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GRID-CONNECTED INTEGRATED COMMUNITY
ENERGY SYSTEM

Final Report

Volume I. Executive Summary

July 1977

Work Performed Under Contract No. EC-77-C-02-4213

City of Independence
Independence, Missouri

ENERGY RESEARCH AND
DEVELOPMENT ADMINISTRATION

Division of Buildings and Community Systems

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CITY OF INDEPENDENCE

VOLUME I

EXECUTIVE SUMMARY REPORT

for

GRID-CONNECTED INTEGRATED

COMMUNITY ENERGY SYSTEM

JULY 1977

to

ENERGY RESEARCH

AND

DEVELOPMENT ADMINISTRATION

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EXECUTIVE SUMMARY

Introduction

This report provides a brief summary of the results of phase I of the Grid-Connected Integrated Community Energy System (ICES) Program in Independence, Missouri. Work on this program was funded by the U. S. Energy Research and Development Administration under Contract No. EC-77-C-02-4213.

Phase I consisted of 5 major tasks that were completed during the period February 1, 1977 to May 31, 1977. These tasks were:

- Task I - Preliminary Energy Analysis
- Task II - Preliminary Institutional Assessment
- Task III - Conceptual Design of ICES
- Task IV - Firming-Up of Commitments
- Task V - Work Management Plan

The outline of contents of this Executive Summary are based upon the above tasks. Further details are contained in Volume II, the main Final Report for phase I. When the City of Independence first expressed interest in the ICES program, an oil fired system was anticipated. However, rapidly developing circumstances at both the local and national level quickly led to the conclusion that coal is the only reliable fuel supply for the foreseeable future. The City of Independence, and its project team recognize that developing a small coal fired unit that can be effectively integrated into the total community environment is a difficult challenge. Nevertheless, the President's recent energy message is clear, and we are prepared to depend on coal as the basis of meeting the City's total energy needs.

Independence offers an excellent environment in which to conduct the ICES demonstration program. The evaluation of institutional factors conducted under Task II indicated that there are no

significant obstacles to overcome in developing the ICES system. The City not only owns the existing electric utility, but also has substantial control over the relevant institutional and financial factors that are involved. This combination of utility ownership, regulatory powers, and financial stability virtually ensures a successful demonstration program.

In 1980, during the initial start-up of the ICES system, fuel savings will be modest. As the demonstration community evolves, fuel savings become quite dramatic, so that in 1990, by the most conservative estimate, fuel savings of 46% will be realized over the energy consumption required by the present all-electric system. Over the twenty-five year life of the ICES program there is a 53% fuel savings potential. In other words, more fuel will be conserved over the program's lifetime than will be consumed in serving the demonstration community.

TASK 1 PRELIMINARY ENERGY ANALYSIS

Task I consisted of defining the Demonstration Community (existing and planned), establishing the conventional energy system that would serve as the basis of comparison with the candidate ICES System, and evaluating (in a very preliminary manner) various ICES candidate systems.

Task I was completed early in phase I and the results were presented to ERDA officials at the midterm project review meeting on April 6, 1977. At that time the City of Independence indicated that although it had anticipated that the ICES candidate would be an oil fired system, circumstances of supply and cost now dictated that coal be used. It was further noted that to meet the future requirements of the City's electric utility the ICES System should be capable of generating approximately 20 megawatts. At that time, Independence received ERDA's concurrence and approval to continue with the analysis.

1.1 DESCRIPTION OF THE DEMONSTRATION COMMUNITY AREA

The Demonstration Community is located in Independence, Missouri, the third largest city in the state. Independence itself is located in the eastern portion of the Kansas City Metropolitan region (Figure I-1).

The center of the Demonstration Community lies at the intersection of two major roadways, Interstate 70 and Missouri Highway 291, which service the Kansas City Metropolitan region. The area has access to excellent air, rail, and bus transportation facilities.

The existing developments in the Demonstration Community consist of single- and multi-family housing and commercial establishments, with a total floor space in excess of 1.6 million square feet. The focal point of the Demonstration Community is the ultramodern Independence Center shopping complex, which is particularly

FIGURE 1-1
STANDARD METROPOLITAN STATISTICAL AREA

well suited for the ICES project due to its size and ease by which a connection to the ICES network can be made. The totally electric Independence Center houses three major department stores and approximately 150 shops under one roof, with 1.2 million square feet. The hot and chilled water used by the Center tenants for heating and cooling is provided by three central mechanical plants. The absence of individual mechanical plants for each tenant will greatly facilitate the connection to the ICES network.

In addition to the Independence Center, there are 627 single-family homes, 130 units of garden apartments, four churches, one elementary school, four banks, one theatre complex, one trucking terminal, one bowling alley, one small shopping complex, a ceramic shop, and several professional offices located in the Demonstration Community area. Of these structures, the Independence Center is the prime initial candidate for connection to the ICES network due to its size, location, and existing heating and cooling systems. The remaining structures offer varying degrees of potential for connection. This potential will be evaluated more fully during phase II of the program.

Present zoning in the Demonstration Community area (Figure I-2) is consistent with the City's Comprehensive Plan which is used to monitor and control development throughout the City. The zoning classifications are identified in Figure I-2.

1.2 ENERGY DEMAND PROFILES

1.2.1 Service Area

The complex that is to be served by the Integrated Community System consists of the existing Independence Center shopping complex of approximately 1.2 million square feet plus an additional 680,000 square feet of commercial building space scheduled for 1980, and additional 1.26 million square feet of commercial buildings and apartment buildings scheduled for 1985, and final

LEGEND

R-1 SINGLE FAMILY
 R-3 GARDEN APARTMENTS
 C-3 GENERAL COMMERCIAL
 C-2 COMMERCIAL
 M-1 LIGHT MANUFACTURING

FIGURE 1-2
 ZONING

300,000 square feet of commercial buildings scheduled for 1990, totaling over 3 million square feet. A conservative estimate of the growth in the demonstration community service area is shown in Figure I-3.

1.2.2 Demonstration Community Heating and Cooling Loads

The monthly average heating and cooling loads used for the Independence Center, shown in Figure I-4, are based on a detailed survey of the electric power consumption history over two years for the shopping center.

Because typical commercial buildings are different in many ways from an enclosed mall facility like the Independence Center, separate heating and cooling load curve was developed to predict the demand for thermal energy from the commercial building sector. This demand curve is illustrated in Figure I-5. The development of separate heating and cooling load curves was necessitated by the fact that the Independence Center is completely enclosed, higher electric light and auxiliary loading, and has a higher people thermal loading than does the aggregate commercial building sector.

