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**GRID-CONNECTED INTEGRATED COMMUNITY
ENERGY SYSTEM**

Final Report

Volume II

July 1977

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

City of Independence
Independence, Missouri

950 5255

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

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City of Independence

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VOLUME II
FINAL REPORT

FOR

**GRID-CONNECTED
INTEGRATED COMMUNITY
ENERGY SYSTEM**

JULY 1977

TO

**ENERGY RESEARCH
AND
DEVELOPMENT ADMINISTRATION**

City of Independence

MISSOURI 64060
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July 6, 1977

Mr. John Rodousakis, ICES Program Manager
Division of Buildings and Community Systems
Mail Stop: 2221C
U.S. Energy Research and Development Administration
20 Massachusetts Avenue
Washington, DC 20001

Reference: Contract EC-77-C-02-4213, Grid-Connected Integrated
Community Energy System

Dear Mr. Rodousakis:

In fulfillment of the referenced contract enclosed are 15 copies of the main final report. Also enclosed are 15 copies of an executive summary which was prepared in response to Mr. Dana Dixon's letter of June 14, 1977. Further distribution of the final report and the executive summary is being made in accordance with Mr. Dixon's letter of March 3, 1977.

The City of Independence's position on cost sharing for subsequent phases of the ICES program is as set forth in Mayor King's letter to Mr. Robert Fri, ERDA Administrator, dated June 6, 1977. The cost estimates for subsequent phases are shown on Tables V-1 and V-2 in the executive summary (Volume I) and Tables V-2 and V-3 of the main report (Volume II).

Questions regarding the final report should be directed to Robert Svehla, Phase I Project Manager.

Sincerely,

Lyle W. Alberg
City Manager

LWA/RLS/skc

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*This appendix submitted in a separate volume.

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EXECUTIVE SUMMARY

This report presents a preliminary feasibility analysis of a grid-connected Integrated Community Energy System (ICES) in the City of 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.

FINDINGS

On a preliminary basis, it was found that the ICES concept can be made feasible in the City of Independence by employing a 20-megawatt coal-fired boiler and turbine and using waste heat to provide the energy for heating and cooling commercial facilities with over 3 million square feet of floor space. When fully loaded thermally, the ICES results in favorable fuel utilization and energy conservation in comparison to conventional energy systems.

DEMONSTRATION COMMUNITY

The Demonstration Community selected by the City of Independence for the ICES Demonstration Project is located on a 1,382-acre tract in the southeastern portion of the city and is considered to be prime development property.

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 suited for the ICES project due to its size and the relative ease with 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 ICBS network.

A conservative estimate of the 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

Energy demand for heating and cooling in the Demonstration Community will grow in proportion to the construction of additional floor space.

ICBS ALTERNATIVES

Several ICBS alternatives were evaluated, including gas turbine systems, diesel generator systems, and several coal-fired generating systems. It was found that all systems operating on demand for heating and cooling save energy when compared to the all-electric system now serving Independence Center.

Because the future supply of oil and natural gas in Independence is questionable, coal was chosen as the fuel to be used for the ICBS project. A 20-megawatt unit was selected so that the grid connection of the ICBS will serve as an integral addition to the City's present power and light network.

FUEL SAVINGS

In 1980, during the initial start-up of the ICBS 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.

INSTITUTIONAL FACTORS

The City of Independence is experienced with all of the institutional factors that may impact the ICES Demonstration Project: citizen involvement and participation; environmental control; land use planning; safety; codes, ordinances, and other legal documents; labor relations; utility regulations; and financial considerations (taxation, issuance of bonds, setting of utility rates, etc.). These factors are dealt with on a continuing basis by members of the City Council and staff. Based on the City's past experiences with similar projects, and a review of the applicable codes, ordinances, and regulations by the ICES project team, it was determined that there are no institutional factors that could seriously jeopardize the successful demonstration of a grid-connected Integrated Community Energy System in the City of Independence.

The City of Independence has the authority to enter into contracts, own and operate utilities (and establish the rates therefor), incur indebtedness, issue revenue bonds, acquire land by the right of eminent domain, and establish land use and zoning regulations. This authority, granted by the Missouri Constitution and State Statutes, places the control of most of the factors essential to the ICES project in the hands of the City Council.

The land use plan for the Demonstration Community area is consistent with the type of development desired for the ICES project. In

particular, the land use in the immediate vicinity of the Independence Center shopping complex is planned for commercial and multi-family development. Since the proposed ICES demonstration facilities (buildings and equipment) will be so designed as to be environmentally and aesthetically consistent with the planned land use, no adverse reaction from persons within the Demonstration Community is anticipated.

During Phase I there were several news articles and meetings regarding the ICES project. No adverse comments were received. It is anticipated that, as the project continues and the need for energy conservation becomes more apparent, the response from citizens and the business community will be highly favorable.

ICES DESIGN AND COST

The proposed ICES power plant will be a coal-fired steam cycle plant with the backup capability to use fuel oil. The plant will be located on a 35-acre (or less) site near the Illinois Central & Gulf Railroad, north of the Independence Center shopping complex. The site will include all power generation equipment, fuel storage and handling facilities, and effluent release control facilities.

A small (approximately 200,000 lb/hr) boiler burning pulverized coal will be used to produce steam at 800 to 900°F. The steam produced will generate approximately 20 megawatts of electrical power via a turbine-generator combination. This power will be added to the City of Independence grid. Steam extracted from the turbine will be used to supply the energy to a separate heating and cooling facility.

The impact of the power plant on the area will be minimized by proper site selection and plant design, including the latest developments in pollution control equipment.

The Independence ICES project would supply hot and cold water (for heating and air conditioning) to commercial customers in the vicinity of the Independence Center, by connecting supply and return pipes from a City-operated heating and cooling plant. Observations of the existing installations indicate that tie-ins can be accomplished without major difficulty or down time.

The estimated cost of the proposed ICES facilities would be \$26,300,000, in 1977 dollars, exclusive of engineering costs and other costs associated with the ERDA demonstration. Annual operating costs are estimated at \$1.4 million.

COMMITMENTS

It is recognized by the City that firm commitments from potential users of the ICES system are a major element in the success of this project. The City is confident that developers in the Demonstration Community, given evidence of the economic benefit to them as a result of the project's feasibility, will participate in the ICES project.

The City of Independence has not, at this time, made a concerted effort to negotiate agreements with prospective ICES customers to purchase electrical or thermal energy at some specified rate. This accounts for the general nature of the commitments (see Section IV of this report) from major owners/developers in the Demonstration Community who are in support of the project.

It is, and has been, the City's opinion that the results of Phase I are too preliminary to permit meaningful negotiations of an agreement to sell and buy at a specific rate(s). The setting of rates must wait until cost-sharing terms are determined and the design of the ICES facilities is more firm. Furthermore, the City currently has a rate study under way to determine what changes should be made in the existing rates for electric service supplied by the City Power & Light Department. Until the results of this

study are available, there is no firm basis on which to base future (1980-1985) rates. The setting of rates for the 1980 time frame is further complicated by the uncertainty at the national level with respect to energy.

It is the City's intention to obtain firm commitments from prospective ICBS customers during Phase II, based on electrical and thermal energy rates that will be determined at the start of Phase II.

WORK PLAN FOR PHASE II

A work plan for Phase II, Detailed Feasibility Analysis and Preliminary Design, incorporates fourteen individual work packages in the following major functional areas:

- o System Analysis
- o ICBS Design
- o Project Management
- o Implementation

Phase II will be performed by the City of Independence and its subcontractors: Public Technology, Inc., and NUS Corporation. It will be completed in eight months and will lead directly into Phase III, Final Design.

Manpower needs for Phase II are estimated at 33,230 man-hours, the majority of which will be expended on engineering design for the ICBS power plant facility. The estimated cost for Phase II is \$847,000.

TASK I - PRELIMINARY ENERGY ANALYSIS

1.1 DESCRIPTION OF THE DEMONSTRATION COMMUNITY AREA

This section describes the Demonstration Community area for the City of Independence grid-connected Integrated Community Energy System (ICES) project. The topics addressed include project location, topography, geology, demography, current land use, proposed land use, zoning, and utilities. Maps, photographs, and drawings are included to enhance this description.

1.1.1 Summary

The Demonstration Community is located in a fast-growing, mixed residential and commercial area in the southeastern sector of Independence, Missouri. The center of the Demonstration Community lies at the intersection of two major roadways, Interstate 70 and Missouri Highway M-291, which service the Kansas City metropolitan region. The area has ready access to public air, rail, and bus transportation facilities.

Independence Center, an all-electric shopping center with over 1.2 million square feet under one roof, is the focal point of the Demonstration Community. The Center, together with existing and near-term development, virtually assures a combined floor space of approximately 2 million square feet by the time the ICES facility is operational.

The Demonstration Community area consists of approximately 1,400 acres, of which less than one-third is currently developed. There is reason to expect that in its ultimate development the commercial and multifamily floor space in the Demonstration Community area will exceed 4 million square feet. How much of this will be connected to the ICES network is not yet determined, but the potential is significant due to the shortage of natural gas in

the Demonstration Community and the increasing costs for all-electric service.

The zoning, current land use, topography, and geology of the Demonstration Community are all favorable to its continued development and to the purposes and needs of the ICES project.

1.1.2 Location

The Demonstration Community is located in Independence, Missouri, the third largest city in the state of Missouri. Independence itself is located in the eastern portion of the Kansas City metropolitan region (Figure I-1). The Demonstration Community area is situated in the extreme southeastern portion of Independence and comprises approximately 1,380 acres (Figure I-2). The boundary lines for the Demonstration Community area are the Illinois Central & Gulf Railroad on the north; Selsa Road on the east; Interstate 70 on the south; and Lee's Summit Road on the west (Figure I-3).

1.1.3 Topography

The Demonstration Community is on gently rolling hills descending from the northwest to the southeast. The elevations at the four boundary corners are 895 feet at Lee's Summit and the Illinois Central & Gulf Railroad; 900 feet at Lee's Summit and Interstate 70; 800 feet at the Illinois Central & Gulf Railroad near Selsa Road; and 750 feet at Selsa Road and Interstate 70. The geologic cross section (Figure I-4) shows the land in profile. A topographical relief map that shows other elevation points (Figure I-5) is also included.

1.1.4 Geology

The City of Independence is located within the Scarped Plains area, approximately midway between the Ozark "uplift," or plateau,

FIGURE I-1
STANDARD METROPOLITAN STATISTICAL AREA

FIGURE I-2
CITY OF INDEPENDENCE

GEOLOGICAL CROSS SECTION

This geological cross section is shown along an east-west line through Jackson County, with the Missouri - Kansas state line on the left and a point $3\frac{1}{4}$ miles west of the Jackson - LaFayette county line on the right. The City of Independence extends from Blue Ridge Blvd. on the left to the Little Blue River on the right.

It should be noted that the vertical scale is exaggerated to indicate the various layers of shale and limestone formations. The layers of rock strata appear level when observed along road cuts and stream valleys. However there is a significant slope of approximately 250 ft. from east to west. A similar slope would occur from south to north if a north-south cross section were shown. The true direction of the slope is approximately North 60 degrees West. For example, the Bethany Falls limestone dips from elevation 1,000 at Lone Jack, in the southeastern portion of the County, to elevation 740 near the Broadway Bridge in Kansas City. It is this strata that is mined primarily for crushed rock.

FIGURE I-4
GEOLOGICAL CROSS SECTION

SCALE 5 MILES

FIGURE 1-5
TOPOGRAPHY OF DEMONSTRATION COMMU

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to the southeast and the Great Plains area to the west. The rock formations in the local area appear to be nearly level, although they have a slight dip toward the northwest, generally between six to ten feet per mile. The rock formations that underlie the Independence area are generally alternate layers of shale and limestone. The most common of these is the Bethany Falls limestone, which is harder than the shale formations and the one most frequently mined for use as crushed rock and aggregate in concrete. The Bethany Falls limestone is consistently found at the five- to twenty-foot levels. The soil structure in the Demonstration Community area is not expected to create any particular problems with respect to residential or commercial development. Boring samples taken in the Demonstration Community from the Independence Center site support this statement.

1.1.5 Demography

The present residential population of the Demonstration Community is about 2,270. The median income for this group in 1970 was \$12,277. Thirty-six percent of the population is nineteen years old or less, with the elderly comprising less than one percent.

The employment statistics for the residents of the Demonstration Community show that approximately twenty-three percent are clerical, eighteen percent are professional, sixteen percent are equipment operators, fifteen percent are craftsmen, nine percent are managers, and eight percent are in sales. Sixty-five percent of the population is in the blue-collar work force. The median school years completed for those persons over twenty-five years of age is 12.5 years. Seventy-six percent are high school graduates, and sixteen percent have attended college.

The median cost per house in 1970 for the Demonstration Community was \$21,300. These houses averaged 5.9 rooms each. A considerable number of the residences in the Demonstration Community have been constructed since 1970 and represent a much higher median cost.

1.1.6 Utilities

The Demonstration Community has all the necessary utilities available for development purposes. Figures I-6 and I-7 show the current distribution mains for gas, water, sanitary sewer, and electricity. Steam lines do not now exist in this area.

1.1.6.1 Gas

Two gas lines penetrate the Demonstration Community area. The first enters from the north considerably west of Highway M-291. This line extends south to 39th Street and then turns west to parallel 39th Street until reaching Lee's Summit Road. The line continues along the east side of Lee's Summit Road and exits the Demonstration Community area. A four-inch gas line abuts the northeast corner of the Demonstration Community area but does not enter the boundaries. A ten-inch line also runs along 39th Street from Lee's Summit Road to several feet beyond the east side of Crackerneck Road.

Gas is currently unavailable for commercial use east of Highway M-291. This should make connection to the ICES network an attractive alternative for commercial developers.

1.1.6.2 Water

A twelve-inch main runs parallel to Selsa Road. A sixteen-inch main extends the length of 39th Street and also extends from the 39th Street line in a southerly direction at the approximate location of Coventry Drive. Coventry Drive is approximately one-half of Lee's Summit Road.

Water for the ICES plant will be supplied by a local water company.

FIGURE I-6
UTILITIES

FIGURE I-7
ELECTRIC UTILITIES

1.1.6.3 Sanitary Sewers

A sanitary sewer main extends along the northern boundary of the Illinois Central & Gulf Railroad and ends at Selsa Road. There is an appendage line attached to this service just west of Highway M-291 that extends southwest to the William Yates Elementary School (in the northwestern sector of the Demonstration Community area). A sewer line south of Interstate 70 projects into the Demonstration Community area at the approximate location of Coventry Drive. All sewage from the Independence Center and commercial business along 39th Street east of Highway M-291 is emptied into the Little Blue Valley interceptor sewer line, which follows the flood plain of the Little Blue River. The Little Blue River lies directly to the east of the Demonstration Community.

1.1.6.4 Electricity

Electric power sources exist along Lee's Summit Road, 39th Street to the Independence Center, Crackerneck Road north to the Illinois Central & Gulf Railroad; and along the Illinois Central & Gulf Railroad from Highway M-291 to Selsa Road (Figures I-6 and I-7).

A City-owned power substation is located on a 7.47-acre site about one-fourth mile north of 39th Street. It was designed to serve development in the Demonstration Community and the area extending north to R. D. Mize Road. Its designed distribution capacity is 13,200 volts. The Independence Center uses about fifteen percent of the substation's capacity. The Independence Center's current peak load of record is 8.5 MWe.

1.1.7 Current Land Use

The Demonstration Community area contains approximately 1,382 acres of land, characterized by four different basic uses: residential, commercial, industrial, and right-of-way. These four uses

are broken down into developed and undeveloped property by acres and percentages in Table I-1.

Table I-2 shows land use in the Demonstration Community area with the totally residential area west of Crackerneck Road excluded. This residential area was initially included in the Demonstration Community. However, it is not expected to connect to the Integrated Community Energy System due to the costs of constructing the distribution system and modifying the existing heating and cooling systems.

1.1.8 Existing Structures in the Demonstration Community Area

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 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.

The Independence Center contains three major department stores (Macy's; Sears; and Stix, Baer and Fuller) and approximately 150 other retail outlets. Included on the Independence Center site are two banks and a theatre. The Center itself contains approximately 1.2 million square feet of floor space under one roof.

The locations of the existing structures are shown on Figure I-8. Photographs of several of these structures, keyed by number to the locations shown on Figure I-8, are provided herein.

TABLE I-1

LAND USE IN THE DEMONSTRATION COMMUNITY

	<u>Residential</u>	<u>Commercial</u>	<u>Industrial</u>	Right- of- <u>Way</u>	<u>Total</u>
<u>Acres</u>	794	383	30	175	1382
Developed	272	84	6	175	537
Undeveloped	522	299	24	0	845
<u>Percent</u>	57.45	27.72	2.17	12.66	100
Developed	34.25	21.93	20.00	100	38.86
Undeveloped	65.74	78.07	80.00	0	61.14

TABLE I-2

LAND USE EXCLUDING RESIDENTIAL AREA
WEST OF CRACKERNECK ROAD

	<u>Residential</u>	<u>Commercial</u>	<u>Industrial</u>	Right- of- <u>Way</u>	<u>Total</u>
<u>Acres</u>	386.4	383	30	142.6	942
Developed	36.6	84	6	142.6	269.2
Undeveloped	349.8	299	24	0	672.8
<u>Percent</u>	41.02	40.66	3.18	15.14	100
Developed	9.47	21.93	20.00	100	28.58
Undeveloped	90.53	78.07	80.00	0	71.42

FIGURE I-8
EXISTING DEVELOPMENT
MAY 1977

1

Independence Center

This is the main entrance on the upper level of the Independence Center on the north side of the mall, located on 130 acres situated on the southeast corner of M-291 Highway and 39th Street. The two level, air-conditioned enclosed mall shopping center contains approximately 1.2 million square feet with a large interior three-level court with a sunken lower level. The mall is total electric with a system of boilers and heated and chilled water and blowers for heating and cooling. The center would be the prime user in the ICES program.

1

This is a view across the north side of the Independence Center looking west. Entrances on the north side of the mall are on the upper level.

1

An interior view of the central three level court, looking t.

Cinema I & II

2

The Independence Cinema is a new, modern brick facility containing approximately 12,000 square feet of floor space. The building is located just south of 39th Street and east of M-291 Highway with access from the Independence Center parking lot. Heating and cooling system is total electric. The Cinema should be considered as a serviceable ICES consumer.

Mercantile Bank

3

This is a modern stone and wood veneer drive-up and walk-in facility bank located in and with access from the parking lot of the Independence Center. It is one of two branches of the Noland Road Mercantile Bank. The structure contains approximately 5,000 square feet of floor space. The bank has two heating and two cooling units, forced air, total electric. Should be considered as a possible user of ICES.

Home Savings

4

Home Savings is a new brick structure located on 39th Street with access from the Independence Center parking lot. It is a drive-up or walk-in facility with an interior floor space of approximately 4,000 square feet. They have a forced air, total electric heating and cooling system.

Commerce Bank

5

Commerce Bank is a drive-up window and walk-in facility located just north of the Independence Center on the northwest corner of 39th Street and Ponca Drive. This modern brick building, containing approximately 4,000 square feet of floor space, has a total electric forced air heating and cooling system. The close proximity of these two institutions makes them favorable prospects for inclusion in I.C.E.S.

King Louie Lanes

6

This modern bowling alley is a steel frame building with masonry walls containing approximately 28,500 square feet of floor space. It is located north of 39th Street and west of Ponca Drive in the developing commercial area just to the northwest of the Independence Center. King Louie has gas (propane) heat and electric cooling system, both forced air. This structure should definitely be considered for ICES.

Substation "K"

8

Located east of Ponca Drive and opposite the Independence Center, approximately 1,500 feet north of 39th Street is Sub-Station "K", an Independence Power and Light 69 KV to 13 KV distribution sub-station, serving homes and businesses in the Demonstration Community. The fenced area contains a little more than one-half acre.

Farm and Home Savings

9

This is a modern brick building containing approximately 3,000 square feet of floor space. It is located on the northeast corner of 39th Street and Bolger Road, just west of M-291 Highway. Heating and cooling is provided by electricity. Farm and Home could be considered as a user of ICES.

Coventry Manor Apartments

10

Located on Crackerneck Road, just south of 39th Street, this garden apartment complex contains twenty-two separate buildings with six units each. Each unit contains approximately 900 square feet for a total of approximately 118,800 square feet. The apartments are frame exterior with a stucco finish, and have gas heat and electric central air with forced air furnaces. Coventry Manor would be a good prospect for ICES.

Souls Harbour Memorial Church

12

Souls Harbour is a modern brick structure containing approximately 5,000 square feet of floor space on two levels. The church is situated on the northwest corner of 39th Street and Davidson Road, three-quarters of a mile west of M-291 Highway. The heating system is gas fired and the cooling is electric.

Saint Paul's Lutheran Church

13

This church at 17200 E. 39th Street is located on the northwest corner of 39th Street and Davidson Road. The modern, highly vaulted, brick structure contains approximately 15,000 square feet of floor space on two levels. It has gas heat and electric cooling systems. Both churches are some distance from the Center area but could be considered for inclusion in ICES.

14

William Yates Elementary School

This recently constructed elementary school is located at the end of Davidson Road north of 39th Street, about two-thirds of a mile west of M-291 Highway. The building has masonry walls and an approximate floor area of 55,000 square feet. There is one floor level on grade. The school has rooftop, gas fired, forced air heat and electric cooling. Its size makes it a likely consumer of I.C.E.S.

Milton Estates

16

This typical upper middle class development is located east of Lee's Summit Road, midway between 35th Street and 39th Street. Living space averages 1,800 to 2,200 square feet. Majority of residential development in the area will have gas heat, forced air furnaces and electric air conditioning. Some houses will be total electric.

Carriage Hills

17

Typical of the housing in this large, middle class subdivision, these dwellings will average 1,200 square feet of living space. This development is characteristic of a majority of the residential areas in the Demonstration Community. Carriage Hills is located on the southeast corner of 39th Street and Lee's Summit Road. Conversion of heating and cooling systems and capital outlay to serve residential areas would probably prove to be economically unfeasible.

1.1.9 Zoning

The present zoning in the Demonstration Community area (Figure I-9) is consistent with the City's Comprehensive Plan. The zoning classifications are identified in Figure I-9. The only deviations from the City Comprehensive Plan are two sections located east of Highway M-291 and north of 39th Street. Requests to rezone these areas from residential to commercial and medium family residential would almost certainly be approved whenever they are presented since this is consistent with the plan for the overall Demonstration Community area.

1.2 ENERGY DEMAND PROFILES

1.2.1 Service Area

The complex that is to be served by the Integrated Community Energy System is detailed in Section 1.1. As mentioned above and illustrated in Figure I-10, the service area consists of the existing Independence Center shopping complex of approximately 1.17 million square feet plus an additional 680,000 square feet of commercial building space scheduled for 1980, an additional 1.26 million square feet of commercial buildings and apartment buildings scheduled for 1985, and a final 300,000 square feet of commercial buildings scheduled for 1990, totaling over 3 million square feet.

For the purpose of this study, the estimated ICES heating and cooling loads were based on an estimated 1980 building floor area of approximately 1.85 million square feet consisting of the Independence Center and the commercial buildings scheduled for completion by that date.

1.2.2 Independence Center Heating and Cooling Loads

The monthly average heating and cooling loads for the Independence Center are shown in Figure I-11. These curves are based on a

LEGEND

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

FIGURE I-9
 ZONING

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- 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)

detailed survey of the electric power consumption history over two years for the shopping center. Also factored are other items that affect thermal loads, such as the average monthly day and night temperatures for the Independence, Missouri, area, the thermal characteristics for the building materials, ventilation recirculation, electric lights and auxiliaries, and people thermal loading.

In Figure I-11, the heating loads are above the horizontal axis and the cooling loads fall below the horizontal axis. For any particular month (say January) the top bar represents the average heating (or cooling) load for the shopping center during the night. The middle (dashed line) represents the monthly average heating (or cooling) loads during the day without the influence of any people thermal loading. The bottom bar represents the monthly average heating (or cooling) loads during the day for the maximum expected people density for the shopping center.

