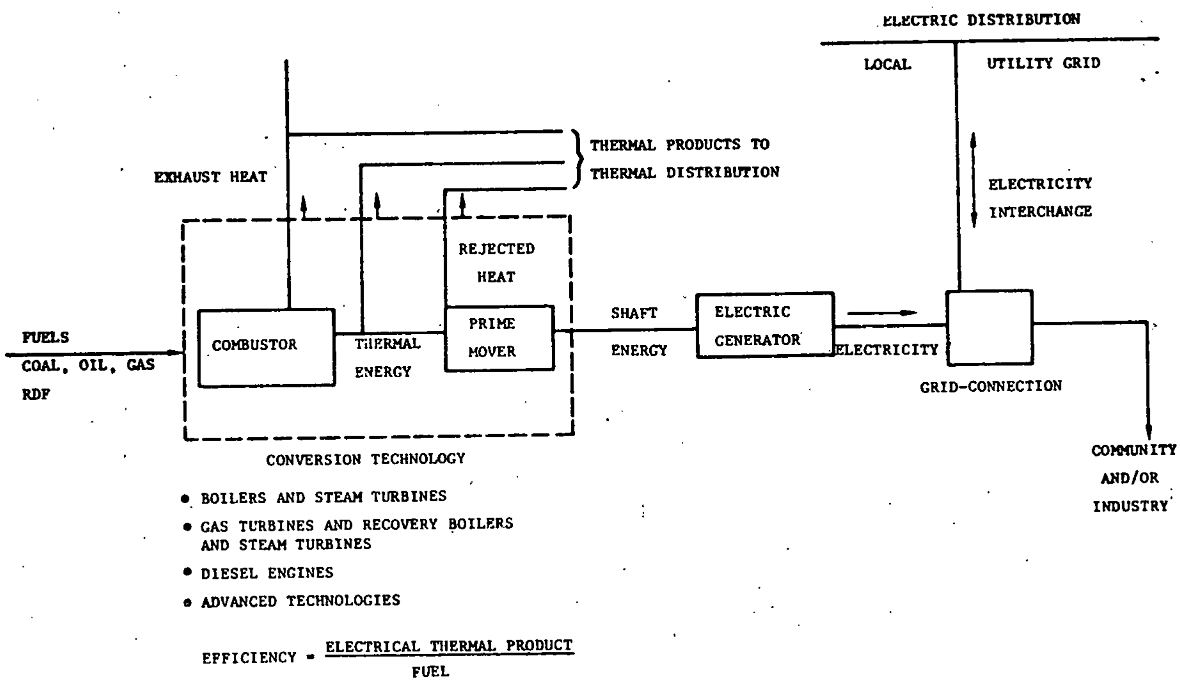

Fig. 1.3 The Grid-Connected ICES Concept

A primary goal of the Grid-Connected ICES Program is to develop and demonstrate grid-connected systems using current technology and providing communities with heating, cooling, and electricity. The developed systems must prove:

(1) conservation of energy,

(2) potential for fuel flexibility,

(3) economic viability,

(4) environmental and institutional acceptability, and

(5) satisfaction of the community energy needs.

Potential application of G-C ICES includes a wide variety of communities and industries, as, for example:

- university campuses and/or medical complexes,
- downtown renewal projects,
- new residential or commercial developments,
- industrial parks and industry in general.

The overall efficiency in these systems is maximized by integrating the energy system with community or building design considerations such as layout and composition.

As proposed, six phases comprise the G-C ICES Plan:

Phase	Effort	Status
I	Preliminary feasibility analysis and evaluation of candidate demonstration communities	Complete
II	Detailed feasibility analysis and preliminary design for the demonstration system	to be Complete 3/22
III	Final design and preparation of construction working drawings for the demonstration system	Awaiting DOE decision in May
IV	Construction of the demonstration system	Planned
V	Initial operation, testing, and performance monitoring of the system	Planned
VI	Long-term operation and evaluation	Planned

ICES offer considerable potential for fuel substitution, thereby allowing the use of non-scarce fuel resources that would not be economically usable in smaller unintegrated systems. Input energy sources for such systems may include low-grade waste heat, solid- and liquid-wastes, solar and geothermal heat, seawater heat dissipation, and use of less scarce fuels, such as coal and biomass.

The ICES concept is more than just a hardware system, although energy supply system research and design are major elements of the Community Systems Program. The concept also includes ways of designing and arranging community structures in space to minimize energy consumption.

Most importantly, an Integrated Community Energy System is a comprehensive energy management concept applied at the community level to obtain an optimal combination of both these dimensions to meet the energy requirements of a particular community in an energy-conserving, safe and reliable, economically stable, and environmentally acceptable fashion.

1.3 COMMUNITY SYSTEMS APPROACH

The comprehensive, integrated approach to community energy conservation adopted by the Community Systems Program is summarized in Fig. 1.4.