In addition to the average monthly demand curves, the Independence Center and the commercial building sector in Independence possess individual daily load demand profiles which were accounted for in estimating overall energy requirements for the demonstration community.

Based on a review of the Independence Center electricity consumption for the past two years, and consumption for typical commercial properties, the estimated lighting and auxiliary electric load is 4.0 million watts for the 1980 ICES service area. All electric power generated by the ICES plant will be transmitted directly to the City of Independence Power & Light grid.

- ① = HOMART SHOPPING CENTER
- ② = ① + 680,000 FT² COMMERCIAL BLDG.
- ③ = ② + 1,260,000 FT² OF COMMERCIAL PLUS APARTMENT BLDGS.
- ④ = ③ + 300,000 FT² COMMERCIAL BLDGS.

FIGURE I-10
 DEMONSTRATION COMMUNITY SERVICE AREA
 INDEPENDENCE MISSOURI
 (Million Square Feet)

FIGURE I-11
INDEPENDENCE CENTER AVERAGE MONTHLY HEATING AND COOLING LOADS

FIGURE I-12
TYPICAL COMMERCIAL BUILDING MONTHLY AVERAGE HEATING AND COOLING*

Other City-owned generating stations will be proportionally unloaded when the ICES system is generating power.

1.3 PROJECTED GROWTH OF THE DEMONSTRATION COMMUNITY

Projecting future development is very tenuous in today's economic environment, particularly in light of the uncertainties associated with future energy costs and supplies. Nevertheless, it is conceivable that the total floor space in the Demonstration Community area will exceed 4 million square feet in the next 10 years. The current floor space is approximately 2 million square feet (perhaps 60 percent of this could be expected to connect to the ICES System.)

The Independence Center shopping complex has been open for two years, and additional development surrounding the Center is increasing. The City Planning staff has prepared a study of several regional shopping centers within the metropolitan area to determine the amount and type of additional development that can be anticipated surrounding the Center. The results of the study show that, at a minimum, a like amount of commercial space can be anticipated within the vicinity of the Center by 1984. Higher density residential land use, generally in the form of medium-rise apartments, townhouses, and condominiums, can also be expected.

A conservative estimate of the future size (square feet of floor space) of the Demonstration Community is presented below.

DEMONSTRATION COMMUNITY FLOOR SPACE

<u>Year</u>	<u>Millions of Square Feet</u>
1977	1.2
1980	1.8
1985	3.1
1990	3.4
Ultimate demonstration community size during project lifetime.	5.4

1.4 INTEGRATED COMMUNITY ENERGY SYSTEM DESCRIPTION

Three types of power plant systems were considered for the Independence, Missouri, Integrated Community Energy System. These systems are:

- o Gas turbine generator burning fuel oil with waste heat recovery and utilization.
- o Diesel generator sets with waste heat recovery and utilization.
- o Coal (or oil) fired boiler with steam turbine, employing waste heat recovery and utilization with extraction steam.

These systems were compared to an all-electric system; that is, all heating and cooling for the demonstration community is

supplied by electric resistance heaters and electrically driven Rankine cycle cooling machines. Electric power is generated the current City-owned power generation system and alternative sources of electric generation supply.

1.4.1 Conventional Energy System

The conventional energy system is defined as the most likely alternative source of electrical power that the City of Independence would develop in the absence of an ICES plant, and is the benchmark that all of the candidate ICES systems are compared to. It consists of the City of Independence electricity-generating supply as it currently exists, plus future optional electricity-generating alternatives that the City may elect to initiate as the demand for electricity grows. For the 1980 Demonstration Community (1.8 million square feet) to be heated and cooled by all-electric systems, the maximum electric power demand for heating is estimated to be 10.6 MWe, consuming 23.8×10^6 kW-hr/yr; and for cooling the maximum electric power demand is 4.0 MWe, consuming 8.06×10^6 kW-hr/yr.

1.4.1.1 Current Systems

Within the last two years, Independence's electricity generating system has converted from natural gas to coal as its primary fuel source. The present system consists of approximately 90 MWe steam units (one 48-MWe and two 21-MWe) using coal as the main source of fuel, 123 MWe of oil-fired turbines (two 19-MWe, two 15-MWe, and one 55-MWe), and 38 MWe of gas-fired turbines (two 19-MWe units).

1.4.1.2 Alternative Future Power Sources

Due to the projected growth of the Independence, Missouri, area and future decommissioning of some of the City's older generating stations, the City of Independence is evaluating the viability

of part ownership in coal fired and nuclear stations with other utilities to increase their generating capacity by approximately 78 MWe. Another alternative for obtaining future power is the purchase of a 42 MWe coal fired plant located in Missouri City.

Current system capacity is sufficient to meet the projected power requirements until 1981. It is estimated that in 1982 an additional 20 MWe of capacity will be required over the present system. The timing of a 20-MWe ICES plant providing heating and cooling as required is consistent with the increased capacity requirements.

1.4.2 Oil-Fired ICES Alternatives

Fuel oil gas turbine generator ICES systems were considered for Independence. Based on the demand for heating and cooling by the community for 1980, gas turbine generator sets providing 7.5 MWe would be required. The exhaust gases would generate steam in a waste heat recovery boiler. The steam in turn would be used to heat water for building heating or diverted to a "piggy-back" steam turbine Rankine cycle/absorption cooling system for providing chilled water for building air-conditioning systems.

For use in an ICES system, one 5-MWe diesel generator is required to support the heating/cooling loads for approximately 370,000 square feet of building area. Hence, 25-MWe diesel generator capacity is required to serve the 1.85 million square foot community in Independence. Most of the waste heat would be recovered from the exhaust gases in an exhaust gas boiler, and some additional low-temperature heat would be recovered from the diesel engine cooling water system.

1.4.3 Coal-Fired Generating Station

Figure I-6 illustrates the basic configuration of a coal-fired ICES system considered for Independence. A coal-fired plant generates electricity by a conventional steam turbine system, in which a boiler generates steam that expands through steam turbines driving the electric generator. Extraction steam from the turbines is used to provide the required energy for heating or cooling. The extraction steam (250 to 350°F) is then condensed to provide hot water for heating, or in an absorption chiller unit to provide chilled water for building air conditioning. Five basic coal fired boiler ICES systems were evaluated, ranging in size from 2.5 MWe (operating on demand for heating only), up to 20 MWe systems.