1.2.3 Commercial Building Heating and Cooling Loads

Because typical commercial buildings are different in many ways from an enclosed mall facility like the Independence Center, a 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-12. The curve explanations are the same as for the Independence Center demand curves. The development of separate heating and cooling load curves was necessitated by the fact that the Independence Center is completely enclosed, has a higher electric light and auxiliary loading, and has a higher people thermal loading than does the aggregate commercial building sector.

1.2.4 Daily Demand Curves

In addition to the average monthly demand curves, the Independence Center and the commercial building sector in Independence possess

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

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

individual daily load demand profiles. These profiles are illustrated in Figures I-13 and I-14. The Independence Center opens between the hours of 9:00 am and 10:00 pm for six days each week. During the daytime hours (assumed to be 9:00 am to 10:00 pm) the average daytime demand fluctuates as people enter and leave the shopping center. During the nighttime hours (10:00 pm to 9:00 am) the average demand for heating/or cooling is assumed to be constant.

For the commercial sector, the daily heating and cooling curves are similar to those for the Independence Center except that the day time working period sensitive to people loading is assumed to be 9:00 am to 6:00 pm for only five days each week. For those days on which the buildings are idle (Sundays, holidays, and weekends for the commercial buildings) the daytime heating and cooling loads are assumed to be the "daytime loads with no people" associated with Figures I-11 and I-12. Typical January daily heating and cooling loads are shown in Figure I-13, while Figure I-14 portrays typical July loadings.

1.2.5 Electric Lights and Auxiliary Electric Loads

Based on a review of the Independence Center electricity consumption for the past two years, the average electric lighting and auxiliary load is approximately 2.2 watts/ft². Therefore, the average (24 hours) electric light/auxiliary load for the Independence Center complex is approximately 2.6 million watts. For the projected commercial sector the electric light and auxiliary load is estimated to be 2.1 watts/ft². Therefore, for the 1.85 million square feet ICES community, the estimated lighting and auxiliary electric load is 4.0 million watts.

All electric power generated by the ICES plant will be transmitted directly to the City of Independence Power & Light utility to the grid. Other City-owned generating stations will be proportionally unloaded when the ICES system is generating power.

FIGURE I-13

TYPICAL DAILY HEATING AND COOLING LOAD (JANUARY)

FIGURE 14. TYPICAL JULY DAILY HEATING AND/OR COOLING LOADS

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, for the reasons stated below, it is conceivable that the total floor space in the Demonstration Community area will reach or exceed 4 million square feet in the next 10 years. The current floor space is approximately 2 million square feet.

Municipal governments are capable of influencing the patterns, standards, and schedule of development through the use of controls such as codes, zoning, taxes, and utility permits. The City of Independence, chartered under Missouri State Statutes, has such planning and zoning authority for all property within its city limits.

Planning for future development in the City of Independence is provided for, and controlled by, a comprehensive and thoroughfare plan that was adopted by the City Council. The portion of this plan that is associated with the Demonstration Community is shown on Figure I-15. The proposed land use east of Crackerneck Road along Highway M-291 and along 39th Street is to be commercial. This area represents the focal point of the ICES Demonstration Community.

The City of Independence is exercising a high degree of public control in the Demonstration Community area because of its prime development potential. However, such control may be less important to quality development than the favorable aspects of private land ownership that exist in the area. The vacant land in the Demonstration Community area is held in large tracts by local citizens who have a long, stable relationship with the City. This avoids many of the problems associated with multiple ownership of small tracts in the hands of persons who are not experienced developers. The major owners/developers in the Demonstration Community area

are listed below. Future developments planned by these persons and firms are discussed in subsequent sections of this report.

- Andes and Roberts Construction Company. This firm is one of the larger development companies in the central United States and is widely experienced in residential, commercial, and industrial development.
- Homart Development Company. Homart, a wholly owned subsidiary of Sears Roebuck, is a major developer of shopping centers on a national scale. It is currently engaged in planning a residential-commercial mix on land near its shopping center (Independence Center).
- Morgan Construction Company. Mr. Frank Morgan has been responsible for a number of regional shopping centers in the Kansas City metropolitan area.
- J. R. Stewart Construction Company. This firm is one of the largest residential construction companies in the metropolitan area.
- Wyss Construction Company. Mr. Ross Wyss has been a major residential developer in Independence and has experience in both single-family and multifamily construction.

All of the above firms have ready access to various financial institutions located in the area, with the capability to finance new construction. They all have a strong interest in seeing increased commercial activity in the Demonstration Community area due to their substantial land holdings therein.

Independence Center provides about one-third of the City's total sales-tax revenue. Consequently, the City is very heavily involved in the promotion of the Demonstration Community area for intensive economic use. Between 1940 and 1970 Independence ap-

proximately doubled in population each decade. The growth has now slowed to a more manageable rate but leaves a critical need to develop an economic base sufficient to support a city of this size. By recent survey, only 27 percent of the working population of Independence actually worked in the City. Since the area is far too large and complex to function as a suburb, greater emphasis is being placed on economic self-sufficiency. On a regional level, the Demonstration Community area has been proposed by the Mid-American Regional Council as one of seven metro-centers in the Kansas City region. A metro-center is a high-activity area that provides a full range of business, recreational, and residential activity serving approximately 200,000 persons within a 15- to 20-minute travel area. The metro-center concept is being employed to help slow the urban sprawl of the region by concentrating high-activity, multiple-use areas around the major transportation hub. The selection of the Demonstration Community area as one of the seven metro-centers planned for the metropolitan region is another major reason to expect its continued development at a faster than normal rate.

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. Higher density residential land use, generally in the form of medium-rise apartments, townhouses, and condominiums, can also be expected.

The Independence Center opened during the height of the recent economic recession. Consequently, the initial expansion phase was slower than had been anticipated, both in the Center and on the adjacent properties. Current expectations are that Independence Center will be fully occupied well before 1977 is completed.

Homart is now actively engaged in marketing about 60 acres of additional land for development. It is known at this time that the Center has under consideration a City fire station; a major service station; a tire, battery, and accessory store; a home-fixtures supplier; and a nursing home. The amount of land available for this ancillary commercial development about equals the land area devoted to the original center.

One of the major developers of the area is now in the process of subdividing and leasing additional commercial space. It appears likely that a mental-health clinic will be constructed in the near future. In addition, it is known that study is under way that may lead to the selection of a site for a major hotel.

The amount of private development within an area is related to the level of public services and expenditures in that area. In the Demonstration Community area, the development of Interstate 70 with the interchange at Highway M-291, the six-lane local roadway development of 39th Street, and the availability of sanitary sewer service are primary physical improvements that have influenced the rate of development. Within the Little Blue River Valley, of which the Demonstration Community is a part, there is an anticipated public investment of several hundred million dollars within the next ten years; including a 25-mile-long interceptor sewer, a U.S. Army Corps of Engineers flood control project on the Little Blue River, the improvement of Highway M-291 and Lee's Summit Road, two new interchanges along Interstate 70, and a new industrial expressway through the City of Independence. The Little Blue River channelization project and the interceptor sewer project are now under construction, and the improvement of Lee's Summit Road will be under construction within two years. With this amount of public investment and the initial private investment for commercial development, the Demonstration Community area is projected to be an intensely developed sector of the City, representing commercial, recreational, and residential development.

1.3.1 Definitive Developments

Listed below are proposed developments that are sufficiently defined to be virtually certain of being carried to fruition. These developments are keyed numerically to Figure I-16. It is expected that the construction of these developments will occur in the 1977-1979 time frame.

1. An extension of Milton Estates, a single-family residential subdivision. This development consists of 37 building lots. The streets and utilities are now completed, and construction has started on some of the houses. It does not appear that this will be suitable for the Integrated Community Energy System due to its present stage of development.
2. A single-family residential subdivision known as Chapels III. This subdivision consists of 31 lots. The streets and utilities are completed, and construction has started on approximately one-half of the lots. It does not appear that this area would be suitable for the Integrated Community Energy System for the reasons stated in (1) above.
3. Coventry Apartments is planning the construction of 150 additional apartment units. The units are planned to be approximately 900 square feet each for a total of 135,000 square feet. It is quite possible that the Integrated Community Energy System could be utilized in this development.
4. The I-470 Development Company is planning to start a commercial-office park. The first phase will be a general commercial unit consisting of 60,000 square feet. The Integrated Community Energy System would be very suited to this project.

5. Andes and Roberts Construction Company is developing a commercial subdivision near 39th Street and Highway M-291. The subdivision consists of 57 lots. It is their intention to sell these lots for private development. Depending on the ultimate development, it is possible that the proposed energy system could be used.
6. Andes and Roberts Construction Company is planning the development of a commercial center with approximately 129,260 square feet. This general commercial center could be designed to fully use the Integrated Community Center System.
7. Mr. Frank Morgan is planning the development of the first phase of a commercial center consisting of approximately 90,000 square feet. The center could be designed to fully utilize the Integrated Community Energy System.
8. William Marx and Company is planning the development of an enclosed tennis club consisting of 40,000 square feet. This development would probably not be a good candidate for the Integrated Community Energy System because of its location.

1.3.2 Long-Range Developments

Following is a list of future developments that are more tentative than those shown in Section 1.3.1. However, experience indicates that many will be carried to completion. The construction period for these developments covers the 1979-1990 time frame.

1. A further expansion of the Milton Estates single-family residential subdivision. This proposed subdivision will include approximately 150 building lots. It may be possible to use the Integrated Community Energy System in this development.

2. A planned high-density residential area. No definite projections as to number or size of units have been made. If this development occurs, it is very likely that the Integrated Community Energy System could be used.
3. A planned commercial center consisting of approximately 400,000 square feet. This development could be designed to use the Integrated Community Energy System.
4. The completion of the I-470 Development Company's commercial office park with an additional 667,000 square feet. This development could be designed to fully utilize the Integrated Community Energy System.
5. Additional development of Mr. Frank Morgan's property (approximately 60,000 additional square feet). This development could use the Integrated Community Energy System.
6. The development of a commercial complex on land owned by Independence Center Properties. This development should consist of approximately 150,000 square feet and could use the Integrated Community Energy System.
7. The development of additional commercial centers along the north side of 39th Street. These centers should contain approximately 200,000 square feet and could utilize the Integrated Community Energy System.
8. An area proposed as a high-density housing area. No projections are available as to size or number of units.
9. An area proposed for general commercial use. No definite plans have been developed at this time.
10. An area proposed for high-density residential purposes. No definite plans have been developed at this time.

1.3.3 Projected Growth in Energy Service Requirements

It has been estimated that the total floor space in the Demonstration Community will reach or exceed 4 million square feet by the year 1990. Of this, approximately 3.41 million square feet, or 85%, is likely to be of a nature suitable for service by the Integrated Community Energy System. This estimate is conservative in that it does not account for the possibility of the ICES-derived energy source actually stimulating development within the Demonstration Community. Development stimulation due to an ICES could become a major factor as fuel costs rise and as alternative methods of energy generation become impossible due to fuel unavailability.

Table I-3 outlines the anticipated growth in energy demand in the Demonstration Community through the year 1990.

The impact of projected growth of the Demonstration Community is of major significance to the performance and the economics of the proposed ICES. From 1980, when the project would first be in operation, to 1990 the thermal demand on the system would approximately double. Thus, an increased benefit in efficient fuel utilization and energy conservation would be ensured.

In addition, by 1990 there would be a net annual power savings to Independence of approximately 72×10^6 kW-hr/yr that would have otherwise gone to heat and cool buildings within the Demonstration Community area.

In summary, the projected growth of the Demonstration Community is a major determinant in the potential success of the ICES project.

It will provide an assured increase in demand for thermal energy provided by the ICES facility.

TABLE I-3
PROJECTED GROWTH IN ENERGY DEMAND
DEMONSTRATION COMMUNITY, INDEPENDENCE, MISSOURI

Year	Service Area (million square feet)	Thermal Demand				Electrical Equivalent of Heating and Cooling*		
		Heating		Cooling		Electrical Equivalent of Heating and Cooling (10 ⁶ kW-hr)	Electrical Power Equivalent to Maximum Heating & Cooling Loads	
		Yearly (10 ¹⁰ Btu/yr)	Maximum Heating Load (10 ⁶ Btu/hr)	Yearly (10 ¹⁰ Btu/yr)	Maximum Cooling Load (10 ⁶ Btu/hr)		Heating (MW)	Cooling (MW)
1977	1.2	3.0	15.4	0.4	39	14.9	4.5	2.8
1980	1.85	8.12	35.5	11.1	55.5	31.9	10.4	4.0
1985	3.11	18.4	73.8	14.7	86.0	64.7	19.2	6.3
1990	3.41	20.8	82.8	15.5	93.5	72.2	24.3	6.8

* Electrical equivalent represents the electric power that would have to be supplied by the City of Independence Power & Light Department for heating and cooling in the absence of an ICES Project.

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

1.4.1 Conventional Energy System

The conventional system represents the most likely alternative source of electrical power that the City of Independence would develop in the absence of an ICES plant. The conventional system (the one all the ICES systems are compared with) 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; 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 sources 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 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 Fuel Oil Gas Turbine Generator System

Figure I-18 illustrates the conceptual fuel oil gas turbine generator system. Based on the demand for heating and cooling by the community for 1980, three gas turbine generator sets (2.5 MWe each) are required. The exhaust gases generate steam in a waste heat recovery boiler. The steam is in turn used to heat water for building heating or is diverted to a piggy-back steam turbine

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FIGURE 1 - 18

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Rankine cycle/absorption cooling system for providing chilled water for building air-conditioning systems.

1.4.3 Diesel Generator System

Figure I-19 illustrates the conceptual design for the diesel generating system. One 5-MWe generator is required to support the heating/cooling loads for approximately 370,000 ft² of building area. Therefore, five 5-MWe diesel generator sets are required to serve the 1.85 million square foot community. Most of the waste heat is recovered from the exhaust gases in an exhaust gas boiler. However, some additional low-temperature heat is recovered from the diesel engine cooling water system. Pressurized hot water or low-temperature steam (350°F) is then used to provide hot water heating or is diverted to a two-stage absorption chiller unit for building air conditioning. A maximum of 22 MWe of power is generated as the system provides the heating and cooling for the 1.85 million square foot building complex. If a single-stage absorption chiller unit was used, then a maximum power of 38 MWe would be generated.

1.4.4 Coal-Fired Generating Station

Figure I-20 illustrates the coal-fired ICES system. The coal-fired generation plant generates electricity by a conventional steam turbine system. A coal-fired boiler generates steam that expands through one or several steam turbines in tandem, driving the electric generator. Extraction steam from the backpressure section of the turbines is used to provide the required energy for heating or cooling. The extraction steam (250 to 350°F) either condenses in the hot water heater, providing for building hot water heating, or condenses in an absorption chiller unit providing chilled water for building air conditioning. The coal-fired boiler also has the capability to burn oil instead of coal if necessary.

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FIGURE 1-20

**CITY OF INDEPENDENCE MO. GRID
CONNECTED INTEGRATED COMMUNITY
ENERGY SYSTEM**

**TYPICAL
EVALUATION MODEL**

**TO EVALUATE THE ADVANTAGE BOLD
SYSTEM PROVIDING ELECTRIC
GENERATION HEATING AND
COOLING CAPACITY**

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Four basic coal-fired boiler systems have been evaluated. They are described below.

1.4.4.1 2.5- to 5.0-MWe Coal-Fired Plant Operating on Demand for Heating Only (Cooling Provided by Electric Rankine-Cycle Chiller Machines)

The coal-fired boiler system operating on demand for heating only generates a maximum of 2.5 MWe of power for the 1.85 million square foot community and 4.4 MWe of power for the potential 3.4 million square foot community.

This coal system ICES plant has the best equivalent heat rate (4400 Btu/kW-hr) of any ICES plant and saves more energy than any other coal system. The cooling load is provided by electric Rankine-cycle machines. In order to provide for the most efficient energy savings operation, it is desirable to install two 2.5-MWe steam turbines to provide for the 1980 and 1990 thermal loads. These two steam turbines could be installed in tandem on a single shaft powering one electric generator or could each be separate power sources for separate electric generators.

1.4.4.2 6- to 10-MWe Coal Plant Operating on Demand for Heating and Cooling (One-Stage Absorption Cooling)

The coal-fired boiler system operating only on demand for heating or cooling (cooling provided by a single-stage absorption unit) generates the maximum amount of electricity during the maximum demand for waste heat. For the 1.85 million square foot community experiencing specified annual thermal loads, a maximum of 6.2 MWe and a minimum of 0.25 MWe of power is generated, delivering a net annual amount of 16.7×10^6 kW-hr and supplying 1.1×10^{11} Btu of cooling and 8.12×10^{10} Btu of heating. For the ultimate 3.4 million square foot community, a maximum of 10.3 and a minimum of 0.56 MWe of power is generated, delivering an annual amount of 38.0×10^6 and supplying 1.55×10^{11} Btu of cooling and 2.08×10^{11}

Btu of heating. This coal-fired system will require three 4-MWe turbines in tandem to provide the most efficient energy saving operations. Two turbines are required at first to support the 1980 thermal load, and the third turbine is required later for the 1990 loads. One boiler is sized to provide steam to all turbines. This system provides a moderate amount of electric power at a reasonably low heat rate of 8319 Btu/kW-hr.

1.4.4.3 2- to 3.2-MWe ICES Coal-Fired Plant Operating on Demand for Heating and Cooling (Cooling Provided by a Two-Stage Absorption Unit)

This system was evaluated to establish the merits of a two-stage absorption cooling unit over a single-stage absorption cooler when integrated with a coal-fired ICES plant. Because of the higher coefficient of performance (0.99) for a two-stage over a single-stage unit (COP = 0.6) and its operation on demand for heating and cooling, the maximum output electrical power is reduced from 6.15 (for a COP = 0.6) to 1.92 MWe (COP = 0.99), resulting in a drop in electricity generation from 16.7×10^6 to approximately 5.8×10^6 kW-hr.

The ICES plant with its two-stage absorption cooler has a better equivalent heat rate of 6895 Btu/kW-hr than the same system with a single-stage absorption. Because of the lower heat rate, less electricity is generated by this plant than by the single-stage absorption unit plant. There is a net increase of 1.1% in total energy consumption for this two-stage absorption cooling ICES plant over a single-stage absorption cooling ICES plant.

As mentioned, the maximum 1980 thermal load output power for this two-stage absorption plant is estimated to be 2 MWe, with a yearly average of 0.77 MWe. When exposed to the 1990 thermal loads, the maximum output power increases to 3.2 MWe. Again, the most efficient operating scheme to save energy is to install two 2-MWe steam turbines. The first turbine would function under the 1980

thermal loads and the second steam turbine would be installed later to serve the 1985 to 1990 thermal loads.

1.4.4.4 20-MWe Coal-Fired Boiler (Heating and Cooling Provided as Required)

Because it is desirable for larger electricity-generating stations to be constructed to provide for growth in future electricity demand or to replace retired generating plants of the same size, a base-loaded coal-fired boiler plant of 16 to 20 MWe, which also provides the necessary heating and cooling on demand, was evaluated. This coal-fired plant would have the capability to deliver approximately 20 MWe of power while supplying heating and cooling to the ICES community. Two 20-MWe coal-fired-boiler steam supply systems were considered: an 850-psi boiler and a 600-psi package boiler.

850-psi Boiler System

A field erected boiler delivering approximately 220,000 lb/hr of steam to a turbine generator at 800 psi and 900°F has been evaluated. Turbine extraction steam is utilized for condensate reheat and is also transmitted to central heating and cooling equipment to provide necessary energy to support community heating and cooling loads on demand. With a turbine capacity factor of 80%, the equivalent system net heat rate is estimated to be 11,880 Btu/kW-hr serving the 1980 community (1.85 million ft²). The system heat rate improves to a low value of 9730 Btu/kW-hr serving the estimated 1995 community (-4 million ft²). Energy saving over the conventional all-electric system at first is very modest, but significantly improves as the community size grows.

600-psi Package Boiler System

Because package boilers are commercially available in the 600-psi range, a 600-psi, 800°F boiler steam plant concept was evaluated to establish the need for further study and evaluation of higher temperature and pressure boiler systems. Results of the evaluation for this boiler system indicate that a 20-MWe 600-psi boiler base-load operation will not save energy in the near term, but it will save energy when the community increases beyond approximately 2.5 million square feet. Also, as discussed in sections that follow, the 20-MWe 600-psi boiler plant can be operated at capacity during peak power demand and then as an ICES plant at lower electrical output power to save energy. As discussed later and illustrated in Figure I-21, the 20-MWe coal-fired package boiler will save energy when the heating and cooling loads have increased to demands larger than associated with a 2.5 million square foot community. Thus, in 1985 when the projected thermal loads are associated with a community size of over 3 million square feet, energy will be conserved. At the present 1.17 and, 1980, 1.85 million square foot thermal loads, energy will be saved when the output power is reduced to less than 10 MWe.

In order to provide for a 20-MWe capacity coal plant to serve peak electrical demand functions (which may occur only 10% of the time) and the balance of the time serve as an energy-saving ICES plant, the steam turbine must be capable of operating at various electrical loads without any loss in thermodynamic performance from the 20-MWe design case. To approach this flexibility two 10-MWe or four 5-MWe steam turbines in tandem on the same shaft could be used to power one electric generator. As illustrated on Figure I-21 for the 1.85 million square foot community size, operating at a yearly average output power of less than 10 MWe will save energy compared to what would be consumed by the present city power generation grid. If this plant is to save energy compared to what would be consumed by one of the other alternative modern electricity generating station options, then the yearly average electrical

FIGURE I-21
AVERAGE OUTPUT P_W R vs HEAT RATE

output of less than 6 MWe is required supplying the same heating and cooling load. The output power becomes more significant when the community size grows to 3.4 million square feet. For this size the heating and cooling loads are sufficiently large to allow the yearly average output power to increase to about 18 MWe and still save energy over the present electricity-generating system. This average output power should be lowered to less than 14 MWe to save energy over an alternative modern electricity-generating station.

1.5 INTEGRATED ENERGY SYSTEM PERFORMANCE

Figure I-22 illustrates the net energy consumption by the various energy systems to provide heating and cooling for the 1.85 million square foot Demonstration Community complex. Figure I-21 illustrates the ICES plant heat rate vs. average net electrical output power for coal-fired ICES power plants. Table I-4 shows energy consumption data and the effective heat rates for each system. The effective heat rate is defined as the quotient of the total annual energy supplied by the fuel (Btu) divided by the sum of the annual electric kilowatt-hours generated plus an equivalent amount of electric energy (kW-hr) required to provide the same amount of heating and cooling as is supplied by the ICES plants.

1.5.1 Energy Consumption

Figure I-22 and Table I-4 show that the ICES system possessing the greatest energy savings characteristics over the all-electric reference case is the fuel-oil diesel generator system. At the other end of the scale, the 20-MWe coal-fired 850-psi boiler ICES plant generating electricity continuously has a modest energy saving in 1980 that improves steadily with community growth. The rankings of each system based on energy saving are listed in Table I-5.