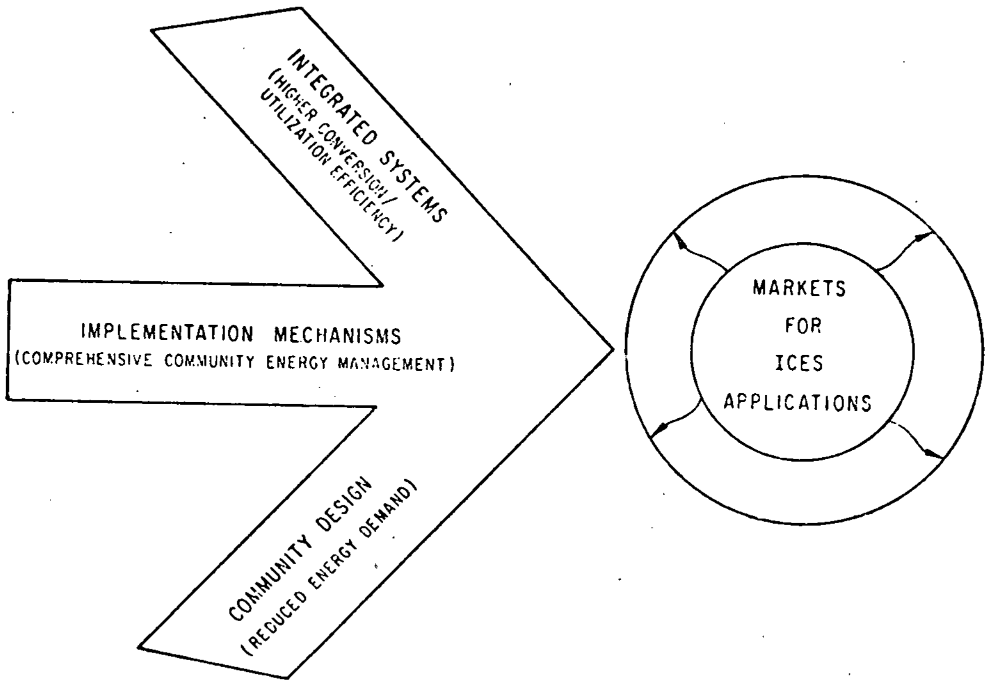

Fig. 1.4 Approach of Community Systems Program

This approach encompasses three closely coordinated areas of effort that attempt to expand continually the set of specific market applications of Integrated Community Energy Systems and thereby to minimize the consumption of non-renewable energy resources. These program elements are organized around the three broad objectives of the Community Systems Program as follows:

- **Integrated Systems** - which research, develop, and demonstrate at the pilot or demonstration level integrated community energy systems that meet targeted energy efficiency, scarce-fuel savings, and other performance (safety, reliability, maintenance, operations, environmental control) criteria at a minimum cost.

- **Community Design** - which researches, develops, and demonstrates community designs that meet targeted energy performance criteria at minimum cost through tradeoffs in building design, community layout, activity mix and density, or other factors of development choice.

- **Implementation Mechanisms** - that research, develop, and demonstrate mechanisms for implementing integrated community energy systems that achieve maximum energy conservation by combining the design of communities and the design of energy systems through a coordinated approach to community energy management that integrates both the community development process and the energy system development process.

1.4 CHARTER

The Community Systems Program at ANL has, as one of its primary purposes, the creation and implementation of "...a comprehensive energy conservation strategy that will achieve the highest priority in the national energy program."* In transferring the functions and R&D programs vested in the former Energy Research and Development Administration, the DOE enabling legislation provides for a Buildngs and Community Systems program of conservation that will improve the efficiency of energy utilization in buildings and community systems by means such as: (1) improved designs and structures, (2) energy and waste utilization, (3)improved consumer products and motivation, and (4) economic analysis and technology transfer.

Acting under this authority, the Community Systems Program has assumed the national technical leadership for research, development, and demonstration activities related to energy conservation in communities.

*Public Act. 95-91, Sec. 102(4).

1.5. ROLE OF THE COMMUNITY SYSTEMS PROGRAM

The role of the Community Systems Program, as a bridge between the target consuming sectors and the base technology research, development, and demonstration programs is emphasized in Fig. 1.5.

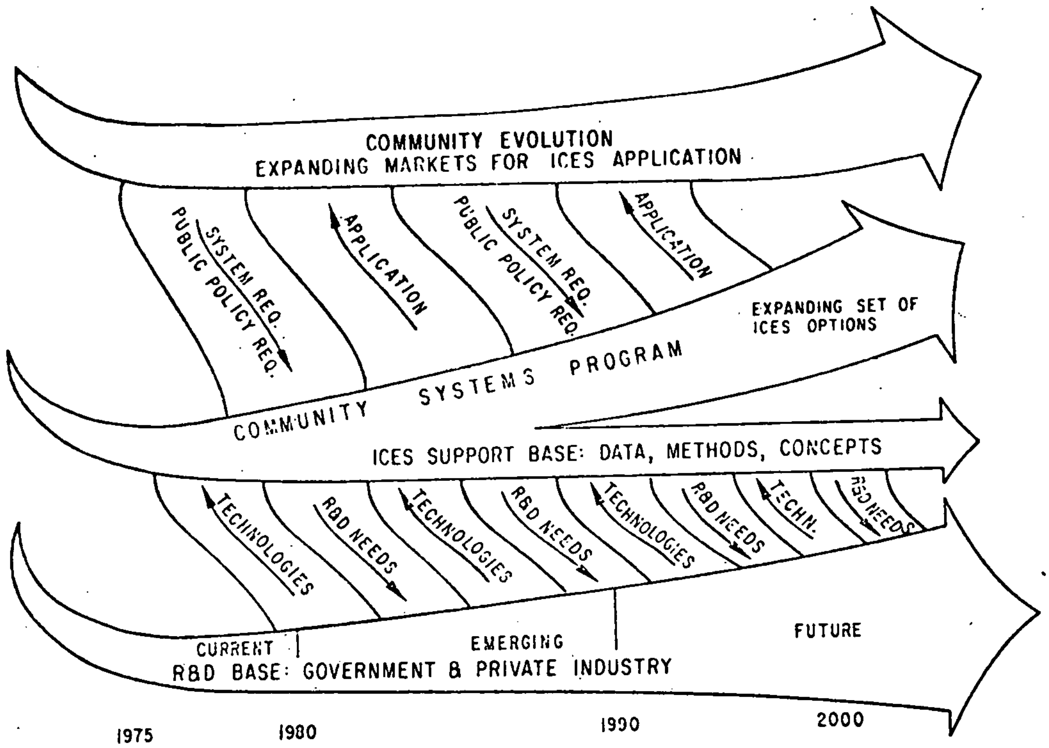

Fig. 1.5 Role of the Community Systems Program

Among the key research-oriented programs that provide the informational base upon which the Community Systems Program draws are those responsible for: waste utilization, fuels technology, solar energy, conservation in buildings, industrial energy conservation, and transportation technologies. The resultant matching of technologies and community designs is the underpinning and focus of the commercialization components, which leads, ultimately, to widespread deployment of proven concepts in an expanding market for ICES application to communities of all types throughout the United States. Figure 1.5 also shows the reverse flow of system requirements, public policy requirements, and R&D needs back from the ultimate end users to the responsible program management.

1.5.1 Role of Argonne National Laboratory in the C.S. Program

Argonne National Laboratory -- with active participation by private industry and cooperation of other national laboratories and governmental agencies -- is principally responsible for designing, managing, and implementing the ICES Program.