1.4.4 Performance of Alternative ICES Systems - Energy Savings

Table I-1 outlines the energy consumption and heat rate characteristics of each of the ICES systems considered, at the startup date of 1980 with a service demand of 1.85 million square feet.

Table I-1 shows that the oil fired ICES systems have the greatest overall potential for energy savings, with the diesel generator system resulting in a maximum potential savings of 7.48×10^{11} BTU/ year. Of the coal fired systems considered, the 2.5 MWe boiler operating on demand for heating only (cooling to be provided by electric Rankine cycle chillers) has the best performance, with net energy savings at 2.17×10^{11} BTU/year. Of the largest systems considered, the 20 MWe - 850 psi boiler results in net energy savings of 0.22×10^{11} BTU/year, while a 20 MWe - 600 psi boiler produces a net energy loss when compared to the all electric system for heating and cooling the 1980 demonstration community.

FIGURE I-6

CITY OF INDEPENDENCE, MO. GRID CONNECTED - INTEGRATED COMMUNITY ENERGY SYSTEM	
System Name	TYPICAL EVALUATION MODEL
System Description	TOTAL ENERGY PACKAGE BOILER SYSTEM PROVIDING ELECTRIC GENERATION HEATING AND COOLING CAPACITY
System Capacity	5111-SK-3

TABLE I-I

ENERGY CHARACTERISTICS OF ALTERNATE ICES SYSTEMS - 1980

<u>System</u>	<u>Energy in 10¹¹ BTU/year</u>		<u>Heat Rate</u> BTU/KW
	<u>Total</u> Consumption	<u>Net Energy</u> Savings	
1. All electric heating and cooling	3.82	--	12,000
2. 2.5 MWe Coal Fired Boiler - Operating on demand for heating only	1.65	2.17	4,432
3. 6.2 MWe Coal Fired Boiler - Cooling by Single Stage Absorption	1.99	1.83	8,163
4. 2 MWe Coal Fired Boiler - Cooling by Two Stage Absorption	1.87	1.95	6,836
5. 20 MWe - 600 psi Coal Fired Package Boiler - Continuously generating electricity	6.92	(3.1) loss	13,760
6. 20 MWe - 850 psi Coal Fired Boiler - Continuously generating electricity	3.6	0.22	11,800
7. Fuel Oil Gas Turbine	1.47	2.35	8,069
8. Diesel Generator System	(-1.34) net energy gain	7.48	6,511

1.4.5 ICES System Costs

Table I-2 summarizes estimated fuel, capital and operating costs for the various ICES systems considered.

A coal fired ICES system operating on demand for heating only would result in the lowest estimated fuel cost, 4.6 mills/KW-hr, while the gas turbine plant would have the highest fuel cost, 22.7 mills/KW-hr. These costs are based on 1.85 million square feet thermal loading and 1977 prices, which are coal at \$25 per ton and fuel oil at 38 cents per gallon.

Capital cost estimates are based on the issuance of 7% tax free bonds for a 25-year term.

Total supply costs, in mills/KW-hr, are obtained by adding fuel costs to generating costs. The present, all electric system offers the lowest possible supply cost for serving the demonstration community in 1980, 21.6 mills/KW-hr. Fuel oil fired diesel and gas turbine systems show the highest supply costs. As thermal loadings increase beyond 1980, and fuel costs escalate, coal fired ICES systems become more economical in comparison to other alternatives. By 1990, it is estimated that all of the coal fired ICES systems considered will be more economical than any of the alternative systems.

1.5 CONCLUSIONS AND SYSTEM SELECTION

1.5.1 Fuel Selection

The City of Independence has concluded that any ICES system developed for the demonstration community must be fired by coal. This conclusion is based primarily on the forecasted availability of oil and natural gas during the lifetime of the proposed ICES project. Over the past two years, the City of Independence electrical generating system has had to convert from almost entirely

TABLE I-2
COST OF ALTERNATIVE ICES SYSTEMS

System	Estimated Plant 1977 Fuel Cost (mills/kW-hr)	Initial Capital (millions of dollars, 1977)	Annual cost for Capital (N = 25 yr) (Annual Interest = 0.07)	Annual Operating Cost	Generation Cost (Annual Capital + Operation) (mills/kW-hr*)	Total Supply Cost (Fuel + Generation) (mills/kW-hr*)	1990 Estimated Supply Cost
Present electrical generation system, 12,000 Btu/kW-hr heat rate. Fuel is coal, 12,000 Btu/lb.	12.6	No further investment	-	-	9	21.6	46.0
2.5- to 5-MWe coal-fired ICES plant operating on demand for heating only (cooling provided by electric Rankine machines) ^c	4.6	4	0.342 million/yr (11.6 mills/kW-hr*)	0.30 million/yr (10.1 mills/kW-hr)	21.7	26.3	25.0
6- to 10-MWe coal-fired boiler operating on demand for heating only (cooling provided by single- stage absorption) ^c	8.56	10	0.856 million/yr (17.8 mills/kW-hr*)	0.40 million/yr (8.3 mills/kW-hr*)	26.1	34.6	37.2
2 to 3.2 MWe. Operating on demand for heating and cooling, two-stage absorption cooling ^c	7.2	5.4	0.462 million/yr (12.2 mills/kW-hr)	0.35 million/yr (9.1 mills/kW-hr*)	21.3	28.5	32.7
20-MWe package boiler coal plant supplying heating and cool- ing on demand (two-stage absorp- tion cooling) ^d	14.4	28	2.4 million/yr (12.5 mills/kW-hr*)	1.4 million/yr (8.6 mills/kW-hr*)	21.1	35.5	47.5
20-MWe (high-pressure boiler) coal plant providing heating and cooling	12.0	28	2.4 million/yr (12.5 mills/kW-hr*)	1.4 million/yr (8.6 mills/kW-hr*)	21.1	33.1	44.3
Fuel oil gas turbine ^c	23.8	6.5	0.556 million/yr (9.3 mills/kW-hr*)	0.26 million/yr (4.7 mills/kW-hr*)	14.0	37.8	62.2
Diesel generator system ^c	19.3	14.0	1.20 million/yr (12.8 mills/kW-hr)	0.475 million/yr (5.0 mills/kW-hr*)	17.8	37.1	63.3

a. "kW-hr*" means the equivalent electric power required for heating or cooling or electricity generation.

b. Based on financial data supplied by the City of Independence.

c. Capacity Factor = 1.0.

d. Capacity factor = 0.80 for electricity generation and 1.0 for heating and cooling.

gas fired units to its present dependence on coal. When this ICES project was initiated, it was anticipated that oil fired systems would be developed for the demonstration community. However, based on present understanding of fuel availability, only coal will be considered for future electrical development in Independence.