NOTE: COMMUNITY SIZE = 1.85×10^6 FT²

- 1 ALL ELECTRIC SYSTEM
- 2 2-5 MW_e COAL ICES OPERATING ON DEMAND FOR HEATING ONLY
- 3 6-10 MW_e COAL ICES OPERATING ON DEMAND FOR HEATING AND COOLING (SINGLE STAGE ABSORPTION)
- 4 2-3.2 MW_e COAL ICES OPERATING ON DEMAND FOR HEATING AND COOLING (2-STAGE ABSORPTION)
- 5 20 MW_e COAL FIRED 600-PSI BOILER SUPPLYING HEATING AND COOLING AS REQUIRED
- 6 20 MW_e COAL FIRED 850-PSI BOILER SUPPLYING HEATING AND COOLING AS REQUIRED
- 7 FUEL OIL GAS TURBINE ICES
- 8 DIESEL GENERATOR ICES

FIGURE I-22

NET ENERGY CONSUMPTION FOR ICES PLANTS

TABLE I-4

**ENERGY CONSUMPTION AND HEAT RATE ANALYSIS
1980 LOADINGS**

	System	Energy Consumption (EC)	Equivalent Heat Rate
1	All electric heating and cooling	3.82×10^{11} Btu/yr	12,000 Btu/kW-hr
2	2.5-MWe coal-fired boiler operating on demand for heat only (cooling provided by electric Rankine cycle coolers)	1.272×10^{11} Btu consumed by ICES plant plus 3.8×10^{10} Btu from electric generating plant Total EC = 1.65×10^{11} Btu Energy savings = 2.17×10^{11} Btu/yr	ICES plant heat rate = 4432 Btu/kW-hr*
3	6.2-MWe coal-fired boiler operating on demand for heating and cooling (cooling provided by single-stage absorption unit)	3.91×10^{11} Btu at ICES plant consumed 1.92×10^{11} Btu saved by excess electricity generated Total EC = 2.90×10^{11} Btu Energy savings = 1.82×10^{11} Btu/yr	ICES plant heat rate = 8163 Btu/kW-hr*
4	2-MWe coal-fired boiler operating on demand for heating and cooling (cooling provided by two-stage absorption unit)	2.59×10^{11} Btu consumed by ICES plant 7.18×10^{10} Btu saved by electricity generated Total EC = 1.87×10^{11} Btu Energy savings = 1.95×10^{11} Btu/yr	ICES plant heat rate = 6836 Btu/kW-hr*

TABLE I-4 (Continued)

	System	Energy Consumption (EC)	Equivalent Heat Rate
5	20-MWe coal-fired 600-psl boiler continuously generating electricity and supplying heating and cooling as required (cooling provided by two-stage absorption)	24.24×10^{11} Btu consumed by 20-MWe plant 17.1×10^{11} Btu saved by electricity generated Total EC = 7.12×10^{11} Btu Energy loss = 3.3×10^{11} Btu/yr	Heat rate = 13,900 Btu/kW-hr
6	20-MWe coal-fired 600-psl boiler continuously generating electricity and supplying heating and cooling as required (cooling provided by single-stage absorption)	24.36×10^{11} Btu consumed by 20-MWe plant 17.1×10^{11} Btu saved by excess electricity generated Net total EC = 6.92×10^{11} Btu Net energy loss = 3.1×10^{11} Btu	Heat rate = 13,760 Btu/kW-hr*
7	20-MWe coal-fired 850-psl boiler continuously generating electricity and supplying heating and cooling	203×10^{11} Btu consumed 16.7×10^{11} Btu saved by excess electricity generated Net EC = 3.6×10^{11} Btu Net energy saved = 0.22×10^{11} Btu	11,880 Btu/kW-hr
8	Fuel oil gas turbine ICES	4.85×10^{11} Btu consumed by ICES plant 3.38×10^{11} Btu saved by excess electricity generated Net EC = 1.47×10^{11} Btu Net energy savings = 2.35×10^{11} Btu	Heat rate = 8069 Btu/kW-hr

TABLE I-4 (Continued)

System	Energy Consumption (EC)	Equivalent Heat Rate
9 Diesel generator system	6.14×10^{11} Btu consumed by ICRS plant 7.48×10^{11} Btu saved by excess electricity generated Net EC = -1.34×10^{11} Btu Net energy savings = 5.18×10^{11} Btu	Heat rate = 6511 Btu/kW-hr

TABLE I-5
RANKINGS BASED ON ENERGY SAVING - 1980

<u>Ranking</u>	<u>System</u>	<u>Energy Saved</u> <u>(Btu x 10¹¹/year)</u>
1	22-MWe diesel generator system	5.15
2	7.5-MWe fuel oil gas turbine system	2.35
3	3-MWe coal-fired package boiler operating on demand for heating only (cooling provided by electric machines)	2.17
4	2-MWe coal-fired package boiler operating on demand for heating and cooling (cooling provided by two-stage absorption).	1.95
5	7-MWe coal-fired package boiler operating on demand for heating and cooling (cooling provided by single-stage absorption)	
6	Up to 10-MWe coal-fired package boiler plant	Some energy saved
7	10- to 20 MWe-coal-fired package boiler plant generating electricity continuously and supplying additional heating and cooling as required	0.22
8	20-MWe, 600-psi, 800°F, coal-fired boiler plant generating electricity continuously and supplying additional heating and cooling as required	-3.3 (loss)

1.5.1.1 All-Electric System (Reference Energy System)

The thermal loads imposed on the 1.85 million square foot building complex have been estimated on an annual basis. The total annual cooling requirements are approximately 11.0×10^{10} Btu of heat removal, and the heating requirements are approximately 8.12×10^{10} Btu of heat supply. Based on the conventional all-electric system, these annual cooling and heating requirements convert to an approximate electrical demand of 8.06×10^6 kW-hr for cooling and 23.8×10^6 kW-hr for heating. The resulting thermal demand totals approximately 3.82×10^{11} Btu of input fuel energy, sufficient to generate 31.9×10^6 kW-hr of electricity annually for a generating plant (system) with a heat rate of 12,000 Btu/kW-hr (12,000 Btu/kW-hr is the current average heat rate for the City of Independence, Missouri, power grid).

1.5.1.2 2.5- to 5-MWe Coal-Fired Boiler (ICES) Operating on Demand for Heating Only (Cooling Provided by Electric Rankine Cycle Chillers)

The coal-fired ICES system that consumes the least energy is a coal-fired boiler system operating on demand for heating only, with the cooling load provided by electric Rankine cycle chillers. Based on a 1.85 million square foot community size in 1980, this system would consume 2.2×10^{11} Btu/yr. The annual coal consumption predicted is 1.27×10^{11} Btu. The cooling demand for electricity of 8.06×10^6 kW-hr exceeds the ICES generated net supply of 5.2×10^6 kW-hr, resulting in a net electric power deficit of 2.8×10^6 kW-hr, to be supplied by conventional power generating stations. Therefore, an additional 0.38×10^{11} Btu (based on 12,000 Btu/kW-hr generating station) is required to generate additional electricity, bringing the net total energy consumption to 1.65×10^{11} Btu, which is 57% less than that consumed by the all-electric system. This ICES plant has an estimated equivalent heat rate of 4730 Btu/kW-hr.

The electric power generated by this system fluctuates with the demand for heating. The 1980 and 1990 thermal heating loads result in an estimated maximum gross power generation of 2.42 and 3.5 MWe, respectively.

1.5.1.3 6- to 10-MWe Coal-Fired Boiler (ICES) Operating on Demand for Heating and Cooling (Cooling Provided by Single-Stage Absorption)

When cooling is added to the function of the coal-fired ICES plant, the net energy savings decrease. For a coal-fired-boiler ICES system operating on demand for heating and cooling (cooling provided by a single-stage absorption unit), the annual net energy saving is 47% over the all-electric system. For the 1980 community size, this ICES plant system possesses an equivalent heat rate of approximately 8160 Btu/kW-hr, generates a surplus of 16.1×10^6 kW-hr, and has a maximum gross power output of 6.13 MWe, which occurs during the maximum cooling load of 55.5×10^6 Btu/hr. The minimum gross power output is predicted to be 0.25 MWe. (For the 1990 thermal loads the heat rate is reduced to approximately 7200 Btu/kW-hr, 28.0×10^6 kW-hr are generated, 10.3 MWe maximum to 0.56 MWe minimum gross output power.)

1.5.1.4 2- to 3-MWe Coal-Fired Boiler ICES Operating on Demand for Heating and Cooling (Cooling Provided by Two-Stage Absorption Unit)

When a higher efficiency two-stage absorption unit (coefficient of performance = 1.0) is utilized instead of the single-stage absorption chiller unit (coefficient of performance = 0.6), the system achieves a better heat rate (6719 Btu/kW-hr), but the net generation of electricity is lower, 5.6×10^6 kW-hr. The annual energy savings over the all-electric reference case is 51%.

For this plant, the maximum gross power output is 1.92 MWe and occurs at the highest cooling load of 55.5×10^6 Btu/hr. The

minimum power output is predicted to be 0.11 MWe. (For the 1990 thermal loads the maximum gross power output is approximately 3.2 MWe.)

1.5.1.5 20-MWe Coal-Fired 600-psi Package Boiler Plant
Continuously Generating Electricity (Cooling Provided
by Two-Stage Absorption)

The 20-MWe coal-fired 600-psi package boiler plant running continuously supplies base load electricity and heating and cooling to the community as required. Due to the combination of system costs and practicality, steam package boiler supply conditions of 800°F, 600-psi steam were used to evaluate the overall cycle (for comparison, large coal-fired stations generate steam at 1200°F and 1000 psi). The effect of supplying steam at the assumed conditions is an electric generation heat rate higher than what can normally be achieved by a modern fossil fuel generating station (approximately 13,500 Btu/kW-hr vs. 10,200 Btu/kW-hr). The equivalent heat rate for a base-loaded 20-MWe, 600-psi, 800°F package boiler coal-fired plant providing the additional heating and cooling (cooling by two-stage absorption) required for a 1.85 million square foot community is approximately 13,900 Btu/kW-hr. Therefore, a net energy loss will be incurred over the present all-electric system. (Net fuel consumption = 5.16×10^{11} Btu/yr; net electricity generated = 145×10^6 kW-hr.)

The heat rate for this system, which is similar to a cogeneration system, can be improved by increasing the percentage of the heating and cooling load provided by the coal-fired boiler system. To increase the percentage of heating and cooling, the output power should be reduced. Figure I-21 shows how this system heat rate improves (i.e., decreases) as the design output power is decreased. As shown, with a maximum net output power less than 9 MWe (10 MWe gross), the equivalent heat rate is less than 12,000 Btu/kW-hr and therefore a base-loaded coal-fired cogeneration plant with a net

design capacity of less than 9 MWe will save energy in providing heating and cooling for a 1.85 million square foot community.

Figure I-21 also shows that, as the community size grows to a maximum of about 3.4 million square feet, the net average output power can be increased while still maintaining a heat rate of less than 12,000 Btu/kW-hr.

1.5.1.6 20-MWe Coal-Fired 600-psi Package Boiler Plant Continuously Generating Electricity and Providing Heating and Cooling as Required (Cooling Provided by a Single-Stage Absorption Cooler)

As part of the evaluation to compare single-stage and two-stage absorption cooling, a 20-MWe base load coal-fired plant providing heating and cooling with a two-stage absorption cooler was evaluated. As shown in Figure I-21, at the same average output power the single-stage absorption cooler power plant possesses a slightly lower heat rate than for the two-stage absorption cooling 20-MWe plant. This 20-MWe single-stage absorption plant results in a net energy consumption of approximately 6.92×10^{11} Btu/yr (81% increase in energy consumption over the all-electric system). It has an equivalent heat rate of approximately 13,760 Btu/kW-hr. It supplies 16 to 20-MWe of power and is estimated to generate 146×10^6 kW-hr of electricity annually.

1.5.1.7 20-MWe Coal-Fired 850-psi Boiler Plant Continuously Generating Electricity and Providing Heating and Cooling

The results obtained using a 600-psi package boiler indicate the need for a higher pressure and temperature boiler to obtain a system heat rate lower than that of the present all-electric system to save energy. Therefore, a coal-fired boiler supplying steam at 850 psi and 900°F was evaluated. Results indicate that this system will have an equivalent heat rate of about 11,880 Btu/kW-hr and save 0.22×10^{11} Btu/yr, 5.7% less than for the

all-electric system in 1980. In 1990, serving 3.4 million square feet, the equivalent heat rate is expected to be reduced to 10,350 Btu, resulting in an annual energy savings of 45% over the all-electric system.

Energy savings occur when the equivalent heat rate for the ICES is less than 12,000 Btu/kW-hr. The equivalent heat rate for this 20-MWe system is sensitive to the turbine capacity factor, community size and actual thermal loadings. Figure I-23 illustrates the equivalent heat rate as a function of community size for a turbine capacity factor of 80%. Also shown is the effect on equivalent heat rate performance if the actual thermal loads are 70% of the expected thermal loads.

The annual energy consumption by this 20-MWe system is compared with the all-electric system in Figure I-24 and I-25 as a function of community size for the expected thermal loads, and for 70% of the expected thermal loads, respectively. From these curves it can be concluded that even if the actual thermal loads are only 70% of the expected loads (due to improved thermal insulation designs and energy conservation practices), energy will be saved when the community grows to beyond 2.3 million square feet.

1.5.1.8 Fuel Oil Gas Turbine ICES Plant

A fuel oil gas turbine ICES plant operates on demand for heating and cooling. The net energy consumption is estimated to be 1.4×10^{11} Btu/yr, a 61% savings in energy consumption over the reference all-electric system. This ICES plant has an equivalent heat rate of approximately 8069 Btu/kW-hr. The plant gross output electrical power fluctuates between 1.8 and 7.6 MWe as the building thermal loads vary throughout the year and supplies an estimated 28.0×10^6 kW-hr of net electricity.

FIGURE I-23

HEAT RATE VS COMMUNITY SIZE
(CF = 80%)

FIGURE I-24
ENERGY CONSUMPTION VS COMMUNITY SIZE
EXPECTED THERMAL LOADS

FIGURE I-25

ENERGY CONSUMPTION VS COMMUNITY SIZE
(70% OF EXPECTED THERMAL LOADS)

1.5.1.9 Diesel Generator ICES Plant

The diesel generator ICES plant consumes the least amount of energy of all the systems. Because the electrical generation efficiency is exceptionally good (36-40% thermal to electrical conversion) the amount of waste heat recovery for building heating and cooling is smaller than the available exhaust heat in the gas turbine system. Consequently, when the diesel generator system is run on demand for heating and cooling, a considerable amount of electricity is generated at an electrical heat rate (9400 Btu/kW-hr) considerably lower than the present conventional electric system (12,000 Btu/kW-hr. As a result there is a net energy savings of 5.2×10^{11} Btu/yr, which represents a 136% savings in energy consumption over an all-electric system. When the electrical equivalent of the thermal loads is added to the kilowatt-hours generated, the equivalent heat rate for the diesel generator ICES plant is estimated to be 6511 Btu/kW-hr.

The gross power from this ICES system will fluctuate from a maximum of 22.8 MWe to a minimum of about 0.82 MWe as the thermal loads vary through the year. The electricity generated is estimated to be 62.7×10^6 kW-hr net. The cooling is provided by a two-stage absorption unit.

1.5.2 Fuel Costs

Table I-6 summarizes the estimated fuel costs for the various systems. Since fuel costs are proportional to heat rate, it follows that the system with the lowest heat rate utilizing the same fuel will also possess the lowest fuel cost. As shown, the system with the lowest fuel cost (4.6 mills/kW-hr) is the coal-fired ICES Plant operating on demand for heating only. The highest fuel cost system is the fuel oil-gas turbine ICES plant with a fuel cost of 22.7 mills/kW-hr.

TABLE I-6. FUEL COST^a

Case	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)	Total Supply Cost (Fuel + Generation)
1	Present electrical generation system, 12,000 Btu/kW-hr heat rate. Fuel is coal, 12,000 Btu/lb.	12.6	No further investment	-	-	9 mills/kW-hr	21.6 mills/kW-hr
1a	Additional electric generation option to purchase 78-MWe from Kansas City Power & Light ^{c,d}						
	a. 42-MWe IRTAN	12.5	39	\$3.34 million/yr (8.16 mills/kW-hr)	\$1.95 million/yr (4.8 mills/kW-hr)	13.0 mills/kW-hr	25.0 mills/kW-hr
	b. 136-MWe Wolf Creek	11.0					
1b	Purchase a 42-MWe coal-fired plant from Missouri City Power & Light ^{c,d}	11.0	12.4	1.4 million/yr (8.64 mills/kW-hr)	1.4 million/yr 6.4 mills/kW-hr	15.2 mills/kW-hr	27.0 mills/kW-hr
2	2.5- to 5-MWe coal-fired ICES plant operating on demand for heating only (cooling provided by electric Rankine machines) ^e	6.6	4	0.342 million/yr (11.6 mills/kW-hr ^a)	0.30 million/yr (10.1 mills/kW-hr)	21.7 mills/kW-hr ^a	26.3 mills/kW-hr ^a
3	6- to 10-MWe coal-fired boiler operating on demand for heating only (cooling provided by single- stage absorption) ^e	0.56	10	0.056 million/yr (17.8 mills/kW-hr ^a)	0.40 million/yr (8.3 mills/kW-hr ^a)	26.1 mills/kW-hr ^a	34.4 mills/kW-hr ^a
4	1 to 3.2 MWe. Same as Case 3, except two-stage absorption cooling ^e	7.2	5.4	0.462 million/yr (12.2 mills/kW-hr)	0.35 million/yr (9.1 mills/kW-hr ^a)	21.3 mills/kW-hr ^a	28.5 mills/kW-hr ^a
5	20-MWe (intermediate boiler coal plant supplying heating and cool- ing on demand (two-stage absorp- tion cooling)) ^e	14.4	20	2.4 million/yr (12.5 mills/kW-hr ^a)	1.4 million/yr (8.6 mills/kW-hr ^a)	21.1 mills/kW-hr ^a	28.5 mills/kW-hr
5b	20-MWe (high-pressure boiler) coal plant providing heating and cooling	12.0	28	2.4 million/yr (12.5 mills/kW-hr ^a)	1.4 million/yr (8.6 mills/kW-hr ^a)	21.1 mills/kW-hr ^a	33.1 mills/kW-hr
6	Fuel oil gas turbine ^e	23.0	65	0.556 million/yr (9.3 mills/kW-hr ^a)	0.28 million/yr (4.7 mills/kW-hr ^a)	14.0 mills/kW-hr ^a	37.0 mills/kW-hr
7	Diesel generator system ^e	19.3	14.0	1.20 million/yr (12.8 mills/kW-hr)	0.475 million/yr (5.0 mills/kW-hr ^a)	17.8 mills/kW-hr ^a	37.1 mills/kW-hr

a. "kW-hr^a" 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. These fuel costs are based on discussions with Burns & McDonnell regarding their power supply study for the City of Independence, Missouri, received April 6, 1977.

d. Capacity factor = 0.6.

e. Capacity factor = 1.0.

f. Capacity factor = 0.91 for electricity generation and 1.0 for heating and cooling.

The system fuel costs based on the 1.85 million square foot thermal loadings are 12,000 Btu/lb coal at a cost of \$25 per ton, and fuel oil at a cost of approximately \$0.38/gal or \$2.96 per million Btu. These are current 1977 prices.

All of the coal-fired ICES plants operating on demand for heating and cooling have significantly lower fuel costs than do the lowest cost alternative generation options (i.e., 11 mills/kW-hr). The fuel cost for the 20-MWe high pressure boiler system (12.5 mills/kW-hr) is predicted to be less than that for the present all-electric system (i.e., 12.6 mills/kW-hr).

The ranking of the systems from a fuel cost perspective based on 1977 prices is given in Table I-7.

1.5.3 System Initial Capital, Operating, and Total Supply Costs

Table I-6 also summarizes the estimated capital and operating cost for the various systems evaluated. In determining these costs, it was assumed that the initial capital is obtained by issuance of 7% tax-free bonds for a 25-year term. The yearly generation cost is the sum of the annual capital cost and the operating costs (exclusive of fuel cost). These costs (i.e., annual capital and operating costs) are divided by the total equivalent kilowatt hours produced (i.e., electricity generated plus the electrical equivalent of the heating and cooling thermal loads) to obtain the costs in mills/kW-hr.

The total supply cost in mills/kW-hr is obtained by adding the generating cost to the fuel costs (all expressed in mills/kW-hr). The present generation system delivers energy at the lowest possible supply cost, 21.6 mills/kW-hr. On the other end, fuel oil gas turbine and diesel generator systems show the highest supply cost. Table I-8 ranks the various systems based on minimum supply costs.

TABLE I-7

FUEL COST RANKING OF SYSTEMS
(based on 1977 prices)

<u>Ranking</u>	<u>System</u>	<u>Fuel Cost</u> (mills/kW-hr)
1	2.5- to 5-MWe coal-fired ICES operating on demand for heating only	4.6
2	2- to 3.2-MWe coal-fired ICES operating on demand for heating and cooling (cooling provided by a two-stage absorption cooler)	7.2
3	6- to 10-MWe coal-fired ICES operating on demand for heating and cooling (cooling provided by a single-step absorption chiller)	8.56
4	Purchase additional capacity to supply all-electric heating/cooling system from Kansas City Power & Light	11-12.5
5*	Build 20-MWe coal plant with high-pressure boiler providing heat and cooling as required	12.0
6	Provide additional electricity for all-electric heating and cooling system by the existing City power generation system	12.6
7	Build a 20-MWe-capacity 600-psi boiler plant supplying heating and cooling as required	14.4

*Recommended ICES System

TABLE 1-7 (Continued)

<u>Ranking</u>	<u>System</u>	<u>Fuel Cost</u> <u>(mills/kW-hr)</u>
8	22-MWe diesel generator system operating on demand for heating and cooling	19.3
9	7.5-MWe fuel oil and gas turbine operating on demand for heating and cooling	23.8

TABLE I-8
SYSTEM RANK AS A FUNCTION OF SUPPLY COST

<u>1977</u> <u>Rank</u>	<u>1990</u> <u>Rank</u>	<u>System</u>	<u>Supply Cost (mills/kW-hr)</u>	
			<u>1977</u>	<u>1990</u>
1	5	Present all-electric system	21.6	45
2	7	Purchase additional electric generation from Kansas Power & Light	25.0	unknown
3	1	2- to 5-MWe coal-fired ICES operating on demand for heat only	26.3	25.0
4	8	Purchase 42-MWe coal-fired plant from Missouri City Power & Light	27.0	53.4
5	2	2- to 3.2-MWe coal-fired ICES operating on demand for heating and cooling (two-stage absorption)	28.5	32.7
6	4	20-MWe coal-fired light-pressure boiler supplying heating and cooling as required*	33.1	44.3
7	3	6-10 MWe coal-fired ICES operating on demand for heating and cooling	34.6	37.2

*Recommended ICES System

TABLE I-8 (Continued)

<u>1977</u> <u>Rank</u>	<u>1990</u> <u>Rank</u>	<u>System</u>	<u>Supply Cost (mills/kW-hr)</u>	
			<u>1977</u>	<u>1990</u>
8	6	20-MWe (600-psi) coal-fired boiler system	35.5	47.5
9	10	Diesel generator ICES system	37.1	63.3
10	9	Fuel oil gas turbine ICES system	37.8	62.2

The ranking in Table I-8 is based on current fuel prices and estimates of future fuel costs. As noted, this ranking will change as the price of fuel increases and as the thermal loading increases from the 1.85 million square feet in 1980 to 3.4 million square feet in 1990. The predicted 1990 ranking is also shown in Table I-8. The 1990 supply costs are estimated on a 7% annual increase in fuel and operation cost and a fixed capital cost. These costs are diluted by the increase in demand for thermal heating and cooling. For the various coal fired ICES plants considered, 1990 supply costs compare favorably to all other systems, including the present all-electric system. Beyond 1990, for the duration of the projected 25-year life of an ICES facility, comparative supply costs continue to improve.

1.6 CONCLUSIONS AND SYSTEM SELECTION

1.6.1 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 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.

1.6.2 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 provide 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

2.0 INTRODUCTION

The primary purpose of this section is to present the results of an analysis of the impact of State and local statutes, codes, and regulations on the ICES project. Important sources that have been evaluated are the City charter, building codes, fire codes, OSHA regulations, Missouri constitutional provisions, Missouri and City statutes, Utility Commission regulations, electricity rate regulations, flood plain regulations, and City bonding documents. Copies of appropriate sections of these codes, statutes, and regulations are contained in Appendix C.

Based upon the preliminary assessment of institutional factors, the City's Law Department foresees no legal problems which would jeopardize the successful completion of the ICES project. In many respects the ICES project is quite similar to other projects that are carried out as part of the City's normal business routine.

Similarly, the City staff does not anticipate any adverse reaction to the ICES project by the community. It is expected that the citizens of Independence will respond favorably to the project due to its emphasis on energy conservation.