1.6 ENERGY SAVINGS

Energy savings that can result from satisfying the program objectives are large. With ICES and community designs that are possible by the year 2000, 50% of the energy required by current designs could be saved in each new application. For a residential community of 7,000 mixed single- and multi-family dwelling units, having a total requirement for energy services of about 7×10^{11} Btu/yr, a 50% savings is equivalent to more than 200 barrels of oil a day in fuels supplied to the community. The national energy savings will depend on the rate of adoption of ICES, which is quite sensitive to the federal role in their implementation.

In addition to absolute energy savings, these systems have the advantage of allowing significant shifts from scarce to more abundant or renewable fuels. The intermediate scale technologies involved can utilize coal, urban wastes, biomass, solar, and geothermal inputs in place of scarce gas and oil. The residential community described above would generate enough solid waste to meet 10% of its energy requirements, thereby potentially replacing more than 40 barrels per day of scarce fuels. In some instances, the shift in fuels possible with ICES could result in a complete replacement of scarce fuels, and save scarce fuels up to the total community requirement of nearly 500 barrels a day.

2 STRUCTURE OF THE COMMUNITY SYSTEMS PROGRAM

2.1 PROGRAM OBJECTIVES

The goals for ICES performance and implementation are expressed in the Program's quantitative objectives which are staged for full penetration of the ICES markets by the year 2000 as follows:

- **by 1983** - Fuel Effectiveness Ratios (FER) for integrated systems of 100% will be demonstrated, and systems with FER $\geq$ 150% will be under development. Community designs that require less than 90% of the energy services of comparable conventional communities will have been proved feasible through demonstrations and case studies.
- **by 1990** - Implementation mechanisms will be successful in reaching enough ICES market applications to cause existing communities to use 10% less energy and new communities to use 30% less.
- **by 2000** - Lowered community energy demands and enhanced system efficiencies of ICES, made possible by evaluation and demonstration of advanced concepts, will achieve essentially full market penetration and result in 20% reductions of energy consumption in existing communities and 50% in new ones. Substitution for scarce fuels, permitted by ICES in place, will amount to 25% of the presently used scarce fuels.

2.2 DEMONSTRATIONS AND IMPLEMENTATION ACTIONS

The program objectives are to be met through a series of demonstrations and implementation actions to prove the validity of ICES concepts and to foster their market application. The essential features of the program leading to fulfillment of the objectives are diagrammed in Fig. 2.1. Evaluation of potentially effective concepts depends on data and methods that are being developed in each of the program's major functional elements. Those concepts having special promise will be subjects of demonstration projects. The figure includes milestones for the completion of construction in demonstrations of some significant concepts based on existing technologies, namely, grid-connected ICES, district heating and cooling systems, and coal-using ICES. Separate demonstrations that focus on community design, energy management, and institutional concepts also are indicated by milestones. However, every demonstration within the program will include aspects of all program elements.

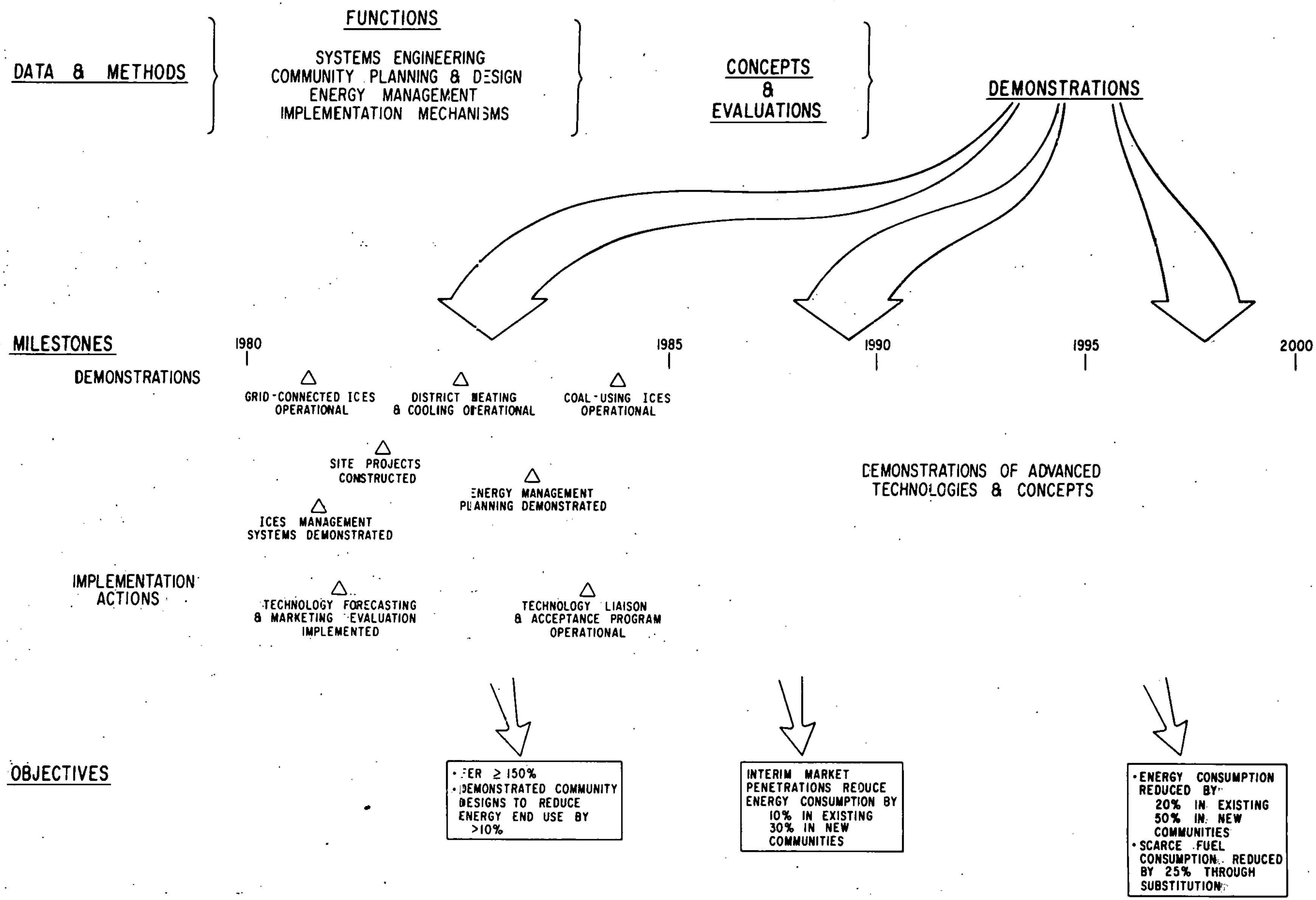

Fig. 2.1 Program Structure for Demonstration and Implementation of ICES Concepts

2.2.1 ICES Demonstration Projects

During 1977, contracts for the following Grid-Connected ICES (G-C ICES) demonstration teams were negotiated:

- City of Independence, Missouri,
- Clark University,
- City of Trenton, New Jersey,
- Health Education Authority of Louisiana (HEAL), and
- University of Minnesota.