1.5.2 System Selection

Integration into the existing City electrical grid is an important consideration to the City of Independence. Unless an ICES facility integrates directly and efficiently into the system, its value to the City's overall energy supply is minimal. For this reason, Independence has concluded that an energy efficient, 20 MWe coal fired ICES plant is the minimum required for overall system integration. At this size, the ICES facility has sufficient capacity to replace an existing 20 MWe oil fired peaking turbine, and can be used to provide 20 MWe of base load capacity. Thus, 20 MWe provides Independence with maximum electrical flexibility.

A 20 MWe coal fired plant will result in considerable energy savings over its lifetime, thus satisfying ERDA's national energy conservation objectives. Smaller units provide a more energy efficient means of serving just the thermal needs of the demonstration community. However, the 20 MWe unit allows for considerable growth in the Independence Center demonstration community. It will supply the total heating and cooling for the community as required, and provides unit integration into the City's electrical grid. In 1980, at the project startup, fuel savings will be modest. As the demonstration community grows, fuel savings become quite dramatic, so that in 1990 fuel savings of 46% will be realized over the present all electric system. Over the 25-year life of the project, there is a 53% fuel savings potential. Based upon these factors, the City of Independence strongly recommends ERDA support for the design and construction of a 20 MWe coal fired ICES facility at Independence Center.

TASK II - PRELIMINARY INSTITUTIONAL ASSESSMENT

The primary purpose of Task II was to conduct a preliminary analysis of the potential impact of statutes, codes, and regulations on the ICES project and to provide data for an environmental assessment. Task II also involved the dissemination of information to the public regarding the ICES program and a preliminary evaluation of potential conflicts arising from the introduction of the ICES System within the community.

2.1 REGULATIONS, STATUTES, AND CODES

During Phase I the Law Department of the City of Independence reviewed pertinent Federal, State, and local laws, including provisions of the Independence City Charter, the Missouri Constitution of 1945, and the Revised Statutes of Missouri. The Charter of the City of Independence, Missouri, establishes the City's authority to contract with ERDA to demonstrate the feasibility of a grid-connected Integrated Community Energy System. The City has full power and authority in this regard as a constitutional charter city exercising home rule powers, including the power to levy taxes and spend funds as well as general corporate and police powers.

Based upon an analysis of potential legal problems resulting from participation in the ICES program and considering appropriate codes, ordinances, environmental regulations, labor-related regulations, safety regulations, utility regulations, fire regulations, and taxes, the Law Department could not identify any areas of potential legal conflict which could not be resolved or which would endanger the authority of the demonstration team to successfully demonstrate a grid-connected Integrated Community Energy System.

The Law Department has determined that the capacity of the City of Independence to raise revenues, the specific taxing powers

available to the City, limitations on expenditures and the collection and distribution of funds, appropriations, and general laws relating to municipal indebtedness will not adversely affect the ICES project from the standpoint of the City's power to undertake the project itself.

2.2 POTENTIAL CONFLICTS

No conflicts with the City's residents or business community are anticipated as a result of the City's participation in the ICES project. During Phase I, the ICES project received public attention on several occasions without any adverse reaction. Public awareness of the need to conserve energy is very high as a result of the President's recent energy messages. Consequently, as the benefits of the ICES project become more apparent and the energy crisis deepens, it is expected that wide community support for the project will develop.

Should conflicts occur, they will be handled by the usual City procedures. Typically, matters involving substantive citizen disapproval are subject to public hearings and meetings between the City staff and the complaining body. These meetings may also be attended by members of the City Council.

Opportunities for citizens to express opinions on any topic are also provided at regular City Council meetings. Citizens may also contact the Mayor's or City Manager's offices to express their views.

Due to the effectiveness of the procedures that already exist for handling complaints from the community, it is not planned that any further procedures will be established for the ICES project.

2.3 INFORMATION DISSEMINATION

Information dissemination concerning the Integrated Community Energy System demonstration is an essential part of the project. The dissemination plan for subsequent phases will address both the local community and potential ICES users nationally. A variety of approaches will be employed to meet the needs of these distinct audiences.

Information dissemination during the first phase of the ICES project was accomplished through City Council meetings, special public meetings, news releases, and news conferences. The ICES project was an agenda item for two Council meetings. Opportunity for public expression is provided at every Council meeting.

Two special meetings were held in Phase I for commercial operators, Independence Center management, and developers who have interests in the Demonstration Community area. A meeting held on March 11 was designed to acquaint potential users with the objectives of the ICES project. A second meeting was held on April 28 with the four major tenants of the Independence Center and the four major developers in the Demonstration Community. The purpose was to discuss in greater detail the technical aspects of the ICES project and the implications for retrofitting their existing mechanical plants.

Several news releases also appeared in the local newspapers during Phase I. Copies of these are contained in the main report.

In addition to news conferences and press releases, the prime dissemination methods to be used during Phase II will be bimonthly newsletters and brochures. Bimonthly newsletters will describe the ICES demonstration system and plant, progress of work, and expected benefits of the project. Newsletters and brochures will be available at locations such as City Hall and appropriate locations visited frequently by local citizens.

An exhibit that will include a model of the center, a model of the ICES plant, and the interface is planned at the Independence Center. Descriptive materials will show the purpose, objectives, operational aspects, and expected benefits of the ICES system.

Information dissemination at the national level will include the distribution of bimonthly newsletters to key individuals and potential ICES users. A second form of national information dissemination will concentrate on direct involvement of potential ICES users from other parts of the nation. During Phase I, approximately 12 persons were selected to serve on a User Requirements Committee (URC). These persons were chosen from jurisdictions with particular interests in co-generation systems. During two URC meetings planned for Phase II, the members will contribute knowledge of technical, operational, economic and other requirements and specifications from their own jurisdictions. At the same time, the URC members will benefit by closely following the Independence demonstration and will be in a position to transfer this new knowledge to their own respective jurisdictions.

2.4 ENVIRONMENTAL FACTORS

Environmental factors, regulatory requirements, control strategies and potential environmental impacts for a 20 MWe coal fired ICES plant at Independence Center were identified and considered in the feasibility evaluation of the proposed ICES project. A detailed environmental assessment will be performed in Phase II of this program to account for environmental impacts and to provide for the most environmentally sound facility design.