2.1 REGULATIONS, STATUTES, AND CODES

Copies of appropriate sections of the most important regulations, statutes, codes, etc., are contained in Appendix C. Due to the number and length of many of the regulations, statutes, codes, etc., which may have an impact on the ICES project, it was deemed inappropriate to include them all in Appendix C.

The City of Independence, as prime contractor for the ICES project and future owner and operator of the facilities to be constructed

as part of that project, has the authority to proceed with subsequent phases of said project as provided by the City Charter and Article VI of the Missouri Constitution of 1945 and Section 70.220 of the Revised Statutes of Missouri.

Specifically, the City may receive and expend Federal, State, and local funds; enter into contracts; levy taxes; issue bonds; incur indebtedness; establish utility rates; exercise the power of eminent domain; furnish all public services; and hold and own property. These broad powers ensure that the City has the necessary authority and control to fulfill the requirements of all phases of the ICES project.

Subsequent sections discuss applicable regulations, statutes, and codes. Section 2.4 contains a summary of the legal aspects of the ICES project that was prepared by the Law Department of the City of Independence.

2.1.1 City Charter

The City Charter contains the rules and regulations by which the City operates.

The following comments and observations pertain to specific sections of the City Charter which provide the authority for the City of Independence to act in matters related to the design, construction, and operation of an Integrated Community Energy System. During the review of the City Charter, no conflicts were identified that would prohibit or seriously restrain the City with respect to its participation in, or completion of, the ICES project.

Article 1

Section 1.3 of Article 1 states that the City is granted self-government and home rule. The powers related to that status are established by the Constitution and Statutes of Missouri (Appendix C).

Section 1.4 is more specific in enumerating basic powers. The City may incur indebtedness, issue bonds upon the credit of the City, issue revenue bonds based upon the credit of income derived from property used in connection with any public utility, accept Federal grants, exercise the power of eminent domain, furnish all public services, establish electric rates, and provide protection against floods.

Article 2

Section 2.10 of Article 2 enumerates the powers of the City Council. The Council has the power to adopt a budget, make appropriations, and regulate fiscal affairs.

Article 3

Two areas may be of interest in this article. These are the sections dealing with the City Manager's responsibilities and the public utilities. The City Manager is responsible for supervising and controlling all administrative departments, advising the City Council of financial conditions, and alerting the City Council to the future needs of the City.

The Electric Utility Department shall operate the electric utility and other public utilities, enterprises, and services. The Electric Utility Department shall be operated from funds separate from the general fund and shall not be used directly or indirectly as a general revenue-producing agency for the City.

Article 8

A balanced budget must be submitted to the City Council for adoption forty-five (45) days before the beginning of the fiscal year. In anticipation of revenues, the Council may authorize the borrowing of money by the issuance of notes. This loan may not exceed 75 percent of the estimated revenue of the fund for the year still outstanding.

Article 10

The City may incur indebtedness and issue bonds as authorized by the State Constitution and City Charter. Bonds may be issued upon the credit of income derived from any public utility or other revenue-producing enterprise or service owned or operated by the City. Prior to the passage of any ordinance submitted to the electors of the City for any bond proposal, the Director of Finance shall prepare a debt Statement on the financial condition of the City.

Article 11

The City has the power to make public improvements. All public improvements will be accomplished by the City or by contract. Public improvements may be paid for by special assessments upon benefited real property. The procedure for special assessment projects and special tax bills are covered in this article.

Condemnation proceedings will be exercised in accordance with the general provisions of State law.

Article 12

The Planning Commission recommends to the Council a master plan for physical development of the City; recommends regulations governing land development; recommends approval or disapproval of

plats; recommends a City zoning plan; submits a capital improvement plan; and recommends zoning approvals or disapprovals. The City Council has the responsibility to make decisions on all the Planning Commission recommendations. The Planning Director shall be the chief planning officer of the City and the principal technical adviser of the City Manager and Planning Commission.

Summary

The above articles clearly demonstrate the City's authority to undertake all phases of the ICES project. Ownership and operation of the ICE system will be vested in the City. Financing of the City's portion of the costs is planned to be accomplished through the sale of revenue bonds. Authority to issue bonds in the amount necessary for the ICES project has already been approved.

2.1.2 City Code

The following discussion is based upon a review of applicable sections of the City Code, which is a compilation of the ordinances and resolution passed by the City Council. The ICES project presents no conflicts with the City Codes related to facility construction, fire regulations, environmental control, or zoning.

2.1.2.1 Building Code

The City of Independence has adopted the following nationally recognized building codes related to structures and enforced by the City's Building Official:

1. Uniform Building Code, 1973 Edition, Article 5, Building Code, Section 4.500
2. Uniform Housing Code, 1976 Edition, Article 1, Housing Code, Section 4.01.001

3. Uniform Plumbing Code, 1976 Edition, Article 4, Plumbing Code, Section 4.04.001
4. Uniform Mechanical Code, 1973 Edition, Article 6, Heating, Ventilating, Cooling and Refrigeration Code, Section 4.06.001
5. National Electrical Code, 1975 Edition, Article 7, Electrical Code, Section 4.07.001

Copies of the above codes are available in the office of the City's Building Official and in libraries, or may be purchased from the International Conference of Building Officials.

Amendments to the above building codes adopted by the City relate primarily to administrative matters, including permit applications, permit fees, certain definitions, and required inspections. Two amendments of importance to the Integrated Community Energy System are the following:

1. Article 4, Section 301, Application for Building Permits, Exception 2:

A permit shall not be required for the construction, removal, modification, alteration, maintenance, repair or operation of public utility transmission and distribution facilities used by such utilities duly franchised or authorized as such in the City.

2. Article 4, Section 2314, Earthquake Regulations:

For purposes of this code, the City shall be considered to be in a zone 0 - no damage area.

2.1.2.2 Fire Code

The Uniform Fire Code, 1976 Edition, as published by the International Conference of Building Officials and the Western Fire Chiefs Association, has been adopted as the fire code for the City of Independence for the control and regulation of conditions hazardous to life and property from fire and explosion. The standards in the fire code have been reviewed, and there are no provisions that would prevent the construction and operation of the ICES facility. All of the standards are policies that the City follows. Examples of regulations that would be considered during the design phase are:

- o Prevention of dust explosions
- o Fire protection systems
- o Storage of flammable and combustible materials.

2.1.2.3 Environmental Control Code

Chapter 7 of the City Code deals primarily with the protection of the natural environment. Article 5, the Air Pollution Control Code, contains the majority of the regulations and restrictions pertinent to the ICES project. The following sections and subsections are particularly noteworthy:

Section 7.390 - Restrictions of Particulate Matter

- B. Maximum allowable emission of particulate matter from fuel burning
- C. Preventing particulate matter from becoming airborne

Section 7.400 - Restrictions of Emissions of Visible Air Contaminants

- B. Restrictions applicable to new installations
- C. Exceptions

Section 7.410 - Restriction of Emission Odors

Section 7.430 - Emission of Sulfur Compounds

Section 7.450 - Review of New Sources

Portions of the City Code pertinent to environmental control are contained in Appendix C.

Several Federal guidelines and regulations have been published governing the preparation of environmental impact statements, assessments, and negative declarations. As a result of other City projects, the City staff is generally familiar with the provisions thereof.

Chapter III of the Federal Register, Volume 42, Number 17 (January 26, 1977) was provided to the City by the ERDA/ICES Project Manager. A review of this document has been completed.

Section 2.5 of this report contains a further discussion of environmental factors as they specifically relate to the ICES project.

2.1.2.4 Flood Plain Management

The provisions for any construction, buildings or otherwise, in a 100-year flood plain are set forth in the National Flood Insurance Act of 1968 and City Resolution 403. The latter document, adopted in 1970, qualified the City for flood insurance as provided by the National Flood Insurance Act.

It is quite likely that a portion of the ICES power generation plant will lie in the 100-year flood plain that runs through the Demonstration Community in the vicinity of the Illinois, Central & Gulf Railroad. A review of the above-mentioned documents suggests that no major technical or legal problems will be involved, should construction in the flood plain be necessary.

The adoption of further flood plain legislation by the City is being held in abeyance, pending receipt of a flood study from the office of Flood Insurance Administration. This legislation will include zoning and land-use ordinances required for effective flood plain management.

2.1.3 Utility Regulations

The City Charter, Article 3, establishes the authority for the Independence City Council to regulate public utilities. Regulation and control of the Independence Power and Light Department are now accomplished by the City itself. The State of Missouri has no regulations that apply to municipally owned facilities. The Federal Power Commission regulates interstate power transmission (the ICES project will not involve interstate power transmission).

Restriction on the use of natural gas is the only Federal regulation that has impacted the production of power in Independence. Independence is presently in a category 8 priority zone (the lowest category) for the use and distribution of natural gas.

Legislation now being proposed will be even more restrictive regarding the use of natural gas. It has been determined that in the future the use of natural gas for power production will be prohibited. This was a major factor in the City's selection of its candidate ICE system.

Section 3.14 of the City Charter specifically states that the City Council, by ordinance, may direct the Electric Utility Department to operate other public utilities. The rates for such other utilities will be established by the City Council upon the recommendation of the Electric Utility Director or his designated representative (Section 16.05.002, City Code).

In the case of the ICES facility it is planned that the rates for hot and chilled water will be established late in Phase II, following an economic evaluation of the capital, operating, and maintenance costs for the ICES facility.

2.1.4 Occupational Safety and Health Regulations

The State of Missouri at present does not have an approved plan meeting Occupational Safety and Health Administration (OSHA) requirements. As such, Federal regulations prevail in the State. Since the Federal law excludes public employees, OSHA does not have jurisdiction over City employees, including employees of the City utility company, which is a City department.

If the City were to contract with a private company for the design, construction, and/or operation of the Integrated Community Energy System, then that company would be responsible for the safety of its employees and would be subject to the requirements of the Occupational Safety and Health Act.

Although no legal requirement currently exists for the City to comply with OSHA regulations, the City has great concern for the safety and well-being of its employees and as such takes all available standards, including those of OSHA, into consideration.

2.1.5 Personnel and Union Regulations

The City staff of over 900 is comprised of both union and non-union members. Additionally, the City routinely contracts with firms whose employees are represented by various labor organizations. Accordingly, the City is experienced with all Federal, State, and local regulations associated with personnel practices, both union and nonunion.

Personnel policies for both City and contractor employees are covered by one or more of the following: City Charter (Section 3),

Personnel Board procedures, union or other contractual agreements, and the City's Affirmative Action Plan. Grievance proceedings are handled by the City's Personnel Department and the Personnel Board. The latter is appointed by the City Council as provided by the City Charter.

The only potential impact that the City's Personnel Department foresees relative to the ICES project are possible misunderstandings of our Affirmative Action Program or union agreements which would result in hearings or grievances.

The City of Independence has a union agreement with IBEW Local 53, which represents the electrical workers who work in the transmission, distribution, and production divisions of the Independence Power and Light Utility. It is not felt that there is a problem in this area in relation to the construction and operation of the ICES project. However, if it were determined that certain people were doing work that should be assigned to union members of the Power and Light Department, it may cause a conflict in the Memorandum of Understanding between the City and the Union. Should a grievance be written on the ICES project, the City would handle it in the same manner as other grievance procedures.

Copies of the City's agreements with IBEW Local 53 and the Affirmative Action Plan will be made available to ERDA if desired.

2.1.6 Bond Regulations and Covenants

An issue of Power and Light (referred to in bond ordinances as the electric light works) revenue bonds may be made under authority granted in Article VI, Section 27, of the Constitution of Missouri, 1945, as amended. Such constitutional provision has been held by the Supreme Court of Missouri to be self-enforcing, no legislation being necessary to make such provision effective. (State ex rel. City of Fulton vs Smith, 355 Mo. 27, 1945, W. 2nd 302 (1946).)

Such bonds must be approved by a more than four-sevenths vote of the qualified electors of the City. An election was held on September 15, 1970, to approve issuance of 50 million dollars in bonds and the proposition was approved. Three million of this authorized amount was sold in a 1971 issue and 14 million was sold in 1975; therefore, 33 million remain unissued.

Power and Light bonds are payable solely from the revenues derived by the City from operation of the Electric Utility Department. The bond covenants, made to the holders of currently outstanding bonds, place the following income restrictions on the issuance of additional bonds which would be at parity with outstanding bonds:

1. Net annual income as defined in the covenants must be at least twice the highest annual interest required on outstanding bonds. That total interest is currently \$1,600,857.06.
2. Net annual income as defined by the covenants must exceed 135 percent of the total amount required to pay interest and principal for the highest year on outstanding bonds. That total payment is currently \$4,600,860.40.

The net annual income, as defined by the bond covenant (two years average) was \$7,600,860.40. Thus, the City may issue bonds up to an amount which can be paid for at a total annual payment of:

Net income	\$7,600,860.40
Less 135% of current payments	<u>6,211,161.00</u>
Income available for interest and principal of additional bonds	<u>\$1,389,699.40</u>

Based on the above, the City could qualify to sell up to \$15 million of additional revenue bonds to be paid in 20 years at 6 percent interest. It presently takes about four and one-half months to complete the sale of revenue bonds that have been previously authorized.

2.1.7 Zoning Regulations

The zoning of land within the City limits (and hence the Demonstration Community area) is governed by Sections 89.010 through 89.140 of the Missouri Statutes and Chapter 14 of the City Code. These documents provide the specific authority for the City to control the land use within the Demonstration Community.

Excerpts from the State Statutes are shown below. Copies of appropriate sections of the Statutes and the City Code are contained in Appendix C.

89.010. Applicability of law

The provisions of sections 89.010 to 89.140 shall apply to all cities, towns and villages in this State.

89.020. Powers of Municipal Legislative Body

For the purpose of promoting health, safety, morals or the general welfare of the community, the legislative body of all cities, towns, and villages is hereby empowered to regulate and restrict the height, number of stories, and size of buildings and other structures, the percentage of lot that may be occupied, the size of yards, courts, and other open spaces, the density of population, the preservation of features of historical significance, and the location and use of buildings, structures and land for trade, industry, residence or other purposes.

89.030. Zoning Districts

For any or all of said purposes the local legislative body may divide the municipality into districts of such number, shape, and area as may be deemed best suited to carry out the purposes of sections 89.010 to 89.140; and within such districts may regulate and restrict the erection, construction, reconstruction, alternation or use of buildings, structures, or land. All such regulations shall be uniform for each class or kind of buildings throughout each district, but the regulations in one district may differ from those in other districts.

The proposed land use for the Demonstration Community area is consistent with the needs of the ICES project. Accordingly, no conflicts with the provisions of the State Statutes, the City Code, or the Comprehensive Plan are foreseen.

The procedures for the rezoning of land are established by the City Code, drafted in accordance with the revised Statutes of the State of Missouri. The specific procedure of rezoning land within the City of Independence is as follows:

1. The property owner or his agent files an application for rezoning, on forms provided by the City, with the City Planning Department.
2. The application is reviewed by the Planning Department and is advertised in the local newspaper fifteen days prior to such public hearing.
3. After the public hearing the Planning Commission makes a recommendation to the City Council for approval or denial of the rezoning request.

4. A complete transcript of the public hearing before the Planning Commission is made by a certified court stenographer and transmitted to the City Clerk along with the application and supporting data for presentation to the City Council.
5. The City Clerk advertises for another public hearing to be held before the City Council, again fifteen days prior to such hearing. At this public hearing only new evidence certified by the Planning Director and Law Department as being new evidence not available at the time of the Planning Commission hearing can be submitted.

After the public hearing the City Council will give first reading to an ordinance authorizing the zoning change.

6. The ordinance authorizing the zoning change is given the second required reading at the next regularly scheduled City Council meeting. After the second reading the City Council will either approve or deny the requested zoning change. If approved by the City Council, the ordinance becomes effective ten days after the date of the approval.

The above-mentioned procedure generally requires ninety days from the date of the submission of the application until the final City Council action.

2.1.8 Missouri Constitution and Statutes

Appendix C contains sections of the Missouri Constitution and Statutes which establish the City's authority to establish a charter form of government; incur indebtedness; enter into contracts; acquire private property by eminent domain; hold properties; levy taxes; issue revenue bonds; and own and operate utilities.

Based upon a review of appropriate constitutional and statutory articles, the City's Law Department concluded (Section 2.4 of this report) that the City is empowered to do all those things necessary for the construction and operation of the ICES plant. This is not to say that legal questions will not arise. However, those that do are expected to be of the type that the Law Department routinely handles as part of the City's typical business activities.

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 (see Section 2.3) 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 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 community at large and potential ICES users nationally. A variety of approaches will be employed to meet the needs of these distinct audiences.

The urban community at large will include residents, commercial operators, and developers in the Demonstration Community area; the City of Independence; and surrounding communities such as Kansas City, Missouri. The City of Independence uses a number of techniques to provide information to the public as well as to provide opportunities for public input. These techniques include public hearings, special meetings, news conferences, news releases, brochures, newsletters, and model displays.

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

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 their mechanical plant conversions.

During Phase I several news releases also appeared in the local newspapers. Those articles are displayed in the addendum to this section.

Besides 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 may 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.

Since the City owns and operates the electric utility, it is planned to mail out with the electric bills one or more brochures describing this energy conservation program.

Another level of information dissemination planned will include the distribution of bimonthly newsletters to key individuals and potential ICES users nationally. A subcontractor to this program is Public Technology, Inc. (PTI), a nonprofit organization established as an institutional mechanism for applying available technologies to the needs of State and local governments. PTI provides information to public users in State and local government concerning many forms of innovative technology and will utilize this existing network to circulate the newsletter and other program information describing the status of the ICES project in the City of Independence. PTI will use both its own newsletter distributed to over 3,500 individuals in State and local government and also publications of its sponsoring organizations which reach nearly all State, county, and municipal governments. In addition, decision manuals will be prepared during Phase II and subsequent activities which will describe detailed experience

gained from the Independence demonstration project. The purpose will be to present a logical process that management can use to consider and implement ICES projects in their respective jurisdictions.

A second form of national information dissemination concentrates on direct involvement of potential ICES users from other parts of the country on the Independence ICES project. During Phase I, PTI selected members for a User Requirements Committee (URC). Members were chosen from jurisdictions with particular interests in co-generation systems. Table II-1 shows the candidate member list by name, title, and jurisdiction represented.

During two URC meetings planned for Phase II, the members will contribute knowledge of technical, operation, economic and other requirements and specifications from their own jurisdictions. At the same time, 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 OBSERVATIONS AND CONCLUSIONS

The Law Department of the City of Independence has reviewed all pertinent Federal, State, and local laws, including provisions of the Independence City Charter, and particularly Article VI of the Missouri Constitution of 1945, and Section 70.220 of the Revised Statutes of Missouri, and Sections 1.1 and 1.4 of Article 1 of the Charter of the City of Independence, Missouri, which established the City of Independence, Missouri, as a public body, with power to contract with the United States of America for the purposes of the City's proposal to 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 a review of applicable laws, it is

TABLE II-1

URC CANDIDATE MEMBER LIST
FOR THE ICES PROGRAM

<u>Name and Title</u>	<u>Jurisdiction Represented</u>
1. Ed Krause, Electric Utility Administrator	City of Garland, Texas
2. Norman Priest, Director of Redevelopment Agency	City of Anaheim, California
3. Terry Sprekel, City Manager	City of Ames, Iowa
4. Bob Dust, Director of Public Utility	City of Saginaw, Michigan
5. Andre Blum, Director of Administration	City of Madison, Wisconsin
6. Doug Weiford, Municipal Manager	City of Anchorage, Alaska
7. George Rowe, Purchasing Agent	City of Cincinnati, Ohio
8. Bob Mauro, Technical Associate	American Public Power Association
9. Robert Loftness, Director, Washington Office	Electric Power Research Institute
10. Don Pinkerton, Executive Director	National Conference of States on Building Codes & Standards
11. Art Holland, Mayor	City of Trenton, New Jersey
12. Vincent Rotando, Public Works Commissioner	City of Stamford, Connecticut

the opinion of the Law Department of the City that the City of Independence, Missouri, is a public body empowered to receive and expend Federal, State, and local funds and to contract with the United States of America. Based upon an analysis of potential legal problems resulting from the inclusion of the ICE System 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 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. As the ICES project proceeds, statutory limitations may become apparent that will require subsequent consideration.

Statutory authority empowering the City to make the public improvements that may be occasioned by the ICES project is reflected in various sections of the statutes. Generally speaking, the City of Independence has ample power to make these improvements. Section 82.190 V.A.M.S. specifically grants Independence exclusive control over public places. Section 82.230 V.A.M.S. provides for regulating public places. Section 82.240 allows the City to acquire (including by power of eminent domain) lands for public use and public purpose.

The City of Independence has full power to acquire, use, and manage property in order to perform their functions and provide municipal services and facilities to the people. Such power includes not only the power of eminent domain but the authority to acquire property for municipal purposes by purchase or other nonjudicial means involving bargain or agreement between a municipality and the owner of property--including lease, gift and devise or bequest, as well as purchase. The City can also acquire property in trust or by dedication.

2.5 ENVIRONMENTAL FACTORS

This section identifies the potential environmental impacts of the ICES project and possible control strategies that might be required to ensure the environmental acceptability of the power plant. A detailed environmental assessment will be performed in Phase II of this program to better account for the environmental impacts of the ICES project. The following discussions are based on the design of a 20-MWe coal-fired power plant that will be utilized in a grid-connected Integrated Community Energy System (ICES) that would supply the thermal energy requirements of both commercial and residential facilities in the vicinity of Independence Center, as well as being connected to the existing electric utility distribution grid.

2.5.1 Site Characteristics

The 20-MWe coal-fired power plant will be located within the tract of approximately 1,400 acres that constitutes the "Demonstration Community," identified in detail in Section 1.1. This area is generally bounded by Interstate 70 to the south, Lee's Summit Road to the west, Selsa Road to the east, and R. D. Mize Road to the north. Within the general area, three locations were seriously evaluated as potential utility plant sites. Two of these locations are near the intersection of Selsa Road and the railroad line passing through the site area, and the third and pre-

ferred site is approximately 1,000 ft west of Selsa Road and 700 ft north of the railroad line.

Natural water resources in the vicinity of the site area appear to be quite limited. The nearest surface water body is the Little Blue River. The flow in this river is generally low. For example, the smallest mean monthly flow during 1975 was 24.8 cfs for July. The flow has actually been as low as 0 cfs at several periods during the past 25 years.(1) Groundwater from local wells does not appear to be a significant source of water, with an assured supply of only 10 to 30 gpm.(2) However, a minimum amount of 300 gpm can be purchased from the Missouri Water Company and supplied to the plant site to serve the needs of the ICES power plant facility.

The City of Independence is presently served by an interceptor sewer line to the Spring Branch secondary waste treatment plant. A tertiary treatment plant to accommodate growth in the Little Blue Valley is presently in the planning stage. This plant will be located at the Atherton Bottoms.

The terrain at the site is somewhat hilly, with elevation differences generally limited to less than 100 ft and with inclines being gradual over most of the site area. The local physiography will present no serious barriers to the construction of the proposed ICES plant and thermal distribution facilities. Some site development work will be necessary to overcome local flooding from the Crackerneck Creek, a small tributary of the Little Blue River.

The quality of air in the vicinity of Independence is generally good. Independence is presently meeting applicable air quality standards for SO₂ (sulfur dioxide), NO_x (nitrogen oxides), and CO (carbon monoxide). However, the Federal ambient air quality standard for total suspended particulates is being slightly exceeded.

Most of the general site area is well isolated from residential areas. However, the two candidate locations for the power plant near the intersection of Selsa Road and the railroad line are in the vicinity of several residences.

Logs of borings⁽³⁾ and data⁽⁴⁾ obtained at the Independence Center and on the site area near the existing substation were examined with regard to the possible suitability of land in the vicinity of the site for disposal of solid wastes resulting from the operation of an electrostatic precipitator for fly ash collection and a flue gas desulfurization (FGD) system for sulfur dioxide (SO₂) control. These data indicate that the water table is generally more than 10 ft below the ground surface and in many cases is 25 ft or more below ground level. The soil surface typically contains a several-foot-thick layer of silty clay, which usually has a low permeability and effectively prevents seepage into groundwater. Thus, the general site area appears to have characteristics amenable to a landfill operation or a pond for disposing of solid wastes generated at the power plant.