By year-end, the four demonstration teams of the G-C ICES had made significant headway in the preparation of preliminary design drawings and in obtaining manufacturers' equipment quotations and delivery times. Moreover, a coal-using ICES, proposed for Georgetown University, also has made noticeable strides toward demonstration of the concept. A summary of Phase I G-C ICES is given in Table 2.1.

Table 2.1 Grid-Connected ICES: Summary of Phase I

Community	Type	Size	Proposed G-C ICES
City of Independence Independence, Missouri	Commercial Residential Shopping Center	2.1 Million ft^2 20 MWe	Coal Boilers
Clark University Worcester, Massachusetts	Small Campus with Education and Residential Buildings	1 Million ft^2 1.5 MWe 20,000 Lb/H Steam	Diesel Engines
City of Trenton Trenton, New Jersey	Downtown Redevelopment - Commercial, Institutional, Residential Buildings	2 Million ft^2 10 MWe 120,000 Lb/H Steam	Gas Turbines
HEAL New Orleans, Louisiana	Hospitals and Health Educational Facilities	3 Million ft^2 Existing 7.5 Million ft^2 Ultimate 11.7 MWe 157.000 Lb/H Steam 12,000 T Cooling	Coal Boilers
University Minnesota Minneapolis, Minnesota	Large Campus and Adjacent Hospitals	14 Million ft^2 7.5-12.5 MWe 300,000 Lb/H Steam	Coal Boilers & Solid Waste Gasifiers

The details of this integration of program elements are represented by the structure of the district heating and cooling demonstrations, as displayed in Fig. 2.2. The progression of phases from generic concepts through the assessment, design, construction, and operation of particular systems utilizes products from community planning and design (general development and master plans; analytical tools for community design), implementation (innovative financing mechanisms; impacts of regulations; and market analysis for ICES), and integrated systems (systems engineering) elements.

2.2.2 Typical Cost Considerations

For a typical proposed Grid-Connected ICES installation, e.g., the Health, Education Authority of Louisiana (HEAL), the following data were obtained from an economic and energy analysis:

- Economic Analysis

Total Program Cost	\$29.2 million
Proposed DOE Participation	1.8 million
Fixed Annualized Cost	3.1 million/yr
Total Annual Cost (W/Fuel)	6.4 million/yr
Total Annual Revenues	7.1 million/yr

- Energy Analysis

ICES Energy Efficiency:	78% $(\text{Eff} = \frac{\text{Output}}{\text{Input}})$
District Heating & Cooling Services provided:	117×10^6 Btu/h (avg)