Although a final site for the ICES generating facility will be determined in the next phase of this project, preliminary site location was based in part upon the following environmental factors related to the sites available within the demonstration community: availability of water resources, sewerage facilities,

terrain, flood hazard, regional air quality, and subsurface conditions in relation to suitability for landfilling of solid wastes.

The principal environmental regulatory factors applicable to the 20 MWe ICES plant under consideration are: Federal new source performance (air emission) standards, local emission and air quality standards, effluent guidelines for liquid discharges, Missouri rules and regulations on solid waste disposal, and EPA noise level guidelines.

The ICES facility will be designed to meet all applicable environmental regulations. Among the control strategies that appear to be necessary are the following:

1. Electrostatic precipitator for fly ash removal.
2. Nonregenerable wet scrubbing system for sulfur oxide removal. (It is not now certain as to the level of SO_x removal, or whether a scrubber will be required, based on boiler size.)
3. Increased stack height and gas velocity to disperse flue gases.
4. Landfilling of flue gas desulfurization sludge.
5. Dry cooling tower (air cooled) to dissipate waste heat.
6. Blowdown treatment and chemical control of water systems.
7. Upgrading coal quality through partial beneficiation.

Environmental impacts from plant waste output will be minimized through the use of the above listed controls. Additionally, plant design will pay heed to the aesthetic requirements of the demonstration community environment, and will minimize adverse

impacts during construction. Finally, because the ICES project will result in net energy savings over its lifetime, a favorable secondary impact on the environment can be anticipated due to the reduction in fuel extraction, transport and combustion which this project represents.

TASK III - CONCEPTUAL DESIGN AND INSTALLED COST ESTIMATE

Task III consisted of the development of a conceptual design of the most promising ICES System alternative that was evaluated as part of Task I. This conceptual design included the preparation of one-line diagrams of the distribution network, central plant schematics, and preliminary cost estimates.

3.1 DESCRIPTION OF THE PROPOSED ICES SYSTEM

The ICES plant design consists of a coal fired electric power plant coupled to a heating and cooling facility. The combined system provides the energy for heating and cooling the Independence Demonstration Community. The energy is in the form of steam extracted from the power plant turbine. The steam is used directly in contact heaters to provide hot water heating, or it is used to generate chilled water in absorption coolers for cooling, depending on the energy requirements of the Demonstration Community. The use of extraction steam reduces the amount of waste heat from the power plant and reduces the fuel usage compared to present electric heating and cooling systems.

The power plant design is one generating approximately 20 MWe (net). This plant is considered to be the minimum practical size coal fired unit in terms of energy efficiency and the use of commercially available equipment. The size of the plant allows for the growth of steam demand for heating and cooling. Since the ICES plant efficiency increases with increased steam demand, the proposed ICES plant will provide a hedge against future fuel cost increases while simultaneously providing a more efficient process in the long term. Coal was selected as the reference fuel because of its relative availability and its relatively low cost.

The design of the heating and cooling facility is based on the use of commercially available equipment. Hot water is produced in cascade heaters and distributed to the demonstration community

via buried, insulated piping. Similarly, chilled water is generated in two-stage absorption coolers selected on the basis of operating efficiency. The power plant steam is transferred to the heating and cooling facility in underground insulated piping, and the condensate is returned to the power plant. The design and location of the heating and cooling facility have allowed for future expansion in the Demonstration Community.

The conceptual design of the ICES plant has considered the potential environmental impact. The power plant design incorporates a flue gas precipitator and double-alkali sulfur removal system, wastewater treatment and recycle systems, and controlled ash handling and disposal systems. The intent is to significantly reduce the adverse effects of the power plant in terms of waste generation and clean water use. However, the actual requirements will be defined in Phase II of this project.

It is concluded that the reference ICES plant is technically feasible using commercially available equipment. For the reference plant design, higher thermal loads result in a decrease of fuel usage compared to the present all electric system. Analysis of the pollution control requirements and optimization of the design will be required to more clearly define the economics of the ICES plant.

The reference ICES plant layout is shown in Figure III-1. The power plant is located on approximately 35 acres, north of 39th Street and the IC&G Railroad. The plant site will include all access roads, rail sidings, coal storage and handling facilities, the boiler plant, pollution control equipment, fuel oil storage, service buildings, etc., as required.

The heating and cooling facility is located in close proximity to 39th Street in order to provide energy to the initial users in the Independence Center shopping complex. Extraction steam from the power plant is piped underground to the heating and

cooling facility, and is used to generate either hot water and/or chilled water. The water is distributed to the demonstration community through an underground piping system.

The initial design basis of the heating and cooling facility was to provide enough capacity for a floor area of about 2 million square feet. The capacity of the power plant and the steam and condensate lines was based on the projected expansion for the area (~4 million square feet). Expansion of the heating and cooling facility and the installation of additional equipment have been considered in the design. Hot and cold water piping main trunk lines are provided in the present design to accommodate future expansion in the Demonstration Community.

The process flow diagram for the ICES plant is shown in Figure III-2. The power plant steam cycle is typical of small power plants. The coal fired boiler will produce steam at 850 psi and 900°F while consuming ~12 tons of coal per hour. The steam will be used to generate 20 MWe (net) of electric power in the turbine generator. A portion of the steam will be extracted at 360°F and transmitted to the heating and cooling facility.

Electrically, the ICES generating facility will be tied in directly to the municipal electrical grid, through connections within the Independence Center demonstration community.

It is planned that the City-supplied hot and chilled water will be connected to the three central plant systems at the Independence Center. The connections would parallel the existing pumps so that the existing heaters and chillers can be used for backup capability. Observations of the existing installation indicate that tie-ins can be accomplished without major difficulty or down time.

3.2 INSTALLED COST ESTIMATE

The preliminary cost estimate is based on preliminary plant layouts, site visits, conferences with concerned agencies and equipment vendor contacts, without the benefit of detailed specifications. Estimated prices are based on current labor and material costs. Land costs, right-of-way and access costs, and labor rates were based on those of the Kansas City-Independence, Missouri, area.

The estimated construction cost of the proposed 20 MWe ICES system is \$28.1 million, exclusive of interest during construction and professional services. This estimate was based on a thorough review of design and construction requirements, and is believed to be conservative.

Should flue gas desulfurization not be required, a net savings of about \$4 million can be realized in the total capital cost. The detailed cost estimate is summarized as follows in Table III-1.

3.3 DEVELOPMENT OF ICES SYSTEM DESIGN

During Phase II of the project the preliminary design of the ICES plant will be completed. A number of cost benefit and design evaluations will be performed to improve the technical and economic viability of the concept, and several major design evaluations will also be made, including:

- o A detailed heat balance and optimization of the steam cycle will be completed to maximize the plant fuel user efficiency.
- o Plant site size requirements and equipment specifications will be formulated.