2.5.2 Regulatory Factors

The principal regulatory factors applicable to the 20-MWe power plant under consideration are discussed below.

2.5.2.1 Boiler Stack Emissions

Federal new source performance standards (NSPS) have been established to limit emissions from coal-fired steam generators with capacities exceeding 250 MM Btu/hr heat input. These NSPS restrict emissions from such plants to 0.1 lb particulates, 1.2 lb SO₂, and 0.70 lb NO_x per MM Btu heat input and to a maximum continuous opacity of 20%. In the case of a typical 20-MWe power plant, the heat input would be nearly 230 MM Btu/hr for a thermal efficiency of 30%. Since the thermal load on the power plant under consideration would require additional heat input to the

boiler, the total heat input may be expected to exceed 250 MM Btu/hr. Thus, for the purposes of this study, it is assumed that the heat input to the power plant will exceed 250 MM Btu/hr and, therefore, that the above NSPS would be applicable.

In addition to the above Federal standards, air quality standards and emission limitations for the Kansas City Metropolitan area, including Jackson County and the proposed site area, have been established.⁽⁵⁾ The local emission limitation for particulates is approximately 0.31 lb/MM Btu heat input, which is considerably less restrictive than the corresponding Federal regulation described above. The visibility of emissions is also restricted, as discussed in detail in Reference (5). The local emission limitation on SO₂ is expressed in terms of restrictions on the ambient air concentrations and frequencies resulting from the emissions. The regulation is stated⁽⁵⁾ as follows: "No person may cause or permit the emission of sulfur dioxide from any premises in such manner and amounts that the concentrations and frequencies exceed those shown in the following table in the ambient air at any occupied place beyond the premises on which the source is located:

<u>Concentration</u>	<u>Averaging Time</u>	<u>Maximum Allowable Frequency</u>
0.25 ppm or more	1 hour	Once in any 4 days at any sampling site.
0.07 ppm or more	24 hours	Once in any 90 days at any sampling site."

In addition to the above regulations, ambient air quality standards presented in Table II-2 are also applicable to the site area.⁽⁵⁾ It should be noted that these air quality standards for the Kansas City Metropolitan Area are more restrictive than corresponding Federal ambient air quality standards established by the U.S. Environmental Protection Agency.

TABLE II-2

AMBIENT AIR QUALITY STANDARDS
FOR THE KANSAS CITY METROPOLITAN AREA(5)

<u>Pollutant</u>	<u>Concentration</u>	<u>Remarks</u>
SO ₂	0.015 ppm by volume	Maximum annual geometric average (24-hour sampling time) at any sampling site
	0.06 ppm by volume	24-hour average not to be exceeded on more than one 24-hour period in any three consecutive calendar months at any sampling site
	0.35 ppm by volume	Maximum one-hour average at any sampling site
Suspended particulates (high-volume sampler)	60 g/m ³	Maximum annual geometric at any sampling site
	150 g/m ³	24-hour average not to be exceeded on more than one 24-hour period in any three consecutive months at any sampling site

2.5.2.2 Liquid Effluents

As a result of the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500, effluent guidelines and standards for chemical discharges from steam electricity-generating plants were promulgated in October 1974. Table II-3 summarizes these limits on chemical-pollutant discharges. It can be seen that limits are placed on several constituents of liquid discharges, including pH, total suspended solids, oil and grease, iron, copper, free available chlorine, zinc, chromium, phosphorus, and various corrosion inhibitors. Discharge of polychlorinated biphenyls (which have been extensively used as oil for electrical transformers) is forbidden. In view of the added emphasis on toxic substances in the 1976 Toxic Substances Act, the U.S. Environmental Protection Agency is currently developing effluent standards for toxic or priority pollutants, including trace elements from coal, chlorinated hydrocarbons resulting from the chlorination of cooling water containing a heavy background concentration of organic material, and zinc and chromium cooling-system corrosion inhibitors. These standards are scheduled to be finalized in March 1979.⁽⁶⁾ Effluent pretreatment requirements were also promulgated in the October 1974 EPA guidelines for power plants discharging into publicly owned treatment works (POTW). These pretreatment requirements were deemed inadequate by the courts, and EPA was required to promulgate new regulations for steam electric power plants discharging into POTW's.

In addition to the above Federal standards, the State of Missouri has established water quality standards for both chemical and thermal discharges.⁽⁷⁾ While waste discharges to the Little Blue River are allowed at the present time, they may be disallowed at some unspecified future date. The discharge of cooling water, however, is expected to be permitted, as long as it is treated to meet the Federal effluent limits given in Table II-3.

TABLE II-3
DISCHARGE LIMITS FOR NEW STEAM ELECTRIC PLANTS (6)

<u>Stream, Pollutant</u>	<u>Maximum Daily Value (mg/liter)</u>	<u>Average of 30 Consecutive Daily Values (mg/liter)</u>
1. <u>All streams</u>		
pH	6.0 to 9.0	6.0 to 9.0
Polychlorinated biphenyls	No discharge	No discharge
2. <u>Low-volume waste streams (a)</u>		
Total suspended solids	100	30
Oil and grease	20	15
3. <u>Bottom-ash transport water (b)</u>		
Total suspended solids	100	30
Oil and grease	20	15
4. <u>Fly-ash transport water</u>		
Total suspended solids	No discharge	No discharge
Oil and grease	No discharge	No discharge
5. <u>Metal-cleaning wastes</u>		
Total suspended solids	100	30
Oil and grease	20	15
Copper (total)	1	1
Iron (total)	1	1
6. <u>Boiler blowdown</u>		
Total suspended solids	100	30
Oil and grease	20	15
Copper (total)	1	1
Iron (total)	1	1
7. <u>Cooling tower blowdown</u>		
Free available chlorine	0.5	0.2
Zinc	NDD (c)	NDD (c)
Chromium	NDD (c)	NDD (c)
Phosphorus	NDD (c)	NDD (c)
Other corrosion inhibitors	CBC (d)	CBC (d)
8. <u>Material storage runoff</u>		
Total suspended solids	50	--

(a) Wastes from wet scrubbers, ion exchange systems, evaporator blowdown, laboratory and sampling streams, floor drains, and cooling tower basin cleaning.

(b) Blowdown rate limited to 5% of bottom-ash sluice water flow.

(c) No detectable discharge for new sources.

(d) Limits determined on a case-by-case basis.

Thermal standards for the Little Blue River are also set forth in the Missouri Water Quality Standards. These standards limit the allowable ambient temperature change in the river due to the thermal discharge to no more than 5°F, and the ambient river temperature is not to be increased above 90°F.

2.5.2.3 Solid Wastes

The principal solid wastes from coal-fired plants include precipitated calcium-base solids from flue gas desulfurization, as well as fly ash and bottom ash. Occluded wastewater contained in such solids can affect the quality of surface and groundwater bodies if transported to them. No Federal regulations or guidelines for the disposal of such wastes have yet been issued. However, the Resource Conservation and Recovery Act of 1976 requires EPA to establish guidelines or regulations for the disposal of solid wastes resulting from air pollution control.(8)

Rules and regulations pertaining to the disposal of solid wastes were promulgated by the 76th Missouri General Assembly in 1973. These rules and regulations are described in detail in Reference (9). Included in these rules and regulations are the following requirements:

- The design of a landfill should account for the groundwater elevation and the proposed separation between the lowest point of the landfill and the predicted maximum water table elevation.
- Soil and bedrock should be described to a depth adequate to allow evaluation of the water quality protection provided by the soil and bedrock.
- Provisions for surface water runoff control should be made to minimize infiltration and erosion of cover material. Surface water courses and runoff should be diverted

from the landfill (especially the working face) by devices such as trenches, conduits, and proper grading.

2.5.2.4 Noise

Noise level guidelines proposed by the Environmental Protection Agency(10) indicate that 55 dBA is the time-weighted day/night outdoor average sound level in a residential community below which no effects on public health and welfare occur due to activity and speech interference. This limit also protects the majority of the exposed population against annoyance under most conditions. These guidelines are not standards, but are merely recommendations by the EPA.

Noise criteria established by the Department of Housing and Urban Development(11) state that levels below 45 dBA are "acceptable" for continuous 24-hour exposure; levels up to 65 dBA are "normally acceptable" provided they are not exceeded more than 8 hours per day; levels exceeding 65 dBA more than 8 hours per day are "normally unacceptable"; and levels which exceed 75 dBA more than 8 hours per day or 80 dBA more than 60 minutes per day are "unacceptable." These criteria are standards only for HUD-sponsored projects and can be considered as recommended guidelines otherwise.

No noise regulations for the State of Missouri have been identified that would apply to a power station.

2.5.3 Environmental Impacts and Possible Control Strategies

Environmental regulations applicable to the 20-MWe coal-fired ICES plant under consideration have been identified in Section 2.5.2. The ICES facilities will be designed to meet all of these regulations, and any others that might be identified in the future, in order to limit the environmental impacts of the project and to facilitate the obtaining of all relevant permits. Possible

control strategies to comply with these regulations are discussed below. Due to the preliminary nature of the plant design during the feasibility phase of this study, the discussions and conclusions presented herein are necessarily tentative.

2.5.3.1 Air Quality

The electrostatic precipitator is the normal means of removing fly ash from the stack gases at new coal-fired plants. If a precipitator is designed to reduce the fly ash emissions at the precipitator outlet to no more than 0.1 lb/MM Btu heat input, additional particulate removal by the flue gas desulfurization (FGD) system will reduce the emissions of particulates from the stack to levels well below the NSPS requirements. This high degree of particulate control is especially desirable as the ICES plant site is located in an area that does not presently meet applicable air quality standards for suspended particulates. Moreover, the above degree of control performance provides flexibility in design and operation, permitting a portion of the precipitator outlet gas to bypass the FGD system and supply scrubbed gas reheat.

Cost considerations are expected to strongly dictate the choice of nonregenerable wet scrubbing systems using lime or limestone and yielding a solid waste consisting of calcium sulfite, calcium sulfate, and wet collected fly ash. Critical gypsum scaling tendencies can be best controlled by designing for system operation in an unsaturated gypsum mode.

The double-alkali system is generally effective in eliminating scaling problems and would thus minimize needed operator attention and required maintenance. Therefore, it will probably be the preferred FGD system process for a small coal-fired plant, such as the one under consideration. Unsaturated mode systems also have the advantage of operating in a zero-effluent closed liquid loop with no FGD blowdown to be discharged and with purge

achieved by the occluded liquid in a wet filter cake. Wastewater treatment facilities for scrubber blowdown would then not be required.

Dispersion of flue gases to minimize ground-level concentrations of pollutants is favored by increased stack height and by increased gas velocity at the stack exit. The buoyancy of moist flue gas from wet scrubbers is improved by reheat of the water-saturated outlet flue gas. In plants burning coal of medium sulfur content and using electrostatic precipitators for fly ash removal, it is possible to obtain economical flue-gas reheat by bypassing a portion of hot flue gas around the scrubber, the FGD process being designed to absorb sufficient SO_2 to meet the overall emission limits.⁽⁸⁾ A dispersion modeling analysis will be made in the next phase of this project to determine the stack height required to ensure adequate limiting of impact on air quality. By employing efficient air pollution control devices to limit emissions and through reheat of exhaust gases to increase buoyancy and plume rise, a stack height of approximately 2.5 times the plant building height (to avoid plume downwash) might well prove to be acceptable.

2.5.3.2 Solid Waste

Two principal options are available for disposing of solid wastes resulting from the operation of the pollution control devices discussed above. Disposing of ash in ponds has long been practiced by the utility industry. Because of its potential for contaminating ground and surface waters, especially with FGD wastes containing small concentrations of a large number of toxic substances, ponding is generally not as environmentally acceptable as the preferred method of stabilizing the solid wastes, with ultimate disposal in a landfill. Thus, the following discussion will be limited to disposal by landfilling. This method of disposal reduces, or ultimately eliminates when reclamation is practiced, the amount of land to be dedicated for disposal and allows

for use of smaller isolated parcels of land requiring only minor site preparation as compared to the construction of large dikes and ponds. (12)

In order to stabilize the solid wastes prior to disposal in a landfill, the dry-collected fly ash should be transported pneumatically and mixed in a prescribed manner with the filter cake from the FGD system and other required dry additives. A stabilized material can thereby be produced that is suitable for landfill, with greatly reduced tendencies for leaching. (12,13) This stabilized material can even be used for grading purposes and as structural fill for contouring, so as to reclaim otherwise useless land. As discussed previously, preliminary inspection of available boring data in the vicinity of the site area indicates that the water table and soil characteristics appear to be favorable for a landfill operation.

Preliminary estimates indicate that the solid wastes produced over a period of 30 years would occupy a volume on the order of 200 to 400 acre-feet, with the lower value based on coal with 2% sulfur and 10% ash and the higher value based on coal with 3.5% sulfur and 12.6% ash. The selection of an optimum location for the landfill will require additional data on the water table and soil characteristics on and around the site area.

2.5.3.3 Cooling

As discussed previously, the availability of a continuous and reliable supply of makeup water appears to be quite limited. Preliminary estimates indicate that the makeup requirements for a plant evaporative cooling system would be approximately 300 gpm, which is equal to the amount of water available from the Missouri Water Company. This obviously would leave little, if any, margin for makeup to other plant systems. In addition, the periodic low flows in the Little Blue River and the thermal standards for this river may present problems with regard to discharging cooling

tower blowdown to the river. Another possibility is to discharge cooling tower blowdown into the interceptor sewer lines discussed previously, after appropriate treatment at the plant site. Thermal discharges to publicly owned treatment works (POTW's) may be restricted, however, by the standards to be established for POTW's.

In view of the above, a dry (air-cooled) cooling tower might prove to be the preferred means of dissipating the waste heat from the condenser cooling water at this particular site area. The use of air cooling would have the additional advantage of eliminating (a) the need for treating cooling tower blowdown to meet the effluent standards in Table II-3 and (b) any objectionable visible water vapor plumes that might result from the operation of an evaporative system. An additional option that might be considered in the final selection of an optimum cooling system is the combination wet/dry tower, which combines evaporative and dry cooling sections in a single tower. This type of tower would have the advantage of reducing water consumption as compared to a totally evaporative system and of improving thermal performance (and consequently reducing turbine backpressures) during hot weather in comparison to a completely dry tower.

2.5.3.4 Wastewater

Methods of treating the various liquid effluents listed in Table II-3 are discussed in detail in Reference (14). The discharge standards to be applied to these liquid effluents will depend on whether discharge is to the Little Blue River, assuming discharge to this river is permitted in the future, or to the interceptor sewer lines discussed previously. Bottom-ash sluice water blowdown can be treated with dewatering bins followed by a clarifier (with flocculant addition where necessary). In the case of potentially leachable bottom ash from dry-bottom boilers, acid feed might also be required for scale control. Fly ash sluice water will not be employed and consequently will not re-

quire treatment since a pneumatic system will be used to transport the collected fly ash.

2.5.3.5 Coal Quality

In addition to the above techniques for minimizing the environmental impacts of this plant, attention should also be given to utilizing an existing source of moderate-sulfur-content coal, such as partially beneficiated coal (i.e., coal washed to inexpensively reduce its sulfur content to 2-3%, as well as substantially reducing its ash content). The estimated overall costs (including emission control, solid waste disposal, and the adjusted coal price) have in many cases been shown to be considerably lower for partially beneficiated coal than for unbeneficiated coal.⁽⁸⁾ The use of reasonably clean coal would also have obvious environmental advantages, such as a reduction in the volume of solid wastes requiring disposal at the plant site.

2.5.3.6 Aesthetics

By being located in, and adjacent to, the high-value commercial and residential development of the Demonstration Community, the aesthetics of the ICES facilities will have an impact on the overall environment of the project area.

The heating and cooling plant will be located near a major commercial area on 39th Street. This structure will be designed to conform architecturally with building styles in the general vicinity. All major piping will be underground, including steam lines from the power plant to the heating and cooling facility, and hot and cold water pipes that will distribute the thermal energy to and from the points of load within the Demonstration Community. No new major power lines will be erected within the community area.

The ICES power plant will be located north of the railroad line through the Demonstration Community. The plant will have all of the major features associated with a coal-fired power station, including coal storage and conveyance, ash handling, and stack. Pollution levels from the plant will meet all Federal and State requirements and will therefore not create negative aesthetic impacts on the area. Because sulfur oxide emissions from the plant will be within acceptable limits, odors will be minimal. While the aesthetics of a power plant may not match those of other facilities that lend themselves to architectural beauty, the proposed ICES plant will not create major negative aesthetic impacts on the Demonstration Community. The City of Independence is contemplating the purchase and development of land adjacent to the power plant site for use as a park and recreation area.

2.5.3.7 Construction Impacts

There should be no severe impacts on the environment due to activities occurring in the construction phase of the ICES project in Independence. Direct access by roads and rail will be available to the power plant site for the movement of heavy machinery and construction equipment. No major areas of wildlife habitat or other ecological settings of significance will be disturbed. The ICES power plant site is well enough isolated from other development that noise, dust, and other temporary construction impacts will not adversely affect neighboring areas.

2.5.3.8 Environmental Impact of Energy Conservation

The major objective of the ICES demonstration program in Independence is to demonstrate the feasibility of satisfying thermal and electrical demands through one energy-efficient community energy system. Because the net effect of the ICES project is the saving of fuel to serve a fixed energy demand, the project can be anticipated to have the major secondary effect of having an overall favorable impact on the environment.

Fuel extraction, transport, combustion, and the disposal of products of combustion from fossil fuels are all major causes of environmental problems. Energy conservation results in net fuel savings and thus in a comparable net reduction in adverse environmental impacts due to fuel utilization. Therefore, in balance, the ICES program represents a small but significant movement toward an improved environment by applying the concepts of energy conservation.

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ADDENDUM

PRESS COVERAGE OF THE INDEPENDENCE ICES PROJECT

Energy Saver

Power Plant Study Gets Council O.K.

By Steve Fink
A member of the staff

Innovative plans to study the possibility of building an energy-saving electrical plant in Independence were tentatively approved yesterday by the city council there.

City officials were notified yesterday that the Federal Energy Research and Development Administration (ERDA) will give the city \$150,000 to spend into negotiations with Public Technology, Inc., Washington, and INEL Corporation of Knoxville, Tenn., which will develop the study in cooperation with the city.

Under terms of the agreement with ERDA, the city and firm would have from today to May 31 to complete the study. Independence was one of two

offices selected by the regional office in Chicago to receive funds. Robert L. Swoboda, assistant to the city manager,

said. The council previously informally approved the plans at a study session.

If the study determines that the plant is a worthwhile idea the council then would have to approve construction. The proposal calls for building a 10-megawatt electrical generating installation near the Independence Center shopping center, 10th and M-30.

In the installation heat from generating turbines, which in a normal plant escapes through vents into the air and thus wasted, would be trapped and recycled. In this way heat and air-conditioning would be provided at a low cost to commercial and residential users in the area, Lyle W. Albright, city manager, said.

Construction of the plant would mean that 10 to 20 per cent of the power generated would be used, Swoboda said.

For the plant to operate efficiently, 3 million square feet of space would be needed so that all of the power generated from the plant would be distributed among users, Albright said. The Independence Center area has 1 1/2 million square feet, he said.

In addition to providing an alternate energy source to help develop the area, Albright said the plant would supplement current energy supplies. Referring to the record cold of this winter and the resulting energy crunch, Albright said: "After this winter the reality of this (project) brings it closer to home."

In other business the council discussed a proposal to increase the monthly sewer service charge in Independence from the current \$2.34 to \$3.39 this year and \$4 in 1978. No action was taken.

THE EXAMINER

Wednesday, January 5, 1977

Grant Approved For Power Study

Independence will receive a grant from the federal government for a feasibility study on the use of heat from a power plant.

Bob Swoboda, city technician, said he was notified by phone Tuesday that Independence has been selected for one of six grants to be given nationally for

the feasibility studies. Independence was one of nine finalists considered.

The city requested a grant of \$150,000 for the study and is anticipated to receive this amount, Swoboda said. Official written confirmation is expected to be received later this week, he added, after which a meeting will be

arranged to work out a contract.

The study will help determine if it is feasible to heat a shopping center or other mass concentration of buildings with the heat from a standard type of electrical power generating plant. Swoboda said the idea is reverting to the days when power plants were located

close to downtown and downtown buildings were heated through a steam system with the waste heat from the plant.

After the initial studies are completed, two of the six cities will be selected for a more detailed study of six to 12 months.

THE EXAMINER

Friday, April 22, 1977

Mayor Backs Energy Plans

Independence Mayor Richard A. King Thursday voiced support for President Jimmy Carter's energy proposals and outlined some ways the program will be followed up locally.

Speaking at a press conference at city hall, Mayor King said that it "was gratifying to hear President Carter recognize the existence of a genuine crisis and propose appropriate drastic steps to respond to it."

Mayor King said the tax incentives proposed by Carter may not be the best approach, but they appear to be the obvious first step. "I would like to see the excess profits tax coupled with deregulation of domestic prices added to the tax package to spur research on new energy sources," he added.

By way of direct response to Independence to President Carter's program, the mayor said he will stress certain areas. He said the city will examine utility rates following completion of a rate study and attempt to discourage peak load usage to a greater extent than is now the case. He said he

hopes to follow up on energy responsive taxes such as a horsepower tax on automobiles. Increased emphasis, he said, will be placed on obtaining the best local transit system in the area.

Continued emphasis will be placed on a federal Energy Research and Development Administration (ERDA) demonstration grant for coordination of an energy system to save energy in the southeast part of the city. A feasibility study is now being conducted by the city to determine if it is economical to heat and cool the Independence Center by the heat produced from a small power plant, with electricity being the by-product in this case.

Independence Seeks Heat-Conserving Plant

By Terrence Thompson
A member of the Staff

Independence is being considered for a federal grant that could lead to the construction of an electrical plant that would use heat normally wasted in generating electricity to heat or cool nearby buildings.

Robert L. Svobda, assistant to the city manager, said today Independence is one of nine cities in the U.S. that is a candidate for the grant from the Federal Energy Research and Development Administration.

Svobda said a decision probably would be made before the middle of January.

The nine cities were screened from a group of 40 cities that had applied for the grant, he said. The grant would be \$100,000 for a 6-month feasibility study on the economic advantages of the system.

The city's proposal calls for construction of a 10-megawatt electrical generating substation near the Independence Center shopping complex, 16-801 and 20th, Svobda said. The substation would generate electricity for the city's electrical distribution system and heat that is normally wasted would be used to heat or cool the shopping complex and new construction in the area, he said.

Under the present system of generating electricity, heat that is used to drive turbines for the generators usu-

ally is released into the atmosphere and wasted, Svobda said.

"We're looking in the process about 70 per cent of our energy," he said.

In the system being proposed the wasted heat would be used to heat water that would be pumped through insulated pipes to nearby buildings, he said. That heat also could be dissipated through a "heat exchanger" and sent to chill water for air conditioning in summer, he said.

In the proposal heating and cooling could almost be considered the main purpose of the plant with the electricity being considered a by-product, he said. The increased efficiency would mean that about 40 to 50 per cent of the heat would be used, that conserving

heat which is important in an age of expensive and scarce fuel, Svobda said.

The city has applied for the grant jointly with Public Technology, Inc., of Washington, and the NUZ Corporation, of Rockville, Maryland, he said.

Public Technology has a federal contract to help Independence and other cities apply modern technology to urban problems, Svobda said. The NUZ Corporation would provide the specific technical help in studying the feasibility of the proposed electrical heating and cooling system, he said.

If the city gets the \$100,000 feasibility study grant and if the proposal then proves feasible, the ERDA would fund any other necessary studies leading to construction of the power station, Svobda said.

The federal government also would share part of the cost of building the plant. Although the exact amount has not been set, 15 per cent federal help has been mentioned, he said.

On Dec. 18 Independence, along with the eight other finalists, made presentations to ERDA officials in Chicago, Svobda said. Independence was one of six finalists that study grants may be awarded, he said.