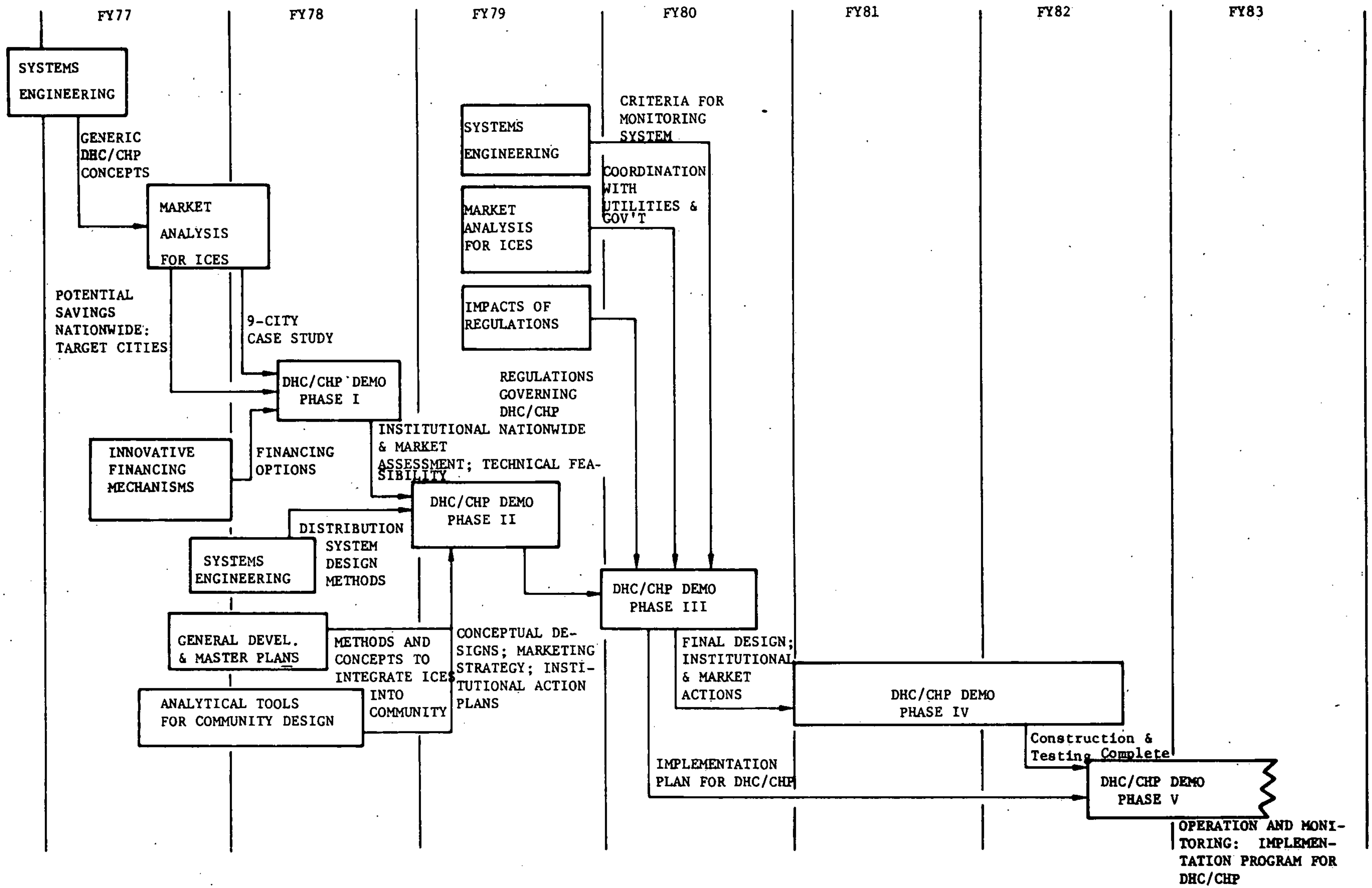

Fig. 2.2 Planned Program for District Heating & Cooling with Combined Heat & Power (DHC/CHP) (Identifying Inputs from Other Community Systems R&D Projects)

Figure 2.3 shows the proposed G-C ICES for HEAL.

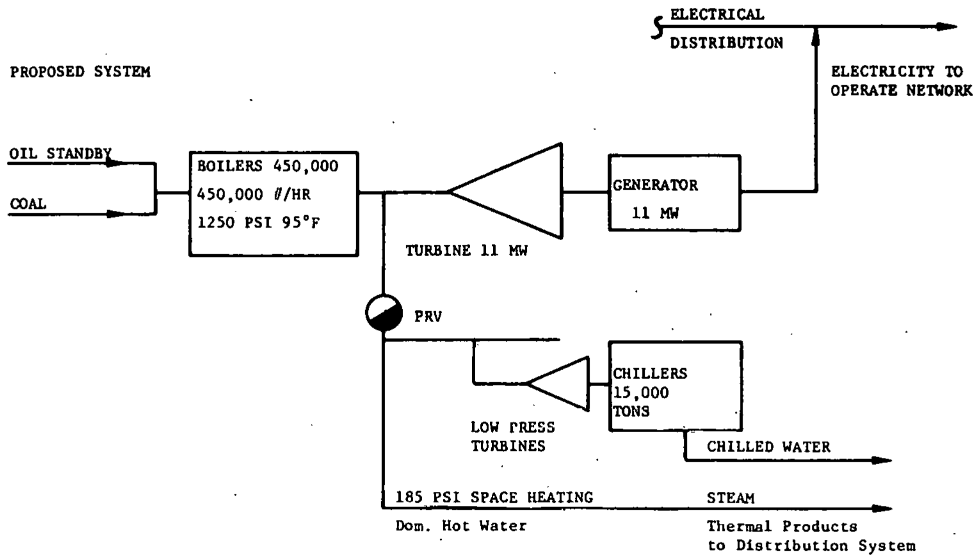

Fig. 2.3 Proposed Grid-Connected ICES-HEAL, New Orleans, Louisiana

Implementation actions, needed to ensure the widest possible application of successful ICES concepts, will be established by the time the results of the demonstrations of current-technology ICES become available.

2.3 MAJOR PROGRAM ACTIVITIES

Several types of activity within each of the program's three major elements are being pursued to accomplish ICES demonstrations and implementation. Three such projects are described here.

2.3.1 Integrated Systems R&D

This project focuses on the technological aspects of the design and implementation of ICES. Major program activities include:

- **Demonstration Programs** - Demonstrations of generic ICES are carried out to verify technological feasibility and resolve potential implementation problems. In addition to system design, construction, and operation, a demonstration includes a marketing strategy and institutional action plan derived from market and institutional assessments. ICES concepts, based on current technologies, are being demonstrated for grid-connected ICES, coal-using ICES, district heating and cooling, heat-pump-centered ICES, and upgrading of total energy plants to ICES.

- **Systems Engineering** - Basic data and methods are developed for the evaluation and design of ICES based on current, emerging, and advanced technologies. Reliable engineering data are provided through laboratory-scale tests on critical ICES subsystems and components. Guidance material on technology evaluations and methods for ICES system design for use by community developers and energy systems engineers is developed, published, and maintained current.

2.3.2 Community Planning and Design R&D

This project addresses the energy benefits to be derived from applying community design principles and concepts to ICES applications. Major program activities include:

- **Site and Neighborhood Project Planning** - Design concepts and principles that enhance energy conservation in the site and neighborhood project planning process are defined, developed, evaluated, and demonstrated.
- **Community Development Subsystems Planning** - Information, strategies, and techniques are developed for use in community development subsystems planning and design processes and in analyzing the energy conservation potential of these systems. Activity location patterns and subsystems networks are evaluated to determine those most desirable and compatible with alternative ICES concepts.
- **General Development and Master Planning**- Energy conservation concepts are developed through case studies of the general development and master planning process of specific community types, such as rural towns, suburban communities, and urban and redevelopment cities of various sizes.
- **Analytical Tools for Planning and Design** - Methods for community energy planning and management to achieve conservation objectives are researched and developed. Guidance materials for community-wide energy conservation planning and management programs are prepared.

2.3.3 Implementation Mechanisms

This project is concerned with those aspects of the Community Systems Program designed to prepare public and private sectors to implement ICES concepts and program products. Major program activities include:

- **Implementation Processes** - Multiphase, decision-making processes used to evaluate the application of ICES concepts in public and private market sectors are developed, demonstrated, and implemented in community and energy system development processes.

- **Technology Forecasting and Strategies for Market Share Objectives** - The data, methods and procedures are developed for estimating the market penetration potential of new and emerging ICES concepts.

- **Energy Management Programs** - Methods and procedures are developed, demonstrated, and implemented at the community level for energy management to achieve conservation objectives.

- **Technology Liaison and Acceptance** - This is the implementing arm of the Community Systems Program that interacts routinely with the public and private sectors to assist them in implementing ICES concepts and program products. It functions as a channel for information flows in and out of the Community Systems Program. Cooperative Demonstration Programs are developed with public and private sectors and other program elements.