TABLE III-1
SUMMARY OF COST ESTIMATE

1.0	Land and Land Rights	\$ 1,036,500
2.0	Structures and Site Improvements	1,621,000
3.0	Boiler Plant Equipment	9,650,800
4.0	Turbogenerator Units	4,701,000
5.0	Data Logger System	387,000
6.0	Accessory Electric Equipment	981,000
7.0	Miscellaneous Power Plant Equipment	115,000
8.0	Transmission Plant	<u>263,200</u>
	Total Power Plant	\$18,775,500
9.0	Service Connections to Heating and Cooling Building	\$ 1,310,000
10.0	Heating and Cooling Facility	2,020,000
11.0	Service Connections to Demonstration Community	670,000
12.0	Service Connections Along 39th Street	<u>1,200,000</u>
	Total Heating and Cooling	\$ 5,200,000
	Total Facilities Cost	\$23,955,500
13.0	Contingency	\$ 2,344,500
14.0	Escalation - to 1980	\$ 1,800,000
15.0	Interest During Construction	0
16.0	Client Expense	<u>0</u>
	Total construction cost less client expense, interest, and professional services	\$28,100,000

- o An evaluation of the need for an extensive scrubber system will be completed and the cost benefit analysis of specifying low sulfur coal will be performed.
- o The use of a dry cooling tower versus a wet tower will be explored as a means of reducing the site water requirements.
- o The location of the heating and cooling facility at the power plant site will be evaluated against the conceptual design (separate facilities) in terms of technical and economic viability.
- o Alternate plant sites will be evaluated with respect to economic and environmental impact and the ability to service the demonstration community.

TASK IV - COMMITMENTS

Task IV consisted of firming up commitments, agreements, and financing for subsequent phases of the ICES program. It also included clarification of ICE system ownership and an evaluation of future fuel supplies.

4.1 FINANCING

The City of Independence intends to finance its share of the capital costs of the ICES plant and equipment from the sale of electric light works revenue bonds. The City's current authorized, but unissued, bonding capacity of \$33 million will be more than adequate for this purpose.

The typical schedule for issuing electric light works revenue bonds that have been previously authorized is shown below.

<u>Activity</u>	<u>Elapsed Time (weeks)</u>
1. Preplanning	1-2
2. Select bond attorney, consulting engineer, and auditor	2-4
3. Prepare and print the prospectus	6-7
4. Receive bids	4-5
5. Print and deliver bonds	<u>3-4</u>
Total elapsed time	16-22 weeks

4.2 FUEL ALLOCATION

The uncertainties surrounding both the availability and cost of traditional fuels, and the specific direction our national energy program will take in developing nontraditional sources of energy, have never been greater. At the present time there are more questions than there are answers with respect to future fuel/energy supplies and costs. No one can say, with any degree of certainty, what can be expected in the next few years except that fuel/energy will become increasingly more expensive and that we must conserve our rapidly diminishing reserves of natural gas and oil.

The "National Energy Outlook - 77" and the City's experience of recent months confirm that natural gas and oil--fuels typically used for the generation of electric energy in the Midwest--are becoming more scarce and expensive. For these reasons, coal is the most feasible conventional fuel for power generation in the short term. Domestic coal reserves are known to be sufficient to meet out current energy needs for several hundred years.

All of the City's steam generating units and some of its combustion turbine units have alternate fuel burning capabilities. Coal, natural gas, and oil can be fired separately or in combination. In the years prior to the allocation of natural gas by the Federal government, over 80 percent of the annual fuel needs of the City's electric utility were provided by natural gas. In this past year natural gas represented only 54 percent of the fuel used and it is expected that natural gas deliveries will be completely curtailed by 1980.

Although oil is currently available, the City's utility does not consider it to be a reliable source at a reasonable cost. The cost of No. 2 fuel oil, which sold for 32.38 cents per gallon in 1976, is now in excess of 39 cents per gallon.

As mentioned above, prior to 1975 the City's electric utility used approximately 80 percent natural gas and 20 percent coal. Due to increasing gas curtailments and prices of fuel oil those percentages are steadily reversing. It is expected that coal will be the primary fuel by 1980.

It was with the above in mind that the City opted for a coal-fired boiler system for the ICES demonstration program. Although the future cost of coal is expected to rise, the domestic reserves are sufficient to meet the demand for many years to come. The ICES System will include provisions for burning fuel oil, should it be available at a reasonable price.

4.3 OWNERSHIP

The specific details for ownership of the grid-connected Integrated Community Energy System are still to be determined insofar as equipment located on or within the customer's facilities are concerned. However, the City of Independence intends to follow its typical procedure for providing utility services, including maintenance of service lines, wherever it is appropriate to do so. Accordingly, the City intends to have ownership of the two ICES plants (the power-generating plant and the hot/chilled water plant) and the properties on which they are placed. The distribution systems between the power plant, the hot/chilled water plant, and the customers' facilities and all metering and control devices at the interface of the City and customer distribution systems will be located in City-owned right-of-ways or easements. In general, the customer would assume his traditional role as owner and operator of the end-use equipment within his facility.

It is anticipated that specific agreements regarding the ownership of all subsystems will be consummated during Phase II as the requirements for metering, instrumentation, and other control devices become more definitive.

4.4 GRID CONNECTION

The power plant, the heating and cooling plant, the distribution lines for electricity, and the distribution lines for the heated and chilled water will be owned, operated, and maintained by the City of Independence. All electric lines and distribution pipes will be located in right-of-ways or easements owned by the City.

Interfacing equipment and distribution systems within each of the developments will be owned and maintained by the owners of such developments.

Electricity, heated water, and chilled water will be provided on a demand basis. Such a distribution method will allow each user to access the amount of service required individually by that user. As a part of the demand service the City, for billing and monitoring purposes, will own and maintain all metering devices.

The City Council, by authority of the Charter of the City of Independence, is empowered to establish rate schedules for the sale of all electrical energy supplied by the City's Public Utilities Department. Present rate schedules were adopted by Ordinance No. 3727 on March 3, 1975. Such rate schedules are established on a level to satisfy repayment of outstanding bond indebtedness and "in lieu of taxes" payments to the City general fund. The rate structure is designed so as to provide lower cost electrical energy to total electric and major electric users. A study of the current City-wide electric service rate structure is presently being accomplished and should be completed during Phase II.