The key to getting a grant for Independence is the likelihood that there will be 1 million square feet of floor space to heat in the Independence Cen-

ter area by 1981, Svobda said.

Independence Center has from 1 million to 1.5 million square feet of floor space and already uses a heating and cooling system involving water that is circulated in pipes, he said. The remaining needed space would have to come from new construction in the area, he said.

He said the center would have to pay for the heat, but whether the cost to the center would be more than the present system would be determined by further study. Center officials have expressed an interest in being involved in the proposal if it is economically advantageous, Svobda said.

Independence has some advantages that will help the city in getting the grant. The city owns the electricity generating and distribution system and has control of other factors that could help make the proposed system work including zoning, he said.

Because of the nature of the system high-density construction is needed to provide a short distance for pumping the heated or chilled water, he said. Therefore a commercial area is preferable to a residential area.

The idea of using wasted heat from an electrical generating plant is not a new one, Svobda said. Before 1950 and the advent of the large central power generating facilities small electricity plants near downtown areas pumped steam in the nearby buildings for heating, he said.

THE KANSAS CITY STAR
Tuesday, December 23, 1975

THE KANSAS CITY STAR Tuesday, January 14, 1976

Study of Power Plant Proposal to Be Made

The Federal Energy Research and Development Administration (ERDA) has selected Independence to participate in a 6-month study that could lead to construction of an electrical plant that would use heat, which is normally wasted, to heat or cool nearby buildings.

Lyle W. Albert, city manager, and Robert L. Svobda, assistant to the city manager, met with ERDA officials today to discuss the study. ERDA could grant the city as much as \$100,000 to determine if the plant is economically feasible.

The city's proposal calls for construction of a 10-megawatt electrical generating substation near the Independence Center shopping complex, 16th and 20th. The substation would generate electricity for the city's electrical distribution system and heat from operating the generating tur-

bines would be piped to the center and other nearby buildings.

Under the present system heat used to drive turbines usually is vented into the atmosphere and wasted, city officials have said, a process that wastes about 70 per cent of the energy.

The city applied for the ERDA grant jointly with Public Technology, Inc., of Washington, and NUZ Corporation of Rockville, Md.

Public Technology has a federal contract to help Independence and other cities apply modern technology to urban problems. The NUZ Corporation would provide the specific help in studying the feasibility of the project, city officials said.

If the project proves feasible a eventually could lead to as much as 15 per cent federal financial participation in the construction of the new electrical plant, city officials said.

Independence May Get Grant for Power Study

A \$100,000 federal grant for a power plant feasibility study may be awarded to Independence, Bob Svobda, city technology agent, reports.

Svobda said the city will be notified in the next couple of weeks if it gets the grant. He said only one of the grants will be awarded out of about 40 proposals made for the grants. Latest word, he added, is that Independence is one of six finalists for the grant, so chances are good Independence will get one of the grants.

What the federal government wants to do, Svobda said, is to test the feasibility of small plants to provide heating and cooling and to generate electricity as a by-product. A high density area such as a shopping center would have to be located nearby to get the benefits of the heating and cooling, he said.

Svobda said that nothing is "cranked up" as to who would own such a plant. The city, he added, has a letter from the Independence Center expressing interest if the plan proves to be economical.

A standard type of plant would be built, Svobda explained. "The system is nothing new. It's reversing back to something that was done years ago when power plants near downtown pumped hot water to heat downtown buildings. Then they started moving the plants further away."

The city technology agent said that if the first study — which would take four months — shows that it is feasible then the federal government would choose two cities for a more extensive study and finally one city would be selected for assistance in building such a small plant.

TASK III - CONCEPTUAL DESIGN AND INSTALLED COST ESTIMATE

3.1 SUMMARY

The reference 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 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. As discussed in Section I, the ICES plant efficiency increases with increased steam demand. Therefore, 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.

The estimated cost of the ICES plant is \$26 million, excluding escalation and professional services. The estimate was based on conceptual drawings and equipment specifications and vendor quotations. The total cost is considered to be a budgetary estimate. Of the total cost, approximately 50 percent is associated directly with the power plant, with the remaining portion representing the cost of the heating and cooling facility and pollution control equipment.

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.

3.2 DESCRIPTION OF THE PROPOSED ICES SYSTEM

3.2.1 General Design Basis

The reference ICES plant layout is shown in Figure III-1. It includes a 20-MWe coal-fired power plant coupled to a heating and cooling facility. The power plant is located on approximately 35 acres between Route 291 and Selsa Road, north of 39th Street.

FIGURE III-1

PRELIMINARY

CITY OF INDEPENDENCE,
MISSOURI GRID CONNECTED
COMMUNITY ENERGY SYSTEM

SITE LAYOUT

NOS 5111-SK-13

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 (refer to Figure III-1). Extraction steam from the power plant is piped underground to the heating and cooling facility. The steam line is sized for the expected future growth (~4 million square feet to be heated or cooled). At the facility, the steam is used to generate either hot water and/or chilled water. The water is distributed to the Demonstration Community through an underground piping system. Condensate is returned to the power plant.

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.

3.2.2 Power Generation Station

A conceptual design of the coal-fired fossil plant was prepared as a means of determining the technical feasibility of the ICES plant and estimating the installed capital costs. The general plant location with respect to the Demonstration Community is shown in Figure III-1.

The process flow diagram for the ICES plant is shown in Figure III-2. The power plant steam cycle is typical of small power

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FIGURE III-2

PRELIMINARY

CITY OF INDEPENDENCE, MO.
GRID CONNECTED
INTEGRATED COMMUNITY
ENERGY SYSTEM SCHEMATIC

5111-SK-6

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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. Additional extraction steam will be used to preheat the boiler feedwater to ~350°F. The turbine will have three extraction points for feedwater heating, with one coincident with that used to provide energy to the heating and cooling facility.

The exhaust steam from the turbine is discharged directly to a condenser containing 18,000 square feet of heat transfer area (tubes). The condenser is considered to operate at 1.5 to 2.5 inches of mercury, depending on the cooling water temperature. The heat removed in the condenser is discharged to the atmosphere by means of an induced-draft wet cooling tower (three cell). The condensate is pumped to the feedwater system to complete the cycle.

An equipment list for the power plant and other ICES facilities is presented in Table III-1. The the major design features are as follows:

- Pulverized-coal-fired boiler with superheater and economizer, producing 200,000 lb/hr of steam at 850 psi and 900°F from feedwater at 350°F. Coal consumption is 11 to 13 ton/hr based on a coal energy content of 12,000 to 10,000 Btu/lb and a boiler efficiency of 85 percent. Flue gas leaving the system is at a temperature of ~320°F.
- An auxiliary oil-fired boiler is provided to produce ~70,000 lb/hr of steam at 360°F for use at the heating and cooling facility. Storage for a 14-day supply of oil is provided with additional day tanks, pumps, and oil purification equipment.

TABLE III-1
CITY OF INDEPENDENCE
20-MW COAL-FIRED PLANT
MOTOR LIST

SERVICE	No. Motors	HP Each	HP Connected	HP Coincidental
<u>4 kv Loads</u>				
Boiler Feed Pumps	2	500	1000	450
ID Fan	1	150	150	120
Pulv. Mill	2	100	200	180
Circulating Pumps	3	800	1800	1100
Precip. Feed	1	200 kVA	200 kVA	200
Scrubber	1		290	228
TOTAL:	10		3540	2258
<u>Plant - 480 Volt Loads</u>				
Pri. Air Fans	2	50	100	80
F.D. Fans	1	75	75	70
Lighting Trans.	1	100 kVA	100 kVA	75
Condensate Pumps	2	50	100	40
Service Water Pumps	2	50	100	40
Sluice Water Pumps	2	75	150	60
Service Air Comp.	1	40	40	-
Combustion Control Air Comp.	1	15	15	12
Coal Feeders	2	2	4	3
Coal Scales	2	1	2	-
Clinker Grinders	1	5	5	-
Turbine Oil Pump	1	25	25	20
Seal Oil Pump	1	5	5	4
Seal Oil Vacuum Pump	1	2	2	2
Turbine Turning Gear	1	5	5	-
Turning Gear Oil Pump	1	-	-	-
Circulating Water Valves	2	2	4	-
Heater Drain Pumps	2	5	10	4
M.O. Valves Boiler Room	4	1	4	-
M.O. Valves Turbine Room	4	1	4	-
Soot Blowers	6	1½	9	-
Vent Fans	3	15	45	40
T.R. Crane	1	10	10	-
Power Recept	8	30	180	-
Chemical Feed Pumps	2	1	2	-
Battery Chargers	2	10 kVA	20 kVA	5
TOTAL:	52		1015	455
<u>Coal Handling</u>				
Crusher	1	10	10	8
Track Hopper Feeder	1	2	2	2
Track Hopper Conveyor	1	5	5	4
Bucket Elevator	1	5	5	4
Conveyor (Hoppers)	1	5	5	4
Shaker	1	5	5	-
Hoist	1	2	2	-
TOTAL:	7		34	22
<u>Cooling Tower</u>				
Fans	3	75	225	180
M.O. Valves	3	2	4	-
Chemical Feed Pump	2	1	2	-
Chlorinator	1	30 kVA	30	15
Make-up Pump	1	10	10	8
TOTAL:	11		271	203

TABLE III-1 (CONTINUED)

SERVICE	No. Motors	HP Each	HP Connected	HP Coincidental
<u>Water Treating</u>				
Filter Pumps	2	10	20	8
Back Wash Pump	1	5	5	-
Brine Pumps	1	5	5	-
Agitators	1	1	1	-
TOTAL:			29	8
<u>Scrubber</u>				
Spray Pump	2	100	200	160
Chemical Pumps	4	1	4	-
Conveyors	4	3	12	6
Thickener	1	2	2	1
Sludge Pumps	2	2	4	2
Vacuum Filter	2	2	4	3
Vacuum Pump	2	10	20	16
M.O. Valves	4	1	4	-
Heaters	-	20 kVA	20 kVA	20 kVA
Lighting and Building Services	-	20 kVA	20 kVA	20 kVA
TOTAL:			290	220
<u>Miscellaneous - 480 Volt Loads</u>				
Yard Lighting	-	-	10 kVA	10 kVA
<u>Heating and Cooling Facility</u>				
Cooling Tower Pumps	5	150	750	540
Chilled Water Pumps	3	200	600	360
Hot Water Pumps	3	100	300	80
Cooling Tower Fans	6	75	450	260
Condensate Pumps	2	10	20	16
Cond. Booster Pumps	2	15	30	12
Sump Pumps	2	5	10	-
M.O. Chiller Water Valves:				
Inlet and Outlet	8	1	8	-
M.O. Chiller Steam Valves	4	1	4	-
M.O. Chiller Cond. Valves	4	1	4	-
M.O. Chiller Cooling Water:				
Inlet and Outlet	8	1	8	-
Chiller Solution Pump	4	10	40	36
Chiller Refrig. Pumps	4	10	40	30
Chem. Pumps	2	1	2	2
Mixers	2	1	2	2
Lighting Trans	2	50 kVA	50 kVA	40 kVA
Vent Fans	4	5	20	15
Unit Heaters	4	1	4	-
Heat Tracing Supply	2	10 kVA	10 kVA	-
Monorail Hoists	2	10	10	-
M.O. Chilled Water Pump Valves	3	1	3	-
M.O. Hot Water Pump Valves	3	1	3	-
Cooling Tower Pump Valves	3	1	3	-
Cond. Pump Valves	4	1	4	-
M.O. Doors	2	1	2	-
Chlorinator	1	20 kVA	20 kVA	12 kVA
TOTAL:	86		2397	1403
<u>Summary</u>				
4 kV Loads	-	-	3640	2258
480 V Boiler & Turbine Plant Loads	-	-	1016	445
480 V Cooling Tower	-	-	271	203
480 V Coal Handling	-	-	34	22
Water Treating	-	-	29	8
TOTAL:			5990	2936

- Coal unloading, storage, handling, and pulverizing equipment is provided. The coal pile is sized for a 100-day supply at a use rate of 15 tons/hr (worst-case coal heat content and losses). The boiler coal bunkers are sized for a 48-hour supply.
- A complete precipitator and sulfur removal scrubber system is provided. The scrubber is a double-alkali type of system, and all absorption units, filters, pumps, chemical storage tanks, and sludge disposal equipment have been included in the conceptual design. The system will handle ~60 tons of sludge per day. A 250-foot-high stack is also included as a means of controlling effluent discharges.
- Flyash from the boiler will be mixed with the scrubber sludge after collection of the ash by means of a pressure-pneumatic system. Bottom ash will be collected with a pressure-hydraulic system and processed in dewatering bins. The sluice water will be recycled and the ash disposed of as landfill. The ash handling systems have been sized for a coal consumption of 15 ton/hr, containing 17 percent ash, with the resultant bottom ash accounting for 25 percent of the total. Dewatering bins have been sized for a 56-hour capacity.
- A water recirculation pond (lined) is provided as a means of meeting surge or peak water demands. Water filtration and purification equipment will be provided to permit discharge or recycle of process water from such sources as cooling tower blowdown, boiler blowdown, and ash handling.
- The plant will include all auxiliary systems, equipment, and tankage as required, and the materials of construction are in accordance with normal engineering practice.

The conceptual design and cost estimate have considered the necessary site improvements, roads, railroad spurs, and buildings. The power plant buildings and yard arrangements are depicted in Figures III-3 and III-4. The arrangements and space requirements are believed to be typical for a unit of this size. The power plant site work has considered the 100-year flood plain of both Crackerneck Creek and the Little Blue River, and these factors have been incorporated into the cost estimate. The location of roads, spurs, and rights-of-way has been based on present commercial and residential units as well as future expansion.

3.2.3 Electrical Systems

3.2.3.1 One-Line Diagram

Figure III-5 is a one-line diagram that shows the principal electrical circuits in the generating plant, the heating and cooling facility, and the method of tying them into the existing power grid through substation K and the two 30-MVA 69/13.8 kV transformers.

The existing 13.8-kV outdoor switchgear at substation K contains two spare feeder circuits which can be used to supply the heating and cooling facility. An additional cubicle can be added at the end of bus 2 for the tie circuit to the new generating plant.

A detailed list of auxiliary power loads in the heating and cooling facility and in the generating plant is given in Table III-1. Maximum coincidental load for generating plant auxiliaries is 2936 kVA. The maximum load at the heating and cooling facility is 1405 kVA.

3.2.3.2 Generating Plant Systems

The generator is rated 20 kW, 0.8 pF, 24,000 kVA, 13.8 kV, hydrogen cooled. The generator main leads run directly to 13.8-kV metal-clad switchgear that contains two breakers, one for the

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FIGURE III - 3

CITY OF INDEPENDENCE, MO
 GRID CONNECTED INTEGRATED
 COMMUNITY ENERGY SYSTEM
 GENERAL ARRANGEMENT
 POWER PLANT

ENUS 6111-SK-11
 SCALE: 1/2" = 1'-0"

FIGURE III - 4
CITY OF INDEPENDENCE, MO
GRID CONNECTED INTEGRATED
COMMUNITY ENERGY SYSTEM
POWER PLANT
YARD LAYOUT
5111-SK-12 A

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generator and one for the unit auxiliary and startup transformers. The power output of the generating plant is carried to substation K via a new underground cable and duct system.

Large auxiliary motors and loads (100 hp and larger) are fed directly from a 4160-volt auxiliary bus in the generating plant. Other motors are fed directly from 480-volt switchgear in the plant or from motor control centers which are strategically located throughout the plant near load centers.

Three auxiliary transformers are provided to supply the auxiliary power requirements:

- One 3750-kVA unit for 4-kV loads
- One 750-kVA unit for 480-V loads
- One 750-kVA unit for standby service.

Large loads in outlying areas such as the precipitator and the scrubber are provided with their own transformers and are supplied at 4160 volts.

3.2.3.3 Heating and Cooling Facility

Two 1500-kVA 13.8/0.48 kV transformers are provided for this facility. Each transformer is fed directly from substation K by underground cables. A two-bus arrangement with bus tie connections is used to provide continuous operation of the system even during periods of maintenance and repair of one of the transformers on one of the switchgear buses.

3.2.4 Control and Monitoring Systems

3.2.4.1 Generating Plant

Control for all major electrical and mechanical equipment in the generating plant will be in the main control room located in the

heater building at the turbine room main floor level. This control room is centrally located and convenient to most equipment in the generating plant. Control panels will be of the semigraphic type and provided with sufficient monitoring devices and indicating devices so that all important systems in the plant can be controlled from the control room by the operators with a minimum of direct access to process equipment.

3.2.4.2 Heating and Cooling Facility

A semigraphic-central control panel will be such that an operator will be required in the building only during periods of emergency or when major equipment is placed in service or removed from service. At all other times an operator's presence will not be required.

3.2.4.3 Data Logger

As this plant is a demonstration plant, an automatic data acquisition system will be provided to continuously monitor and record the operating parameters of major systems and subsystems in the generating plant and the heating and cooling facility so that the performance can be evaluated under all operating conditions.

3.2.5 Heating and Cooling Facility

The proposed Independence ICES project will supply hot and cold water for HVAC purposes to commercial and industrial customers in the vicinity of 39th Street. For the Phase I evaluation, a heating and cooling facility has been sited just north of 39th Street. This facility receives steam from, and returns condensate to, the power plant. Hot and cold water will be pumped to customers in the Independence Center and along 39th Street. The sections that follow present details of the Phase I configuration and potential optimization studies for Phase II.

3.2.5.1 Site Description

The reference heating/cooling site location (see Figure III-1) on the north side of 39th Street has been chosen for this evaluation because it is relatively close to Independence Center (minimizing hot/cold water transport distance), and the building can be architecturally consistent with 39th Street development criteria; there are no significant adverse aesthetic or environmental problems associated with this facility, and the property is currently undeveloped. While the location may change, the site selected for this evaluation is nominal with respect to cost.

During Phase II, the following should be considered with more specific input in order to select a location for this facility:

- If heavy development is expected mostly westward, then the facility should be moved to the west or additional similar heating/cooling buildings should be built close to the load centers.
- A tradeoff between steam transport and cold water transport could result in a location either closer to the power plant or closer to the load.
- Closer proximity to the existing City-owned right-of-way from the substation may be desired for reasons of cost.

3.2.5.2 Process Description (Figure III-2)

The design basis for the heating and cooling systems is the peak load, which for 1.7 million square feet is assumed to be 3.0×10^7 Btu/hr for heating and 5.7×10^7 Btu/hr for cooling. These values were obtained by linear scaling to the Independence Center existing peak loads for Homart, which represents 800,000 square feet.

It was assumed that losses during distribution would be a negligible fraction of the total; that is, because of the current emphasis on energy conservation, the lines would be insulated for negligible losses.

The hot water distribution temperature was assumed to be 200°F with a load drop of 25°F. The cold water distribution temperature was assumed to be 38°F with a load rise of 20°F.

Less pumping power would be feasible for heat distribution if higher temperatures are utilized (refer to next subsection). The number of pumps selected was based on one installed spare for each service. Future optimization could result in a size range for each service in order to operate more efficiently at low load conditions.

A summary of major equipment in this facility is presented in Table III-2. The process flow diagram is shown in Figure III-2, and the general arrangement of the heating and cooling facility is shown in Figure III-6.

3.2.5.3 Heating

The heating process consists of steam-water mixing in a hot water tank. The mass inventory in the distribution system is maintained constant by condensate return to the main plant from the tank. As currently configured, it was assumed that the hot water system would be operating at a lower pressure than the absorption system, and thus booster pumps are required. Since the tank is a passive element, redundancy is not proposed.

When this system was chosen, it was assumed that the hot water would be used directly in the customer's heating units. Because of the desire for separate chemistry control, an intermediate heat exchanger will be required. In this case, higher temperature water or direct steam can be considered for heat transport, which will result in smaller pipes and less pumping power. Higher costs would

TABLE III-2
CITY OF INDEPENDENCE
HEATING/COOLING FACILITY MAJOR EQUIPMENT*

1. Pumps

<u>Use</u>	<u>Number</u>	<u>Flow (gpm)</u>	<u>Head (ft)</u>	<u>Power/Speed (hp/rpm)</u>
Cooling tower	5	4000	120	150/1790
Chilled water	3	3000	120	150/1790
Hot water	3	1200	180	75/1750
Condensate	2	130	100	10/1750
Condensate booster	2	60	240	10/3550

2. Heaters, Cascade

Number of tanks: two

Dimensions: 6 ft diameter x 12 ft high

3. Absorption Chillers

Trane two-stage

Number required: four

Design capacity: 1198 tons each

Dimensions: 29'3" x 10'5" x 13'5"

Input: 27 kW each

4. Pipe Size Assumed

Hot water 12 in

Chilled water 20 in

Steam

Condensate 4 in

*Equipment for cooling tower will be determined at a later date.

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be incurred because of more stringent design/construction control and thermal losses. For purposes of this evaluation, pipe and pumps were sized for a 200°F distribution temperature.

3.2.5.4 Cooling

For purposes of this evaluation, two-stage lithium bromide absorption chillers were chosen because of their higher coefficient of performance relative to single-stage units. For typical units, four Trane chillers are required, with a maximum design capacity of 1198 tons each. The cold water pumping system would be an independent circuit which circulates water in customer cooling units.

3.2.6 Distribution to Existing Facilities and Future Expansion

3.2.6.1 Routing to Independence Center (Figure III-1)

The proposed heating/chilling facility location is north of Independence Center, and the tie-in location is east of the south entrance. For Phase I, a route has been selected that avoids passing through the shopping center. A total of four pipes are required as follows:

1. Hot water supply, completely insulated - 12-inch pipe
2. Hot water return, completely insulated - 12-inch pipe
3. Cold water supply, insulated on exposed portions - 20-inch pipe
4. Cold water return, insulated on exposed portions - 20-inch pipe

To accomplish the routing to the Homart central plant at Independence Center, the following must be considered for the four pipes:

1. Burial depth must be below the frost line, which is about 3 ft.
2. Crossing under 39th Street.
3. Existing buried utilities in parking lot include fire and domestic water, electrical lines, sanitary sewer, storm sewer, fuel oil tanks.
4. Entry into Homart central plant will be under the truck portal, but not aligned with the unloading doors.
5. Branch connections for future development immediately west of Macy's parking lot area (a vault with valves is suggested).
6. High point vents will be required (possibly located in the same vault as item 5).

If, in future design, the heating/cooling facility is located farther westward, then consideration should be given to routing the pipes around the western perimeter of Independence Center.

3.2.6.2 Tie-In to Independence Center

It is proposed that the City-supplied hot and chilled water be connected to the central plant systems (Homart) at the Independence Center. The connections should 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.

With regard to Sears' and Macy's heating/cooling facilities, which are relatively small in capacity, other options are the following:

- Continue to operate as presently configured without modification.
- Pipe chilled water to Macy's via a branch (6- to 8-inch) from the main header (Figure III-7). A typical tie-in scheme is shown in Figure III-8. The equipment is located at grade elevation. Macy's has no hot water heating, and it is not considered economically feasible to convert.
- Pipe heated and chilled water to Sears. Tie-ins would be no problem. However, because the existing equipment is located in a penthouse on the western wing and routing of pipes through the center has been prohibited, a separate set of pipes would be required through the front parking lot.

With respect to the Homart central plant tie-ins, the following functional work tasks are required (Figure III-7):

1. Two hot water connections to 10-inch pipe. Tie-in would be by installation of two sets of a tee, an isolation valve (butterfly or gate), and a check valve. One would replace an existing elbow, and the second would be installed in an existing straight run.
2. Two chilled water connections to 14-inch pipe. Tie-in is the same as with hot water.
3. Controls will have to be modified to allow metering and possible remote-automatic operation of existing equipment or new valves. This will require tie-in to existing control panel, installation of new transmitters on existing flow elements, new pressure transmitters, and new temperature and differential temperature sensors with transmitters.

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Table III-3 contains a list of equipment that could become spare or utilized for backup by the individual owners.