Implementation Mechanisms activities will have impact over a range of community types and time frames. Impacts on a first-order categorization of communities by scale (site, city, and metro region) and status of development (new construction vs. retrofit) are indicated for the program activities in Table 2.2 which also includes the time frame in which each impact

Table 2.2 Community Systems Program: Major Activities

			COMMUNITY			TIME FRAME FOR IMPACT			STATIS OF DEVELOP.		PROPOSED FUNDING
			SITE	CITY	METRO REGION	NEAR	MID	LONG	NEW CONSTRUCTION	RETROFIT	CUMULATIVE THROUGH FY 1982 ($ x 10^6)
INTEGRATED SYSTEMS	DEMONSTRATIONS	Grid-Connected ICES	X			X			X	X	14
		Coal-Using ICES	X	X			X		X		15
		Heat Pump Centered ICES	X			X			X		10
		District Heating & Cooling		X	X		X			X	30
		Total Energy Plant Retrofit to ICES	X			X				X	5
		Advanced Technology ICES	X	X	X			X	X	X	8
		Systems Engineering for ICES	X	X	X	X	X	X	X	X	15
COMMUNITY PLANNING AND DESIGN		Site & Neighborhood Design	X	X			X		X		5
		Community Subsystems Development Process			X	X			X	X	3
		General Development & Master Plans		X	X			X	X	X	9
		Analytical Tools for Community Design	X	X	X	X	X	X	X	X	4
IMPLEMENTATION	PROCESSES	Impacts of Regulation	X	X	X	X			X	X	1
		Innovative Mechanisms for Financing & Managing ICES	X	X		X			X	X	.5
		Market Analysis for ICES Targets of Opportunity	X			X			X		4
	ENERGY MANAGEMENT	Community Capacity Building for Energy Management	X	X	X	X			X	X	4
		Comprehensive Energy Planning Demonstration		X			X			X	9

will occur. The cumulative funding projected through FY 1982 is weighted strongly in favor of Integrated Systems Demonstrations that will have impact in the near and mid-terms on a variety of community types.

2.4 PROJECT MILESTONES

Some of the projects that are being carried out within the major program activities and their principal milestones are listed in Tables 2.3 through 2.5.

Table 2.3 Integrated Systems Milestones

Major Program Element	Completion	Event
1. ICES Systems Engineering:		
Technology Evaluations	10/78	a. Complete Initial Evaluation of Current and Emerging Technologies
Design Methods and Manuals	1/79	b. Simulation and Optimization of ICES (OASIS) Computer Code Series -- Tested and Validated
Systems Development	10/80	c. Publication of ICES Systems Guide
ICES Test Facility	10/79	d. Facility Operational
2. ICES Demonstrations:		
Grid-Connected ICES	6/80	a. System to be Operational
Coal-Using ICES (Georgetown)	9/80	b. System to be Operational
Coal-Using ICES	1/82	c. System to be Operational
Heat-Pump-Centered ICES	6/81	d. System to be Operational
District Heating and Cooling	6/80	e. System to be Operational
Total Energy Plant Retrofit to ICES	9/80	f. System to be Operational
Advanced Technology ICES	6/82	g. System to be Operational

Table 2.4 Community Planning and Design Milestones

Major Program Element	Completion	Event
1. Community Development and Energy Master Planning	10/82	a. Complete Demonstration/ Case Studies
2. Community Subsystems Planning	3/81	a. Test Planning Methods; Guidelines Changed
3. Site and Neighborhood Project Design	10/79	a. Complete Final Designs Not Requiring Regulation Changes
	10/81	b. Complete Final Designs Requiring Regulation Changes
4. Analytical Design Tools:		
Land Use/Energy Data Sets	4/79	a. Complete Research and Data Set Development
Comprehensive Community Energy Planning	1/78	b. Complete "Planners" Methods
Ekistic Energy	10/78	c. Complete Integrated Design Methods
Community	6/82	d. Test "Ideal" Community Concepts

Table 2.5 Implementation Mechanisms Milestones

Major Program Element	Completion Date	Event
1. Implementation Processes:		
Financial Mechanisms	10/78	a. Applications of Economic Analysis Procedures
	10/79	b. Demonstrate Financial Instruments
Imacts of Regulation	11/79	c. Reguation Analysis
	6/80	d. Model Legislative Policies and Initiatives
Management Systems	6/81	e. Demonstrate ICES Management Systems
2. Technological Forecasting and Market Share Objectives:		
Technological Forecasting	10/81	a. Develop and Test Technological Forecasting Methodologies
Private Sector Plan	6/79	b. Develop and Adopt Market Objectives and Strategies for Various Market Sectors
Load Research for ICES	10/79	c. Demonstrate Feasibility of Electric-Thermal Load Balancing Methodology for ICES
Load Management for ICES	10/80	d. Demonstrate Economically Optimal Load Management Techniques for ICES
Market Share Objectives Analysis	10/81	e. Develop and Test Methods for Market Share Objectives Analysis for a Given ICES
3. Energy Management Programs:		
Community Energy Planning Demonstrations	6/80	a. Complete Six Demonstrations of Community Energy Management Systems and Procedures Transferable to Cities of Various Sizes
Community Capability for Energy Management	6/79	b. Implement Strategies to Strengthen State and Local Government Energy Management Capabilities
	6/81	c. Plan and Demonstrate Energy Management Programs in State/Local Environments

3 MARKETS FOR ICES APPLICATION

3.1 INTRODUCTION

The potential markets for ICES applications encompass a wide variety of sizes and types in both the community development and energy services system environments. Table 3.1 lists highly potential targets for ICES market application. These community and energy system targets have been identified because their characteristics readily lend themselves to energy-conserving and economically-competitive ICES concepts. Figure 1.3 illustrates the Grid-Connected ICES concepts.