The rates charged for the consumption of electric service are established by the City Council in accordance with Section 16.04.002 of the City Code of the City of Independence. Such rates are established in accordance with load demands and consumption as related to the type of electrical service provided.

The users of the electric service in the Demonstration Community would pay rates according to their respective classification of service rates.

4.5 TERMS OF SERVICING INDEPENDENCE CENTER

Several meetings were held with local and regional officials from all major tenants of the Independence Center. The current understanding between the City and the major tenants of Independence Center (i.e., Homart, Sears, Macy's, and Stix, Baer and Fuller) is that connections to the ICE System will take place whenever interfacing of the new (ICES) and existing equipment is possible.

Rates for each segment of the ICES system are not established at present because all factors affecting the rate schedules are not known. For example, there are three possible sites available on which to locate the plant. Each site involves separate variables in terms of the final rate structure: initial acquisition cost, length of service supply lines, geological influence on service line routing, etc. Additionally, the cost sharing arrangements between the City and ERDA have not been negotiated. Rate schedules will be defined as the above information, and other data, becomes available. Such schedules must be adopted by legislative action of the City Council as referred to above.

4.6 CONSTRUCTION OF NEW DEVELOPMENTS

Major developers in the Demonstration Community are planning to have more than 414,000 additional square feet in place as of 1979. Other new construction by smaller developers will also be started within this time frame. However, for the purpose of phasing the ICES System, the City is concentrating on those major structures that will be a reality at the time service connections will be possible. Approximately 2,000,000 square feet is expected to be in place when the ICES facility is first ready for operation.

When users are brought on line, service contracts will be signed with each user. Such contracts will encompass peak loading arrangements, etc., which are a part of standard service procedures already administered by the City.

TASK V - DETAILED WORK MANAGEMENT PLAN

Task V consisted of the development of a work management plan for subsequent phases of the ICES program. The effort included the identification of tasks or work packages; estimation of the costs, schedules and level of effort involved; and establishment of the project team. It is planned that Phase II will be accomplished by the same team used in Phase I, namely the City of Independence, the NUS Corporation and Public Technology, Inc. Greater participation by the owners/developers in the Demonstration Community is also planned.

5.1 DESCRIPTION OF WORK PACKAGES

Fourteen major work packages have been identified for the accomplishment of Phase II. Each work package represents a major project task which consists of several related subtasks. Some of these work packages will continue beyond Phase II into succeeding phases of the project, while others will terminate with the completion of Phase II. At the start of Phase III, several new work packages will be initiated based on the development of a work management plan in Phase II.

The project work packages for Phase II were grouped according to four major functions within the overall work management plan. These functions are System Analysis, ICES Design, Project Management, and Implementation. Senior project team members will have responsibility for these four functional areas. Table V-1 outlines the principal work packages to be performed in Phase II and shows their estimated cost. Table V-2 provides cost estimates for work packages associated with phases subsequent to Phase II.

A brief description of each Phase II work package is presented in the following sections. Detailed descriptions which include

TABLE V-1

COST BREAKDOWN - PHASE II OF DEMONSTRATION PROGRAM

<u>Function</u>	<u>Work Package</u>	<u>Estimated Cost (\$1000)</u>
A. System Analysis	1. Environmental Assessment	75
	2. Energy Audit	10
	3. Cost Analysis	28
	4. System Operation	<u>40</u>
	Subtotal	153
B. ICES Design	5. Thermal Distribution and Hookup	41
	6. Thermal Transmission and Conversion	60
	7. Power Plant	396
	8. Control and Feedback System	<u>57</u>
	Subtotal	554
C. Project Management	9. Project Management	20
	10. Value Engineering	15
	11. Information Dissemination	<u>37.5</u>
	Subtotal	72.5
D. Implementation	12. Regulatory Obligations	10
	13. Service Commitments*	27.5
	14. Work Management Plan	<u>30</u>
	Subtotal	67.5
TOTAL PHASE II COST		\$847,000

*Includes \$12,500 for a rate study by an outside consultant to the City of Independence.

TABLE V-2

COST BREAKDOWN - PHASES III-VI OF THE DEMONSTRATION PROGRAM(a)

<u>Work Package</u>	<u>Cost (\$1000) by Project Phase (1977 Dollars)</u>			
	<u>III</u>	<u>IV</u>	<u>V</u>	<u>VI(b)</u>
Energy Audit	10	10	10	10
Cost Analysis	50	0	0	0
System Operation	0	0	100	50
Thermal Distribu- tion and Hookup	76	2,197		
Thermal Transmis- sion and Conver- sion	110	3,206		
Power Plant	735	21,163		
Control and Feed- back System	108	1,521		
Project Management	36	42	36	36
Value Engineering	15	0	0	0
Information Dissem- ination	40	45	50	50
Bond Issue	100	0	0	0
Construction Man- agement	50	250	150	0
Testing and Moni- toring	0	0	250	50
O&M of Monitoring System	0	0	100	50
Plant Operation	<u>0</u>	<u>0</u>	<u>1,400</u>	<u>1,400</u>
	1,330	28,434	2,096	1,646

(a) Independence is prepared to finance the capital and operating cost of an ICES facility commensurate with the cost of acquiring and operating equivalent system capacity. In today's environment, the City's capital investment would amount to \$500 per installed kilowatt and an operating expense of 14.6 mills per kilowatt hour. The City is prepared to negotiate funding principles at this time and to agree upon a definitive financing formula at the conclusion of the next program phase.

(b) For Phase VI, all costs are in thousands of dollars per year.

a discussion of the subtasks, expected results, and relationships with the effort in other phases are contained in the main report (Volume II).

5.1.1 Environmental Assessment

The objective of Work Package 1, Environmental Assessment, is to develop and document baseline environmental information and the potential environmental impacts of construction and operating in sufficient detail to permit preparation by ERDA of a draft environmental impact statement on the Independence ICES facility.

5.1.2 Energy Audit

The objective of Work Package 2, Energy Audit, is to determine profiles of energy consumption with respect to time in all buildings to be served by heating and cooling from the ICES project. The audit will include consideration of the functional and architectural characteristics of each building such as the period of occupancy, usage, type of construction, etc.

5.1.3 Cost Analysis

The objective of Work Package 3, Cost Analysis, is to develop detailed capital and operating costs for the Independence ICES project, to analyze costs in relation to other generating costs in the Independence Power & Light utility system, to examine the impact of the ICES project on energy rates in Independence, and to perform other economic analyses that may be appropriate.