3.2.6.3 Future Expansion

To allow for future expansion, an east-west hot and cold water distribution system along 39th Street is proposed. A branch connection from the Independence Center header to the east can also be envisioned. The installation of these lines should wait until development specifics become available. Phase II studies should include decisions on whether a ring-type or spoke-type distribution system is optimal. Potential expansion of the Independence Demonstration Community is shown on Figure III-9.

TABLE III-3
HEATING AND COOLING EQUIPMENT AVAILABLE
AT PRESENT INDEPENDENCE CENTER INSTALLATION

<u>Location*</u>	<u>Equipment Item</u>	<u>Number at Location</u>	<u>Description</u>
A	Water chillers	2	Carrier 19EA 8573DM, 940 tons
	Water chillers	1	Carrier 19EA 8985DP, 1075 tons
B	Water chillers	2	Carrier 19DG 5542CD
C	Water chillers	2	York HT E1 C2BD
A	Water heaters	2	Electric, PRFC Z8-2250; 7.7 MBH each
		1	Oil, Kewanee 63W-250-0; 8.4 MBH
B		1	Electric, PK 800-936/ 480/125/S+1
C		None	All electric with duct units
A	Cooling tower pumps	2	2535 gpm at 66' head (each)
		1	3225 gpm at 66' head
B		2	--
C		2	865 gpm at 50' head (each)
A	Chilled water pumps	2	1325 gpm at 155' head (each)
		1	1750 gpm at 155' head
B		2	--
C		2	720 gpm at 70' head (each)

TABLE III-3 (Continued)

<u>Location*</u>	<u>Equipment Item</u>	Number at <u>Location</u>	<u>Description</u>
A	Hot water	2	725 gpm at 150' head (each)
B		2	--
C		None	--
A	Cooling tower	1	Marley 459-203, Series 15, 3 cells
B		1	--
C		1	--

*A refers to Homart, B refers to Sears, C refers to Macy's

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FIGURE III - 9

CITY OF INDEPENDENCE, MISSOURI	
GRID CONNECTED INTEGRATED	
COMMUNITY ENERGY SYSTEM	
DEMONSTRATION COMMUNITY	
MAP	
NUS	5111-SK-7
DATE: 10/1/81	BY: B

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3.3 INSTALLED COST ESTIMATE

The preliminary 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.

Although the estimate must be considered preliminary, we believe it is conservative and adequate for budgetary purposes. The estimate is summarized on the pages that follow.

Sheet No. 1 of 4

ACCT NO.	ITEM OF WORK PRELIMINARY ESTIMATE	MATERIAL \$	LABOR \$	TOTAL \$
1.0	LAND AND LAND RIGHTS			1 0 3 6 5 0 0
2.0	STRUCTURES & IMPROVEMENTS			
2.1	GENERAL PLANT SITE			
2.1.1	SITE PREPARATION INCL CONNECTIONS TO SITE			4 2 5 5 0 0
2.1.2	SITE WORK			2 8 0 0 0
2.1.3	ROADS WALKS & PARKING AREAS			1 3 0 5 0 0
2.1.4	SANITARY FACILITIES			5 0 0 0
2.1.5	STORM SEWERS ALLOW			6 0 0 0 0
2.1.6	YARD PIPING			1 4 1 0 0 0
2.1.7	YARD LIGHTING			5 0 0 0
2.1.8	GATE OR GUARD HOUSE			6 0 0 0
2.1.9	PAINTING			8 0 0 0
2.1.10	STORAGE TANKS IN YARD			2 0 0 0 0 0
	TOTAL GENERAL PLANT SITE			1 0 0 9 5 0 0
2.2	POWER PLANT BUILDING			
2.2.1	POWER PLANT BUILDING			4 7 0 0 0 0
2.2.2	SERVICE BLDG EQUIPT INCL IN MISC P.P. ACCT			6 0 0 0 0
2.2.3	FILTER HOUSE EXCL EQUIPT			1 2 0 0 0
2.2.4	OFFICE BUILDING			7 0 0 0 0
	TOTAL POWER PLANT BLDGS			6 1 2 0 0 0

GENERAL ELECTRIC CORPORATION
ENGINEERING DIVISION

Date 5-9-77 Client CITY OF INDEPENDENCE, MO. Page No. 2
Job No. 5111-01 ICES FACILITY Sheet No. 2 of 4

ACCT NO.	ITEM OF WORK PRELIMINARY ESTIMATE	MATERIAL \$	LABOR \$	TOTAL \$
3.0	BOILER PLANT EQUIPT			9 650 8 00
4.0	TURBOGENERATOR UNITS			4 701 0 00
5.0	DATA LOGGER SYSTEM			3 870 0 00
6.0	ACCESSORY ELECTRIC EQUIPMENT			9 810 0 00
7.0	MISC POWER PLANT EQUIPMENT			1 150 0 00
8.0	TRANSMISSION PLANT			2 632 0 00
	TOTAL POWER PLANT			1 875 5 500
9.0	SERVICE CONNECTIONS TO HEATING AND COOLING BUILDING			131 000 00
	TOTAL POWER PLANT INCLUDING SERVICE CONNECTIONS TO HEATING AND COOLING BUILDING INCLUDING CONDUIT AND CABLE RUN			2 006 5 500

[illegible]

Total

3.4 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. These items form part of the Function B ICES Design Work Packages (5 through 8) as described in Section V. Several major design evaluations are also noted herein.

- A detailed heat balance and optimization of the steam cycle will be completed to maximize the plant fuel user efficiency.
- Plant site size requirements and equipment specifications will be formulated.
- 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.
- The use of a dry cooling tower versus a wet tower will be explored as a means of reducing the site water requirements.
- 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.
- Alternate plant sites will be evaluated with respect to economic and environmental impact and the ability to service the Demonstration Community.

TASK IV - COMMITMENTS

This section of the report contains information regarding the proposed financing and ownership of the facilities and equipment associated with the Integrated Community Energy System (ICES) project. It also presents statements of commitment by the City Council, major tenants/owners of the Independence Center, and key developers in the Demonstration Community area.

4.1 FINANCING

Pursuant to the provisions of Section 27 of Article VI of the Constitution of Missouri, 1945, and Ordinance No. 2335 of the City of Independence, a special election was held on September 15, 1970, for the purpose of submitting to the qualified electors of Independence a proposition to issue and sell electric light works revenue bonds in the principal amount of \$50 million. The votes cast at the special election were duly canvassed as provided by law, and it was determined that more than four-sevenths of the qualified electors who voted were in favor of the proposition. To date, \$17 million of the above principal amount has been issued.

The City of Independence intends to finance the capital costs of the ICES plant and equipment from the sale of the above mentioned electric light works revenue bonds. The current authorized, but unissued, bonding capacity of \$33 million is 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
6. Print and deliver bonds	3-4
Total elapsed time	<hr/> 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 this reason, coal is the most feasible fuel for power generation in the short term.

Domestic coal reserves are known to be sufficient to meet our 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 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. 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 ICE 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, 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. Letters of authority for the ownership and operation of the ICES plant and equipment--Mayor and City Manager, signatories--are appended to this section.

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 (Figure IV-1). 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 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 new study of the City-wide electric service rate structure is presently being done and should be completed during Phase II of the feasibility study.

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 as related to the type of electrical service provided. The users of the

FIGURE IV-1
GRID CONNECTION
CITY OF INDEPENDENCE ICS FACILITY

system in the Demonstration Community would pay rates according to their respective classification of service rates.

Ordinance No. 3727 and the applicable sections of the City Charter of the City of Independence (Public Utilities) and the City Code of the City of Independence (Article 5, Electric Utility) are appended to this section.

AN ORDINANCE ESTABLISHING THE SCHEDULE OF RATES AT WHICH ELECTRIC ENERGY WILL BE FURNISHED TO ALL CUSTOMERS OF THE CITY POWER & LIGHT DEPARTMENT WITHIN THE CORPORATE LIMITS OF THE CITY OF INDEPENDENCE, EFFECTIVE ON AND AFTER THE 20TH DAY OF MARCH, 1975, AND PROVIDING FOR SUCCESSIVE RATE INCREASES OF FOUR PERCENT EFFECTIVE JANUARY 1, 1976, AND FOUR PERCENT EFFECTIVE JANUARY 1, 1977, AND REPEALING ALL ORDINANCES AND PARTS OF ORDINANCES IN CONFLICT HEREWITH.

NOW, THEREFORE, BE IT ORDAINED BY THE COUNCIL OF THE CITY OF INDEPENDENCE, MISSOURI, AS FOLLOWS:

SECTION 1. That on and after the 20th day of March, 1975 the schedule of rates hereto attached shall be the rates charged by the City Power & Light Department for electric energy furnished to its customers within the corporate limits of the City of Independence, said schedule of rates being incorporated by reference herein and made a part hereof as though fully set out herein. Said schedule of rates shall apply to all bills for the general ledger month of April, 1975 beginning with Cycle 1 and thereafter.

SECTION 2. That the rates at which electric energy shall be furnished to all customers of the City Power & Light Department shall be increased by an additional four percent (4%) effective January 1, 1976.

SECTION 3. That the rates at which electric energy shall be furnished to all customers of the City Power & Light Department shall be increased by an additional four percent (4%) effective January 1, 1977.

SECTION 4. That all ordinances or parts of ordinances in conflict herewith shall be and the same are hereby repealed.

PASSED THIS 3rd DAY OF March, 1975, BY THE CITY COUNCIL OF THE CITY OF INDEPENDENCE, MISSOURI.

Presiding Officer of the City Council
of the City of Independence, Missouri

ATTEST:

City Clerk PL-12

APPROVED AS TO FORM ONLY:

City Counselor

REVIEWED BY:

City Manager

Public Utilities

Section 3.12. Electric utility department: Created, director. There shall be an electric utility department, the director of which shall be the electric utility director.

Section 3.13. Electric utility department: Powers and duties. The electric utility department shall operate the electric utility of the city.

Section 3.14. Electric utility department: Other utilities, enterprises, and services; changes of title of the department. The council by ordinance may provide that the electric utility department shall operate other public utilities, enterprises, and services which the city may operate; and also by ordinance may change the title of the department and of the director to department of public utilities and director of public utilities respectively; provided that nothing herein shall prohibit the council by ordinance from creating a separate department or departments for any one or more such other utilities, enterprises, and services.

Section 3.15. Public utilities advisory board: Created, membership. There shall be a public utilities advisory board, which shall consist of five members appointed by the council for overlapping four-year terms. The council shall appoint the five original members so that their terms will expire on July 1 in the years as follows: One in 1963, one in 1964, one in 1965, and two in 1966.

Section 3.16. Public utilities advisory board: Powers and duties. The powers and duties of the public utilities advisory board shall be solely advisory. It shall have power to inspect all public utilities owned and operated by the city and all public utilities operating under franchises or permits granted by the city; to require from any city department, officer, or agency any information available concerning public utilities; to subpoena witnesses to testify and to compel the production of documents and other effects as evidence; and to conduct public hearings on matters relating to public utilities. The board shall report its findings and recommendations to the people of the city, to the council, and to the city manager, as it deems appropriate. It shall report to the people and to the council at least annually. On request by the council or the city manager, the board shall study and give its findings and recommendations on any question or matter pertaining to the use, ownership, service, operation, or franchising of public utilities.

Section 3.17. Municipally owned and operated utilities and enterprises. The municipally owned and operated electric system is a public utility and shall be operated in a businesslike manner.

The electric utility shall not be operated for the benefit of other municipal functions, and shall not be used directly or indirectly as a general revenue producing agency for the city, but it may pay to the city an amount in lieu of such taxes as are normally placed upon private business enterprises. After providing for depreciation accruals and amortization of bonds, and for reasonable accumulation of surplus, the electric utility shall apply all annual profits to rate reductions.

City Charter of Independence
Section 3.17. (continued)

The electric utility and such other public utilities and enterprises as the council may require, shall be operated from funds separate from the general fund. An accounting system for each such fund shall be established within the general accounting system of the city, and shall be so set up and maintained as to reflect annually or as often as the council may require the financial condition of the enterprise and its income and expense.

(City Code of the City of Independence)

ARTICLE 5. ELECTRIC UTILITY

SEC. 16.05.001. DEFINITIONS.

In this article, unless the context requires otherwise:

1. CITY means the City of Independence, Missouri.
2. ELECTRIC UTILITY DIRECTOR means the Electric Utility Director of the City Power and Light Department or his designated representative.
3. PERSON means person, firm, corporation, partnership or association.

SEC. 16.05.002. SCHEDULE OF ELECTRIC RATES TO GOVERN CHARGES.

A schedule of electric rates duly adopted by ordinance upon the recommendation of the Electric Utility Director shall govern the charges to be made by the City for electric service rendered by the City Power and Light Department.

SEC. 16.05.003. SCHEDULE OF ELECTRIC RATES - FILED WITH CITY CLERK.

A schedule of electric rates, as amended from time to time by the City Council, shall be kept on file in the office of the City Clerk and shall be available for public inspection during all regular business hours.

4.5 TERMS OF SERVICING HOMART CENTER

Although the task outline indicates Homart only as the focus for negotiations for energy supply, meetings and conferences have been held with local and regional officials from all major tenants of the Independence Center. The assumption has been made and agreed to by the City and the major tenants of Homart Center (i.e., Homart, Sears, Macy's, and Stix) that connections to the ICE System will take place when interfacing of the new and existing equipment is possible.

Rates for each segment of the energy 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 influences on service line routing, etc. Rate schedules will be further defined as information 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 square feet in place as of 1979. As indicated elsewhere in this report, other new construction will be started within this time frame. However, for the purpose of phasing the ICE System, the City is concentrating on those structures that will be a reality at the time service connections will be possible.

Rate schedules will be similar to the existing rate schedules for electric service in terms of scheduling according to user size and type. 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.

PROPOSALS BY MAJOR DEVELOPERS (1977-1979)

<u>Developer</u>	<u>Structure</u>	<u>Size (ft²)</u>
Paul Roberts	Commercial Center	129,260
Frank Morgan	Commercial Center	90,000
J. R. Stewart	Office Park	60,000
Ross Wyss	Apartment Complex	135,000

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TASK V - DETAILED WORK MANAGEMENT PLAN

5.1 WORK MANAGEMENT PLAN

This section presents a detailed work management plan for Phase II of the City of Independence grid-connected ICES project and, to a lesser degree, the succeeding phases.

The objective of Phase II is to perform a detailed feasibility analysis and preliminary design of a grid-connected ICES facility to serve the thermal needs of the Independence Center Demonstration Community located in Independence, Missouri. Performance of Phase II by the City of Independence project team will provide the necessary documentation of project feasibility and design for review by the U.S. Energy Research and Development Administration.

Succeeding project phases will include the following:

Phase III - Final Design

Phase IV - Project Construction

Phase V - Installation, Startup, and Performance Testing
and Management

Phase VI - Operation and Maintenance Management and Long-
Term Demonstration Evaluation

In many respects, the demonstration team holds the key to the successful design and operation of the Independence ICES project. The demonstration team consists of the original Phase I participants,* ERDA, owners and operators of the Independence Center Demonstration Community, and the public.

*Original team members: City of Independence (prime contractor); Public Technology, Inc., and NUS Corporation.

Because of the complexity and demands on the Demonstration Community presented by Phase II, it may become necessary to further subcontract some specific work package subtasks of a specialized nature. This will depend on the project schedule, work load of members of the demonstration team, and identification of specific subtasks that can best be accomplished in this manner.

ERDA - Through Phase I, ERDA has emphasized its role as a "partner" in the implementation of the Independence ICES project. This partnership will be particularly welcome in Phase II, which represents a considerable expansion of the level of effort over Phase I. Experience gained in Phase I calls attention particularly to problems created by a very confining schedule--one that shows no signs of relaxation for the accomplishment of Phase II. As a partner vitally interested in the success of this project, ERDA can be of tremendous assistance by expediting contractual arrangements, maintaining simple reporting requirements, and minimizing the requirement for effort other than that bearing directly on achieving of the objective of Phase II.

Demonstration Community - Members of the Demonstration Community include Homart, operators of major department stores in the Independence Center Shopping Mall, and local developers of adjacent properties. In Phase II, firm commitments will be obtained from the Demonstration Community for participation in the ICES facility and for utilizing the system's thermal output. In addition, members of the Demonstration Community will play a key role in determining the exact layout of the system's distribution network as well as the specifics of system hookup to the users.

Public - Because ICES is a public project undertaken with public funds, an involved public is a necessity. This includes the overall community of Independence which is to build and operate the ICES plant, neighbors of the project, and a general national public for whom energy conservation is becoming a growing concern.

5.1.1 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, subject to finer delineation by subtask. Several of the work packages will carry through 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.

Project work packages are grouped according to four major functions within the overall work management plan. These functions are System Analysis, ICES Design, Project Management, and Implementation. Table V-1 outlines the principal work packages to be performed in Phase II.

Figure V-1 links the Phase II functions and work packages to one another and to the key project participants. Although the actual performance of Phase II is far more complex than that shown, Figure V-1 represents a very effective means of relating work packages to each other and to the organizations with major responsibilities for this project.

The individual work packages and the subtasks that comprise them are described in this section.

5.1.1.1 Environmental Assessment - Work Package 1

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

TABLE V-1
WORK PACKAGES - PHASE II ICES PROJECT

<u>Function</u>	<u>Work Package</u>
A. System Analysis	1. Environmental Assessment 2. Energy Audit 3. Cost Analysis 4. System Operation
B. ICES Design	5. Thermal Distribution and Hookup 6. Thermal Transmission and Conversion 7. Power Plant 8. Control and Feedback System
C. Project Management	9. Project Management 10. Value Engineering 11. Information Dissemination/Technology Transfer
D. Implementation	12. Regulatory Obligations 13. Service Commitments 14. Work Management Plan

FIGURE V-1

MAJOR PROJECT ELEMENTS, PHASE II

Relation to Phase I Work

In Phase I, environmental considerations were reviewed and outlined with respect to their impact on the ICES project and the impact of the project on the environment of the Demonstration Community. Phase II subtasks expand greatly on this effort and provide for ERDA the material it needs to fulfill the requirements of the National Environmental Policy Act with respect to the environmental impact of the Independence ICES project.

Relation to Phase III Work

Although environmental considerations will be important throughout the design, construction, and operation of the ICES facility, environmental assessment as a major, separable work package will be completed at the end of Phase II.

Detailed Subtasks - Environmental Assessment

The subtasks of Work Package 1 can be categorized as follows:

- a. Perform meteorological and air quality studies, including atmospheric dispersion of stack effluents, stack height optimization, and flue gas cleaning systems. Analyze cooling tower impacts; makeup, blowdown, and water consumption; visible plume; fogging and icing; and acid rain potential. Predict atmospheric impacts during construction, including fugitive dust, construction equipment exhaust emissions, etc., and identify mitigating measures.
- b. Evaluate and review impacts associated with the noise of construction and operation.
- c. Identify major characteristics of terrestrial ecology, using aerial photographs and limited site reconnaissance

on land area affected by the construction and operation of the ICES facilities. Describe probable animal species in the area and evaluate the project's impacts, particularly on any rare and endangered species.

- d. Characterize the ecology of the Little Blue River and any tributaries (Crackerneck Creek) impacted by the ICES project.
- e. Using baseline geologic and hydrologic information, predict the impacts of construction and operation on local ground and surface waters.
- f. Compile socioeconomic and sociocultural characteristics of the affected site and environs, including archaeology, proximity of historic sites, recreational areas, aesthetic views, surrounding land uses, availability of construction labor, highway local tax base, schools, housing, public services, etc. Predict impacts of construction (e.g., increased demand for public services, increased traffic, disrupted archaeological resources, etc.) and operation (aesthetics, local tax base, etc.).
- g. Coordinate all environmental investigations. Provide interface with ERDA and architect-engineer. Prepare progress reports. Integrate inputs from architect-engineer (plant design, site selection, evaluation of alternative systems, geologic/hydrologic data, etc.) and from environmental studies.

Interim Output from Work Package 1

The interim output from Work Package 1 will be a draft report for review and comment by ERDA.

Final Output from Work Package 1

The final output from Work Package 1 will be the final environmental assessment report, which will contain information required by ERDA for the preparation of a draft environmental impact statement. ERDA comments will be reflected in the final environmental report.

5.1.1.2 Energy Audit - Work Package 2

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..

Relation to Phase I Work

Actual and projected energy demands for Independence Center and for new development in the Demonstration Community were calculated in Phase I. However, no assessment was made with regard to energy utilization and energy conservation in the existing facilities of Independence Center. The energy audit, therefore, is a logical component of any energy conservation project of the nature of the ICES.

Relation to Phase III Work

One major user of the ICES facility, the Independence Center, is presently in existence. Other major users will be developed prior to the operation of the ICES, with additional incremental development taking place through the year 1990. Low-level audits will be performed on new buildings in the Demonstration Community when they are in the design stage. Once the ICES is on-line, periodic evaluations will be made of each ICES user to ensure that all possible energy conservation measures are being implemented.

Detailed Subtasks - Energy Audit

The subtasks of Work Package 2 are the following:

- a. Review of energy consumption records for Independence Center, based on utility billings, fossil fuel billing (if any), and in-place observations.
- b. Assessment of the functional characteristics of each building, including period of occupancy, operational characteristics, lighting, etc.
- c. Review of the architectural, electrical, and mechanical features of each building with respect to energy conservation.
- d. Determination of retrofit modifications for the reduction of fuel and energy inputs.
- e. Compilation of an energy utilization index (in 10^3 Btu/ft²-yr) for each facility.

Interim Output from Work Package 2

The interim output from Work Package 2 will be the results of individual facility audits for discussion with building owners and operators.

Final Output from Work Package 2

The final output from this work package will consist of energy audit reports that pinpoint deficiencies and opportunities for energy conservation.

5.1.1.3 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.

Relation to Phase I Work

Detailed capital and operating costs for the ICES facility were developed in Phase I. These represented a preliminary cost estimate, which is one of three cost estimates normally produced in a detailed engineering design of large magnitude. Most cost analyses performed in Phase II will begin where Phase I left off; that is, they will build on data already obtained and generated.

Relation to Phase III Work

Control estimates are normally produced when design is 70% complete. Final cost estimates are produced when design is 100% complete. Both of these estimates of major significance to the project will be made in Phase III.

Detailed Subtasks - Cost Analysis

The detailed subtasks of Work Package 3 are the following:

- a. Refinement of the capital cost estimate on a continuous basis as design studies are completed and design decisions are finalized (links to Work Packages 5 to 8)
- b. Development of detailed operating costs, maintenance, manpower, etc., as systems analysis of ICES is performed and completed (links to Work Package 4).

- c. Review of the power-generating costs in the City of Independence grid, relating to projected ICES costs.
- d. Development of appropriate electrical and thermal rate structures based on costs of the ICES facility. Presentation of proposed rate structures to developers in the Demonstration Community.
- e. Performance of other appropriate economic and cost analyses.

Interim Output from Work Package 3

The interim output will be continuous cost estimate refinement and comparison to City generating costs.

Final Output from Work Package 3

The final output from this work package will be the rate structure design for electrical and thermal energy service.

5.1.1.4 System Operation - Work Package 4

The objective of Work Package 4, System Operation, is to perform analyses of the ICES system and its components to develop efficient system operation.

Relation to Phase I Work

Several systems studies were performed as part of the preliminary feasibility analysis of the ICES project for the City of Independence. These studies related to the selection, size, and operation of the particular ICES system selected for detailed design.

Relation to Phase III Work

Optimizing system operation will be a continuous activity throughout the life of this project. However, most significant system operation studies will be completed in Phase II. Once the ICES is constructed and put into operation (Phases V and VI), it will be necessary to monitor the system's performance and compare the results to analyses made in Phase II. Adjustments in the operating schedule may need to be made at that time.

Detailed Subtasks - System Operation

- a. Perform fuel evaluation studies to analyze boiler performance with different grades of coal and oil to determine an acceptable range of fuels.
- b. Analyze final boiler steam supply conditions in order to maximize boiler performance in relation to thermal and electrical demands.
- c. Optimize absorption chiller unit configuration (single stage vs two stage).
- d. Determine turbine load and number to optimize energy output for steam input.
- e. Develop discussions with customers (Demonstration Community) in order to establish user needs and preference with regard to system operation, supply of hot and chilled water.
- f. Relate ICES operation to the City of Independence electrical grid system in order to optimize the production of electricity for grid interconnection.