Table 3.1 Potential Markets for ICES Applications

Community Targets	Energy System Options
• Federal Facilities - Office Complexes - Military Bases	• District Heating/Cooling Systems
• Federally Funded Community Development Programs - Hospitals/Retirement/Nursing - Revenue Sharing - University/Colleges - Housing Programs - Urban Renewal - Transportation Facilities	• Utility Heating/Cooling/Cogeneration Systems
• State/Local Government Complexes	• Utility Grid-Connected ICES
• Regional High Density Metrocenters	• Upgraded Total Energy Systems
• New Communities, Urban Development, other Major Development (e.g., Retirement, Recreation)	• Integrated Energy, Urban Waste, and Wastewater Treatment Systems ICES
• Shopping Centers Commercial Complexes Industrial Parks	• Heat-Pump-Centered ICES
• Medium- or High-Density Residential, Mixed Use, or Planned Unit Developments	• Coal-Using ICES
• Agricultural Centers	• Solar-Centered ICES
	• Advanced ICES Technologies

3.2 ACCEPTANCE OF ICES CONCEPTS

General marketplace acceptance of ICES concepts in the Unites States without a federal initiative has been, at best, sporadic. During the late 19th and early 20th century, district heating systems fluorished to serve highly dense downtown areas in northeastern and north central cities. Although the advent of cheap energy in the form of natural gas and oil limited the spread of these systems, many of them are still operating today. On a smaller scale, the total energy concept made its initial market penetration in the mid-1960s under the impetus of diesel-engine manufacturers and natural gas utilities. Today, the number of operational total energy plants is declining because some owners -- particularly in the private sector -- find the rising fuel prices or uncertain supply unacceptable; thgerefore, they frequently abandon their facilities and purchase electrical energy from the grid.

The one market segment where the Integrated Community Energy System concept has proved viable is in the public institutional sector. Historically, these facilities are spatially clustered, under centralized administrative control, have relatively balanced space conditioning, lighting, and process energy demands, and have access to low-cost capital. Other market sectors, however, appear to be declining, or, at best, are in a "hold pattern;" whereas, other promising community systems markets have yet to be penetrated at all.

A second historical factor that tends to act as an inhibitive force to ICES market application is the trend of utility service institutions to large-scale, single-service, investor-owned, and publically regulated structures -- a trend that has increasingly divided the community development process and the energy supply system development process. Each process has associated with it a unique set of institutions and regulatory apparati to deal with problems of implementation. Large-scale utility systems continue to expand to accommodate growth in the aggregate as it occurs. Rarely, if ever, does the community development process consider energy options as an important design or growth factor. To integrate effectively community design and integrated community energy systems concepts in community applications will require an implementation process that coordinates these two sets of institutions for the purpose of realizing the joint benefits of maximizing energy efficiency and conserving scarce resources.

Therefore, the Community Systems Program presented here is a blend of two strategies: (1) research, development, and demonstration to achieve realistic performance goals for Integrated Community Energy Systems options at reasonable costs, and (2) an implementation process designed to stimulate and expand the marketplace for the application of emerging community system technologies. This dual thrust is necessary because the achievement of energy conservation in communities through a comprehensive, integrated approach to energy management entails a more complex process of design and implementation than that required by current procedures providing separate energy services. Although technological challenges exist in developing new community energy supply systems, broad nontechnical challenges also must be met. These include tailoring energy supply systems to new community growth, integrating energy conservation and management principles into the community development process, and developing public and private fiscal policies and regulatory practices with broader perspectives and greater flexibility.

The Community Systems Program presented here is, in fact, a dynamic, adaptive process of defining and meeting these challenges. The federal role is one of providing the rationale and stimulus for change. However, the true leadership must come from persons in the public and private sector responsible for the design of energy systems and the development of communities. These leaders or implementors, as identified in Table 3.2, can

Table 3.2 Public and Private Sector Implementors of ICES Concepts

Community Development	Energy Systems Development
• State/Local Elected and Appointed Officials (Implementors of Energy Planning and Management Programs)	• Public Utility Regulatory and Siting Commissions
• State/Local Regulators (Regulation Administrators That Will Impact Implementation of Energy Management Program-Building and Zoning, Land Use and Growth Controls, Critical Areas Programs, Environmental Management)	• State/Local Regulators (Regulation Administrators that Will Impact Implementation of Energy Systems - Licensing, Safety Standards, Environmental Control)
• Community Design Professionals (Architects, Site Planners, Structural Engineers, etc.)	• Utility Planners and System Designers
• Public/Private Developers	• Public and Private Utility Companies
• Contractors and Construction Management	• Contractors and Construction Management
• Community Operations and Maintenance Management and Administration	• Utility Operations and Maintenance Management and Administration
• Development Financial Institutions and Consultants	• Utility Financial Institutions and Consultants
• Building Materials and Systems Manufacturers and Suppliers	• Energy Supply System Equipment Manufacturers and Suppliers

participate in the achievement of the goals of the Community Systems Program in three distinct modes:

(1) **Implementation Processes and Energy Management Programs.** Public and private sector participants are encouraged to implement these products of the Community Systems Program that are designed to create the institutional environment necessary to evaluate and implment ICES concepts.

(2) **R&D Needs and Concepts Feedback.** Mechanisms are being developed within the program to allow for a continual flow of information from the public and private sectors to the Community Systems Program in the form of identified R&D needs and ICES concepts that can be addressed within the structure of the program or channeled to other R&D organizations within the DOE.

(3) **Cooperative Demonstration Programs.** Virtually all demonstrations of ICES concepts are designed with the intent of public and private sector leadership so that the full array of potential implementation problems can be identified and resolved in addition to verifying technical feasibility. Participation of the public and private sector in all stages of ICES development is actively planned and solicited and includes proof of concept, research and development, testing and evaluation, and pilot or full-scale demonstration.

APPENDIX A

ARGONNE NATIONAL LABORATORY
ENERGY AND ENVIRONMENTAL SYSTEMS DIVISION

Integrated Community Energy Systems (ICES) Publications

ANL Prepared

Integrated Community Energy Systems (ICES) Commercialization Case Studies (1977)
Documents a case analysis of alternative concepts of Integrated Community Energy Systems applied to a development currently under construction.

Potential for Scarce-Fuel Savings in the Residential/Commercial Sector through the Application of District Heating Systems (1977)
Presents a perspective on the potential for the use of District Heating systems as a means of saving energy and reducing energy costs in the U.S.

Conserving Fuel and the Environment through Grid-Connected ICES (1977)
Examines philosophy of a grid-connected ICES and discusses five sites selected for efforts of Phase I - Preliminary Feasibility and Analysis

The Future of Integrated Community Energy Systems (1976)
Presents an overview of entire Community Energy Systems Program, including objectives, elements, commercialization factors, examples of proposed systems, and financial considerations.