5.1.4 System Operation

The objective of Work Package 4, System Operation, is to perform analyses of the ICES system and its components to develop efficient system operation. This will include various system optimization evaluations associated with the use of alternative grades of coal,

boiler steam supply conditions, system configuration, turbine loads, and scheduling.

5.1.5 Thermal Distribution and Hookup

The objective of Work Package 5, Thermal Distribution and Hookup, is to perform a preliminary design of the thermal distribution and hookup components of the ICES facility. The major subsystems that comprise this package include:

- a. Hot and chilled water pipes from the heating/cooling plant to Independence Center and return flow pipes.
- b. Tie-in to existing facilities at Homart, Sears, and Macy's.
- c. Distribution lines for hot and chilled water throughout the Demonstration Community.
- d. Hookups to new development.
- e. Site work, including excavation, pavement replacement, and grading.

5.1.6 Thermal Transmission and Conversion

The objective of Work Package 6, Thermal Transmission and Conversions, is to perform a preliminary design of the thermal transmission and conversion components of the ICES facility. The major subsystems that comprise this package include:

- a. High-pressure steam line from power plant to heating and cooling facility.
- b. Heating and cooling facility building

- c. Cascade heaters
- d. Adsorption liquid chillers
- e. Condensers
- f. Pumps
- g. Cooling tower
- h. Auxiliary oil-fired boiler

5.1.7 Power Plant

The objective of Work Package 7, Power Plant, is to perform a preliminary design of the power plant and all of its ancillary facilities. The major subsystems that comprise this package include:

- a. Coal-fired boiler
- b. Turbine generator
- c. Coal unloading, storage, and feeder system
- d. Feedwater system
- e. Boiler flue gas pollution control equipment
- f. Fly ash and bottom ash handling
- g. Wastewater handling
- h. Mechanical cooling tower
- i. Switchgear and transformer

j. Buildings, sidings, roads, and pipe tunnels

k. Instrumentation and control center.

5.1.8 Control and Feedback System

The objective of Work Package 8, Control and Feedback System, is to conceptualize and do a preliminary design of a control and feedback system for the complete ICES facility, including power plant, grid connection, heating and cooling plant operation, distribution of hot and cold water, metering to customers, and feedback from customers's internal systems.

5.1.9 Project Management

The objective of Work Package 9, Project Management, is to guide and control the total project effort in Phase II and to report progress and results to ERDA. This work package includes the preparation of periodic financial and progress reports, the preparation of the final report and intermediate reports on major tasks, the monitoring of project schedules, and the conduct of periodic review meetings.

5.1.10 Value Engineering

The objective of Work Package 10, Value Engineering, is to independently analyze the cost effectiveness of the ICES project design and to use the functional approach toward obtaining optimum value for each dollar spent on construction and operation. It is planned that GSA and EPA techniques for value engineering will be used.

5.1.11 Information Dissemination/Technology Transfer

The objective of Work Package 11, Information Dissemination/Technology Transfer, is to disseminate information on the Independence

project and on the ICES concept of energy conservation to a broad segment of the interested public. A User Requirements Committee (URC), composed of persons located throughout the United States, will be used to provide technical, operation, and economic requirements to the project, in addition to guidance, market data, and performance evaluation criteria. Newsletters containing information regarding the purpose, scope, project status, and benefits of the ICES demonstration project will be prepared and distributed to individuals in the Demonstration Community and to other interested persons nationally.

5.1.12 Regulatory Obligations

The objective of Work Package 12, Regulatory Obligations, is to obtain all licenses, permits, and necessary approvals required for the construction and operation of the ICES facility.

5.1.13 Service Commitments

The objective of Work Package 13, Service Commitments, is to firm up all commitments with users of the ICES system in the Demonstration Community and with key suppliers of fuel, equipment, and supplies for the ICES facilities. It is expected that several meetings will be necessary to negotiate the terms of the service agreement between the City of Independence and the ICES customers.

5.1.14 Work Management Plan

The objective of Work Package 14, Work Management Plan, is to facilitate the implementation of the later phases of this project through the development of a detailed work management plan for those phases. The schedule established for initial plant operation, as dictated by the development plans of potential users, requires that the overall ICES program proceed without delay. A detailed work plan is essential to the timely completion of the program in order to meet customer requirements.

5.2 PROJECT SCHEDULES

Figure V-1 presents the tentative design and construction schedule for the Independence ICES project. It shows Phase II ending in February 1978, and Phase III continuing into 1979.

It will be possible to obtain thermal energy production from the ICES facility prior to the time of electricity generation. This is due to the long lead time necessary to purchase a turbine generator and field-erect a boiler package. Thermal service, fired by an auxiliary oil-fired boiler, can be provided early in 1980. This service includes the steam line in place between the power plant and the heating and cooling facility, heaters and chillers, and hot and cold water service to Independence Center. Power generation will be available late in 1980, with the installation of the coal-fired boiler and turbine generator.

All schedules are subject to equipment delays and other unforeseen events. These schedules depend on quick turnaround of approvals and inputs from ERDA, with no unnecessary delays created by the ERDA funding and contractual processes.

Figure V-2 shows key milestones for each of the fourteen work packages.

5.2 ORGANIZATION PLAN

To ensure the continuity of the Independence ICES project in Phase II and beyond, the project team that performed Phase I will remain intact. It is planned that the major owners/developers in the Demonstration Community will increase their participation in the design, analysis and planning processes.

The City of Independence will continue to serve as the principal contractor to ERDA and will carry out all functions of management

FIGURE V-1

TENTATIVE DESIGN & CONSTRUCTION SCHEDULE

FIGURE V-2 PHASE II MILESTONE CHART

and coordination in Phase II. The City of Independence will assume the primary responsibility for the following Phase II work packages:

- Work Package 9: Project Management
- Work Package 12: Regulatory Obligations
- Work Package 13: Service Commitments
- Work Package 14: Work Management Plan

Public Technology, Inc., will serve as a subcontractor to the City, providing general staff assistance as well as taking responsibility for the following Phase II work packages:

- Work Package 2: Energy Audit
- Work Package 11: Information Dissemination

NUS Corporation will be responsible for technical and design functions to be performed in Phase II. These include the following work packages:

- Work Package 1: Environmental Assessment
- Work Package 3: Cost Analyses
- Work Package 4: System Operation
- Work Package 5: Thermal Distribution and Hookup
- Work Package 7: Power Plant
- Work Package 8: Control and Feedback System
- Work Package 10: Value Engineering

The organizational structure for Phase II is shown on Figure V-3.

FIGURE V-3
PROJECT ORGANIZATION CHART