J.M. Calm

Energy Effectiveness Measurement for Integrated Energy Systems (1977)
Presents a performance measure, based on a consideration of dissimilar output enthalpies, varying load demands, and different energy sources used as inputs.

Proposed Energy Effectiveness Factor, Ee: A Response (1977)
Defines a coefficient of performance (COP) for integrated energy systems; discusses problems associated with the energy effectiveness (Ee) concept; and compares the concept to the COP approach.

Technology Characterization: Integrated Energy Systems (10/77)
Identifies the various projects within the Program, reviews specific ovjectives of each, discusses past progress and future deliverables, and estimates funding and staffing for FY78.

K.G. Croke

Financial Overview of Integrated Community Energy Systems (1977)
Provides an overview of the utility and municipal investment decision-making process and identifies promising federal initiatives that may aid in encouraging ICES investment. Answers questions about financing an ICES, available federal instruments, and what actions may be taken to encourage ICES commercialization.

Municipal Financing of ICES (1978)

Evaluates the various methods of financing an ICES; decides appropriate amount of financing and repayment schedule; considers financing costs and methods of managing revenues. Looks at outside consutlants and scheduling of ICES projects.

Program Plan for Community Systems (11-9-77)

Identifies the various projects within the Program, reviews specific objectives of each, discusses past progress and future deliverables, and estimates funding and staffing for FY78.

P.F. Donnelly

Integrated Energy Systems: The Community Systems Approach (1978)

Describes the role of Integrated Energy Systems in the Dept. of Energy's Community Systems Program. Explains the aims of the Programmed issues related to the role of integrated systems within the program, and looks at steps undertaken to deal with issues related to using ICES to supply community energy needs.

R.J. Faddis

Total Energy Questionnaire For ______________________________ (1977)

Questionnaire designed to obtain an indepth look at an operating integrated community energy system.

Total Energy Case Study - Franklin Foundation Hospital, Franklin, La. (1977)

Discusses site selection; describes Total Energy plant; looks at reliability and maintenance; and considers fuel supply, staffing, regulatory impediments, and finance and accounting. Shows relationship to other energy conservation activities.

The Performance of Operating Total Energy Plants (1977)

Characterizes various Integrated Systems technologies; defines areas of application, and discusses projected programs and impact on end use.

R.E. Holtz

On the Grid Connection of an Integrated Community Energy System (1976)

Describes a grid-connected ICES in the grid mode and grid-to-ICES mode and calculates energy savings.

Conceptual Design Studies of Integrated Community Energy Systems for a Shopping Center - Residential Complex (1977)

Documents preliminary engineering analysis of alternative concepts of ICES applied to a development using conventional energy service systems.

Potential Energy Savings in Commercial/Residential Communities Based on Integrated Systems Design (1977)

Investigates the potential for an ICES to meet the total energy requirements of communities in an energy-conserving, cost-effective manner. Included are estimates of potential energy savings and possible economic savings.

A.S. Kennedy

Factors that Influence the Acceptance of Integrated Community Energy Systems (1976)

Considers establishment of a program to deal with potentially serious institutional factors that might hinder commercialization of integrated community energy systems.

Economic Analysis of Integrated Community Energy Systems (1977)

Explores various ICES options applied to a large metropolitan development, and computes three quantitative measures for each option: (1) net energy conserved; (2) net scarce-fuels conserved; and (3) economic viability.

Preliminary Proposal: ATMES Community Systems Test Facility (1976)

Documents needs and objectives of a Community Systems Test Facility (CSTF) toward establishing available test program involving existing, emerging, and future technologies that could lead to successful ICES demonstration projects. Discusses four options to achieve this goal.

Integrated Community Energy Systems (ICES) Commercialization Case Studies (1978)

Updates on earlier effort to explore various ICES options as applied to a large metropolitan development. Documents a case analysis of alternative concepts of ICES applied to Fox Valley Village. Compares ICES concepts with conventional systems and identifies potential commercialization problems.

T.J. Marciniak

An Overview of Urban Systems - Technology Options (1977)

Investigates technologies that are designed to help an urban community meet its electrical, space conditioning, and miscellaneous energy needs.

ATMES Technology Review (1977)

Tabulates the results of an ATMES/Technology Evaluation questionnaire and looks at cost estimates for the effort.

Solid Waste Utilization in Integrated Community Energy Systems (5/78)

Defines Integrated Community Energy Systems (ICES) in the context of various kinds of communities and their energy needs. Considers incineration with heat recovery and solid-waste pyrolysis. Looks at conceptual designs and evaluations and estimates, cost savings.

V. Rabl

OASIS - A Computer Program for Simulation and Optimization of Central Plant Performance (1977)

Describes a computer program developed for purposes of simulation and optimization of central plants. Within the library of subroutines are performance and economic data for several major components, e.g., prime movers, generators, boilers, chillers, etc.

J.J. Roberts

The Community Systems Program of ERDA/Conservation: Objectives, Structure, and Application to Central Chilled-Water Systems (1976)

Considers objectives of the Community Systems Program and looks at possible application to central chilled-water systems.

The Advanced Technology-Mix Energy Systems (ATMES) Program (1/25/77)

Proceedings of the Solar Total Energy Symposium, Albuquerque, New Mexico.

D.J. Santini

District Heating and Cooling Utilizing Differences of Chicago Waters

Investigates the feasibility of using cold water from Lake Michigan and waste-heat water from Commonwealth Edison Company's Fisk Generating Station to cool and heat the buildings of a redevelopment project in Chicago.

M.J. Senew

Impacts of Environmental and Utility Siting Laws on Community Energy Systems (1977)

J. Tschanz

Urban Planning as an Impediment to Energy Conservation: An Examination of Potential Conflicts between Existing Planning Regulations and Energy Conserving Site Planning Alternatives (1977)

Investigates energy inefficiencies in urban areas; suggests implementation of energy-conserving ideas at the site-planning level; and examines conflicts that might arise if existing planning regulations were to be applied in such reviews.

K.L. Uherka

Final Report on the Community Systems Test Facility Workshop

Summarizes comments of participants of a 2-day Community Systems Test Facility workshop.