- g. Develop operating schedules, guidelines, and rules for system operation.

Interim Output from Work Package 4

The interim output will consist of the results of analyses of impact on system design criteria and on customer acceptance of ICES.

Final Output from Work Package 4

Reports on system operations and optimization as well as a manual for system operation will comprise the final output from Work Package 4.

A network chart for Work Package 4 is presented in Figure V-2.

5.1.1.5 Thermal Distribution and Hookup - Work Package 5

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.

Relation to Phase I Work

Phase I included conceptual designs of all the components being designed in this work package.

Relation to Phase III Work

Phase III constitutes the detailed facility design that continues directly from Phase II.

Detailed Subtasks - Thermal Distribution and Hookup

- a. Preliminary design analysis of piping and hookup components.
- b. Engineering calculations to determine pipe, valve, and pump sizes, types, and other specific characteristics.
- c. Detailed site survey, including grade, requirements for excavation and paving, drainage, erosion control, footings, and all site-related design characteristics.
- d. Schematic and block diagrams of piping and hookup to Independence Center.
- e. Discussion with users on details of hookup.
- f. Detailed design of pipe entrance to buildings and hookup to existing heating and cooling systems.
- g. Materials and process specifications listing.
- h. Preliminary mockup and model, and development of design report.

Interim Output from Work Package 5

The interim output will consist of (1) a schematic and block diagram of the thermal distribution system and hookup to Independence Center and (2) materials and process specifications listing.

Final Output from Work Package 5

The final output will consist of (1) preliminary mockup and model and (2) design report.

A network chart for Work Package 5 is presented in Figure V-3.

5.1.1.6 Thermal Transmission and Conversion - Work Package 6

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. Absorption liquid chillers
- e. Condensers
- f. Pumps
- g. Cooling tower
- h. Auxiliary oil-fired boiler

Relation to Phase I Work

Phase I included a conceptual design of all components being designed in this work package.

Relation to Phase III Work

Phase III constitutes the detailed facility design that continues directly from Phase II.

Detailed Subtasks - Thermal Transmission and Conversion

- a. Preliminary design analyses of high-pressure steam line.
- b. Engineering calculations to determine piping and pump sizes.
- c. Preliminary design of heating and cooling facility structure, its optimal location, size requirements, site characteristics, and service requirements.
- d. Schematic and block diagrams of all mechanical equipment, steam lines, etc.
- e. Detailed design of all structures, footings, and equipment bases, including architectural design.
- f. Materials and process specifications listing.
- g. Preliminary mockup, model, and development of design report.

Interim Output from Work Package 6

The interim output from Work Package 6 will be (1) schematic and block diagrams of the thermal transmission system and heating

and cooling facility and (2) materials and process specifications listing.

Final Output from Work Package 6

The final output will consist of (1) preliminary mockup and model and (2) design report.

5.1.1.7 Power Plant - Work Package 7

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

Relation to Phase I Work

Phase I included a conceptual design of all components being designed in this work package.

Relation to Phase III Work

Phase III constitutes the detailed facility design that continues directly from Phase II.

Detailed Subtasks - Power Plant

The power plant represents the largest component of the ICES facility and contains many subsystems and facilities, each requiring detailed design attention. The detailed subtasks of this work package are the following:

- a. Analysis of power plant site: evaluation of the site tentatively selected in Phase I and comparison with nearby sites for cost, subsurface conditions, flood hazard, site preparation work, and distance from heating and cooling plant.
- b. Layout of the power plant site with regard to railroad siding, drainage, road access, coal handling and storage, and ash removal and handling.
- c. Evaluation of the necessary environmental controls and performance of preliminary design analyses on all environmental control systems.
- d. Preliminary design analysis of boiler system, steam transmission, and combustion package; turbine generator and electrical grid connection; and all water and piping systems.
- e. Engineering calculations with regard to fuel handling, storage and conveyance, ash pond and cooling system, and overall materials handling packages.
- f. Building laying, structural design, stack, equipment placement, and architectural design.
- g. Schematic and block diagrams of all internal process and combustion systems.

- h. Detailed design of all mechanical and electrical equipment.
- i. Materials and process specifications listing.
- j. Preliminary mockup and model, and development of design report.

Interim Output from Work Package 7

The interim output will consist of the following:

- a. Schematic and block diagrams
- b. Site plan and layout
- c. Building layout and preliminary designs
- d. Materials and process specifications listing

Final Output from Work Package 7

The final output will consist of (1) preliminary mockup and model and (2) design report.

5.1.1.8 Control and Feedback System - Work Package 8

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 customer's internal systems.

Relation to Phase I Work

Control and feedback systems were considered in Phase I to be a necessary part of the ICES facility. However, no design of such systems has been initiated to date.

Relation to Phase III Work

Detailed design of necessary control and feedback systems will continue directly in Phase III.

Detailed Subtasks - Control and Feedback System

- a. Perform a functional analysis of all control and feedback systems needed for the ICES facility and its customers.
- b. Develop a conceptual design of control systems, including control locations, functions, inputs, and responses.
- c. Develop a conceptual design of feedback systems, including information required, input data, response to information, storage and data analysis requirements, and real-time feedback.
- d. Investigate computer and data processing systems and links to be considered as part of an overall control and feedback system.
- e. Analyze and design metering systems for thermal energy transfer from ICES to the system's customers.
- f. Develop schematic diagrams of all systems.
- g. Confer with Demonstration Community users on their control system needs.

- h. Link control systems concepts to actual ICES hardware being designed for the power plant, thermal transmission, and distribution systems.
- i. Develop feasibility analyses and evaluate alternative control and feedback systems.

Interim Output from Work Package 8

The interim output from Work Package 8 will consist of the schematic diagrams of all systems.

Final Output from Work Package 8

The final output from this work package will be a feasibility report and a recommended control and feedback system.

5.1.1.9 Project Management - Work Package 9

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.

Relation to Phase I Work

Project management is a continuous function throughout all phases of this project. As in Phase I, the City of Independence will be responsible for overall project management.

Relation to Phase III Work

All project management functions will continue into Phase III.

Detailed Subtasks - Project Management

- a. Preparation of monthly status and financial reports to ERDA.
- b. Preparation of reports on major task outputs.
- c. Review meetings between subcontractors, developers, ERDA, and the project management team.
- d. Monitoring of all project schedules.
- e. Preparation of draft and final reports.

Interim Output from Work Package 9

The interim output will consist of monthly status and financial reports.

Final Output from Work Package 9

Draft and final reports on all project tasks will comprise the final output from Work Package 9.

5.1.1.10 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.

Relation to Phase I Work

The value engineering exercise bears no relation to work initiated in Phase I, other than to the degree that Phase I design decisions may affect the ultimate cost of the ICES project.

Relation to Phase III Work

Value engineering is best performed at a design stage early enough to impact on the final design, but late enough for sufficient information to be at hand. GSA and EPA recommendations vary, but generally indicate that value engineering should take place at the 30-60% completion point in project design. To conform with these recommendations, two value engineering reviews will be scheduled, one late in Phase II and the other in Phase III.

Detailed Subtasks - Value Engineering

Recommended GSA and EPA techniques for value engineering will be followed. Standard procedures relate to the following subtasks:

- a. Undertake pre-workshop preparation to distribute relevant background information to members of the value engineering team.
- b. Collect all data, facts, and opinions pertinent to the design being considered.
- c. Create an extensive list of alternative ways to perform essential project functions. Use a matrix approach to develop a functional analysis and cost model for the project.
- d. Analyze and evaluate each alternative functional approach to project design.
- e. Investigate in detail the most feasible alternatives to project design, concentrating on realistic cost data provided for each project function.
- f. Recommend alternative design strategies for those functions where cost effectiveness can be enhanced over original design.

- g. Follow up on recommendations and expedite their implementation.

Interim Output from Work Package 10

The interim output will consist of oral presentation and preliminary report of value engineering findings.

Final Output from Work Package 10

The final output from this work package will be the final value engineering report to the project manager.

5.1.1.11 Information Dissemination/Technology Transfer - Work Package 11

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.

Relation to Phase I Work

In Phase I, the City of Independence began a public dialogue within the community on the ICES project. This included newspaper coverage in major local dailies and discussion of the project by Mayor King at a news conference. Also in Phase I, Public Technology, Inc., developed the membership for a User Requirements Committee from key individuals from jurisdictions having an interest in cogeneration systems. These efforts will be expanded greatly in Phase II.

Relation to Phase III Work

Efforts in providing public information and transfer of important energy conservation technology will continue throughout Phase III and for the duration of this demonstration program.

Detailed Subtasks - Information Dissemination/Technology Transfer

- a. A User Requirements Committee (URC), formed in Phase I, will be used to provide technical, operational, and economic requirements to the project, in addition to guidance, market data, and performance evaluation criteria. The URC has been found to be a practical, convenient method of approaching the problems of technology transfer.
- b. 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. Public Technology, Inc., will use its existing national communications network to disseminate the newsletters, including its own newsletter with 3500 subscribers, as well as publications of its sponsoring organizations (e.g., the International City Management Association, National Association of Counties, National Governors' Conference, National League of Cities, and the U.S. Conference of Mayors).
- c. Public Technology, Inc., will begin work in Phase II on an ICES Decision Manual that documents the planning process for the ICES for use by others in the future.

Interim Output from Work Package 11

Two User Requirements Committee meetings will be held during Phase II, with feedback on project design resulting.

Final Output from Work Package 11

The principal final output in Phase II will be newsletters that are widely distributed both in Independence and beyond, and informational material provided to other publications.

5.1.1.12 Regulatory Obligations - Work Package 12

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.

Relation to Phase I Work

Phase I included a review of all obligations, regulations, and laws that the City would need to conform to in implementing its ICES facility. The Phase II effort will be to implement the necessary approvals.

Relation to Phase III Work

It is anticipated that this work package will continue into Phase III as necessary.

Detailed Subtasks - Regulatory Obligations

- a. Meetings with appropriate regulatory agencies to present the basis for the ICES project and to receive guidance on submitting applications.
- b. Public hearings related to all permits, licenses, and approvals.
- c. Submission and "bird-dogging" of regulatory applications.

Interim Output from Work Package 12

Applications for regulatory approvals accompanied by appropriate ordinances will constitute the interim output.

Final Output from Work Package 12

The final output from this work package will consist of the licenses and permits obtained.

5.1.1.13 Service Commitments - Work Package 13

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.

Relation to Phase I Work

Meetings and discussions with developers in the Demonstration Community took place in Phase I. Letters of commitment from developers are presented in Section IV of this report. Phase II efforts will bring these commitments to fruition.

Relation to Phase III Work

All commitments from Independence Center developers will be obtained in Phase II. As other developers in the Demonstration Community firm up their plans, commitments will be obtained in Phase III and in later project phases. Bonds for project financing will be issued in Phase III, under a separate work package.

Detailed Subtasks - Service Commitments

- a. Meetings with owners and developers to present the ICES proposal for service.

- b. Calculation and development of thermal and electrical rates to the ICES users.
- c. Contact with key suppliers to firm up commitments to supply necessary materials and equipment for the ICES project.
- d. Preparation of contracts and agreements with the ICES users.
- e. Negotiations leading to signed contracts for service.
- f. In Phase III, the issuing of bonds will entail the selection of a bond attorney, preparation of a prospectus, evaluation of bids, and the printing and delivery of bonds.

Interim Output from Work Package 13

The interim output will consist of electrical and thermal service rate structures.

Final Output from Work Package 13

The final output from this work package will be signed contracts from owners and developers for ICES service.

5.1.1.14 Work Management Plan - Work Package 14

The objective of Work Package 14, Work Management Plan, is to facilitate the implementation of the²later phases of this project through the development of a detailed work management plan.

Relation to Phase I Work

Task V in Phase I was the preparation of a work management plan for subsequent phases of the demonstration program. This work package for Phase II represents a continuation of that activity.

Relation to Phase III Work

Work Package 14 will provide the City of Independence and ERDA a detailed work management plan for Phase III and beyond. Because of the complexity of this project and the very tight schedule, it is essential that no time be lost in the transition between Phases II and III. Therefore, a work management plan will be in effect as Phase III begins.

Detailed Subtasks - Work Management Plan

- a. Describe tasks (work packages) necessary to complete Phase III and subsequent phases.
- b. Establish a continuing program management team with responsible officials of organizations participating in this project.
- c. Provide network and milestone charts as guidance for the performance of Phase III tasks.
- d. Develop manpower/resource plans and cost estimates for each task in Phase III.
- e. Allocate Phase III responsibilities for the performance of required tasks.

Interim Output from Work Package 14

There will be no interim output from this work package.

Final Output from Work Package 14

The final output will consist of detailed work management plan.

5.1.2 Network Charts

Typical project management network charts for Phase II are presented in Figures V-2 and V-3. Detailed charting for each project work package will be performed prior to the initiation of Phase II.

Figure V-2 represents a network chart for Work Package 4, System Operation. As shown in the chart, the final work package output is a series of operating guidelines for the ICES facilities, based upon the system operation analyses indicated on the chart.

Figure V-3 shows a network chart for one of the ICES design work packages, Thermal Distribution and Hookup. The design tasks are the most complex and detailed tasks of Phase II, and a considerable amount of work planning and scheduling will be necessary in order to carry out these tasks.

5.1.3 Milestone Charts

Figure V-4 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.

FIGURE V-2

TYPICAL PHASE II NETWORK CHART
WORK PACKAGE 4, SYSTEM OPERATION

FIGURE V-3

TYPICAL PHASE II NETWORK CHART FOR A DESIGN WORK PACKAGE
WORK PACKAGE 5, THERMAL DISTRIBUTION AND HOOKUP

FIGURE V-4

TENTATIVE DESIGN & CONSTRUCTION SCHEDULE

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-5 shows key Phase II milestones for each of the fourteen work packages established.

5.1.4 Cost Breakdown

This section presents cost breakdowns by work package for Phase II (see Table V-2) and subsequent phases (Table V-3). Because the degree of detail for Phase II exceeds the level of specificity known for the later phases, only the cost breakdown for Phase II can be considered to be better than approximations at this time.

The total estimated cost for Phase II is \$847,000. The estimated total costs for the succeeding phases are as follows:

	<u>Total Cost</u>
Phase III, Final Design	\$1,330,000
Phase IV, Construction	\$28,434,000
Phase V, Initial Operation, Testing, and Monitoring	\$2,096,000
Phase VI, Long-Term Operation and Monitoring (cost per year)	\$1,646,000

DATE (1977-1978)

FUNCTION

WORK PACKAGE

7-1 8-1 9-1 10-1 11-1 12-1 1-1 2-1 3-1

A.

SYSTEM ANALYSIS

1. ENVIRONMENTAL ASSESSMENT
2. ENERGY AUDIT
3. COST ANALYSIS
4. SYSTEM OPERATION

B.

ICES DESIGN

5. THERMAL DISTRIBUTION
6. THERMAL TRANSMISSION
7. POWER PLANT
8. CONTROL & FEEDBACK

C.

PROJECT MANAGEMENT

9. PROJECT MANAGEMENT
10. VALUE ENGINEERING
11. INFORMATION DISSEMINATION

D.

IMPLEMENTATION

12. REGULATORY OBLIGATIONS
13. SERVICE COMMITMENTS
14. WORK MANAGEMENT PLAN

KEY

- INTERNAL PROGRESS REVIEW
- PROGRESS MEETINGS
- PROGRESS REVIEW WITH DEMONSTRATION COMMUNITY
- DEMONSTRATION COMMUNITY DECISION POINTS
- △ DRAFT REPORT
- ▲ FINAL REPORT
- X PROGRESS REPORT

FIGURE V-5 PHASE II MILESTONE CHART

TABLE V-2

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 Manage- ment	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-3

COST BREAKDOWN - PHASES III-VI OF THE DEMONSTRATION PROGRAM

<u>Work Package</u>	<u>Cost (\$1000) by Project Phase</u>			
	<u>III</u>	<u>IV</u>	<u>V</u>	<u>VI*</u>
Energy Audit	10	10	10	10
Cost Analysis	50	0	0	0
System Operation	0	0	100	50
Thermal Distribution and Hookup	76	2,197		
Thermal Transmission and Conversion	110	3,206		
Power Plant	735	21,163		
Control and Feedback 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 Manage- ment	50	250	150	0
Testing and Monitoring	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

*For Phase VI, all costs are in thousands of dollars per year (1977 dollars).

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.

The City of Independence will continue to serve as the principal contractor to ERDA and will carry out all functions of management and coordination in Phase II. The City of Independence will assume the primary responsibility for the following project 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 to Independence 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 6: Thermal Transmission and Conversion
- Work Package 7: Power Plant
- Work Package 8: Control and Feedback System
- Work Package 10: Value Engineering

5.2.1 Organization Charts

This program brings together a multidisciplinary team from three organizations, each with explicit project responsibilities. Management of the project is effected through a three-level hierarchy of management control, as follows:

Level 1: Program Director

Level 2: Project Manager, each participating organization

Level 3: Task Manager, each work package

Reporting to each task manager will be the senior and support personnel assigned to this project. An overall project organization chart is shown in Figure V-6. Organization charts for each participating organization are presented in Figures V-7 through V-9.

5.2.2 Responsible Officials

Responsible officials with decision-making authority for the City of Independence include the Mayor and members of the City Council, as follows:

<u>Name</u>	<u>Title</u>	<u>Evidence of Authority</u>
R. A. King	Mayor*	City Charter
E. L. Comer	Council Member*	
C. E. Cornell	Council Member*	
R. A. Heady	Council Member*	
D. Holder	Council Member*	
M. A. Overman	Council Member*	
R. G. Williamson	Council Member*	
L. W. Alberg	City Manager**	

*Ultimate decision-makers regarding the City's role in ICES project.

**Chief Administrative Officer for the City of Independence.

FIGURE V-6
PROJECT ORGANIZATION CHART

FIGURE V-7
ORGANIZATION CHART
CITY OF INDEPENDENCE WORK PACKAGES

FIGURE V-8

**ORGANIZATION CHART
PUBLIC TECHNOLOGY, INC., WORK PACKAGES**

FIGURE V-9
ORGANIZATION CHART
NUS CORPORATION WORK PACKAGES

Developers and owners in the Demonstration Community represent the users of the ICE system. The responsible officials empowered to act on behalf of the Demonstration Community include the following:

<u>Company</u>	<u>Responsible Official</u>
Homart Development Co.	William R. Steinman, Corporate Engineer
Andes & Roberts Construction Co.	Paul R. Roberts
Morgan Construction Company	I. I. Ozar, Counselor at Law
J. R. Stewart Construction Co..	J. R. Stewart
Macy's Missouri-Kansas	Thomas J. Kenny, Senior Vice President and Director of Operations

Each organization represented on the demonstration team is assigning top-level personnel to take responsibility for this project. In each case, the project manager of each respective organization reports directly to that responsible individual, as follows:

City of Independence:

Responsible Individual - Lyle W. Alberg, City Manager
Project Manager - Robert L. Svehla

Public Technology, Inc.:

Responsible Individual - Ronald J. Philips,
Senior Vice President
Project Manager - William M. Mascenik

NUS Corporation:

**Responsible Individual - Peter D. Arrowsmith,
Vice President and General
Manager, Engineering Division**

Project Manager - Thomas A. Russell

The lines of authority within each participating organization are clear-cut and go directly to senior officials with specific authority to carry out all assigned responsibilities.

5.2.3 Manpower and Resources

Each participant in the project team has estimated the need for the following manpower resources for the completion of Phase II:

City of Independence	2,830 man-hours
Public Technology, Inc.	1,600 man-hours
NUS Corporation	28,800 man-hours

The estimated manpower needs for Phase II by work package are presented in Table V-4.

The qualifications of key individuals participating in Phase II are presented in Appendix B.

TABLE V-4
MANPOWER ESTIMATE - PHASE II

<u>Work Package</u>	<u>Estimated Man-Hours</u>			
	<u>City of Independence</u>	<u>PTI</u>	<u>NUS</u>	<u>Total</u>
1	150		1,536	1,686
2	80	400		480
3	240		1,100	1,340
4	240		1,400	1,640
5	100		1,640	1,740
6	100		2,400	2,500
7	600		16,964	17,594
8	100		2,280	2,380
9	600		80	680
10	100		600	700
11	100	1,200		1,300
12	160			160
13	300			300
14	<u>100</u>	<u> </u>	<u>800</u>	<u>800</u>
TOTAL	2,830	1,600	28,800	33,230

APPENDIX A

ICES PLANT EVALUTION, METHODOLOGY, AND COMPUTER CODE

This appendix presents a description of the evaluation techniques, methodology, and computer programs used to predict the performance of the various Integrated Community Energy System (ICES) concepts. The appendix is divided into three parts. Part 1 discusses the optimization for coal-fired ICES plants in terms of a split between absorption and electric Rankine cycle cooling. Part 2 discusses the methodology employed to predict the heating and cooling loads, the fuel consumption for the various ICES systems, the net output power, the fuel credit, economic models, and other pertinent characteristics. Part 3 is a listing of the computer program developed to assist in evaluating the ICES concepts.

A.0. System Optimization Regarding Absorption Cooling or Electric Rankine Cycle Cooling

The present Independence Center community (1.17×10^6 ft²) obtains cooling by electric Rankine cycle machines. With the development of an ICES project, these machines will be used mainly if additional capacity over that provided by the ICES plant absorption coolers is required. Recognizing that there may be an optimum split between electric Rankine cycle and absorption cooling, a study was performed on the coal-fired ICES plants alone to establish the merits of an absorption/electric Rankine cycle split. The results of this study are described below.

A.0.1 3-MWe Coal-Fired ICES Plant Operating on Demand for Heating and Cooling (Cooling Provided by Single-Stage Absorption and Electric Rankine Cycle Machines)

Figure A-1 illustrates five characteristics evaluated to establish an optimum absorption/electric Rankine cycle split. The system operation is based on 1980 thermal loads. As shown in Figure A-1,

FIGURE A-1

COAL-FIRED ICES PLANT OPERATING ON DEMAND FOR
HEATING & COOLING (COOLING VIA SINGLE-STAGE
ABSORPTION VS ELECTRIC CHILLER CAPACITY)

the cooling load will primarily be supplied by absorption cooling. When the demand for cooling exceeds the capacity of the absorption coolers, the electric Rankine cycle machines make up the difference in cooling capacity.

The first characteristic, net annual fuel consumption (curve 1), decreases from 1.77×10^{11} to 1.53×10^{11} Btu/yr as the electric Rankine cycle cooling increases to 100% of the total. Therefore, from a fuel consumption viewpoint, cooling should not be provided at all by absorption coolers.

The second characteristic (curve 2), supply cost for heating and cooling (dollars per million Btu of heat addition or heat removal) shows a minimum value when the electric cooling capacity is approximately 44% of the maximum cooling load (i.e., absorption cooling capacity is 31.1×10^6 Btu/hr and electric Rankine cycle capacity is 24.4×10^6 Btu/hr). Curve 3 (electricity supply cost in mills per kilowatt-hour) also shows a slight minimum at this absorption/electric Rankine cycle split.

Curve 4 (maximum output electrical power) drops as the percentage of electric Rankine cycle cooling increases. Therefore a smaller size turbine-generator set is required. At the above optimum cooling split, the maximum output power for the 1980 thermal load is approximately 3.4 MWe. Curve 5 (ICES system heat rate) also shows improvement (i.e., decreasing heat rate) as the percentage of electric Rankine cycle cooling increases. The lowering of the heat rate reduces the fuel cost per unit of energy supplied.

Since the capital requirements are lowered due to the reduced absorption cooler capacity, the turbine-generator capacity is reduced, and the fuel costs are lowered due to the lowering heat rates, the supply costs for heating, cooling, and electricity are lowered to a minimum value at the above-discussed optimum cooling split. However, these supply costs begin to rise as the fraction

of electric cooling increases because the total capital requirements begin to level off, but the total quantity of absorption cooling continues to drop. Thus, the supply costs begin to rise as shown by these curves.

This evaluation shows that there is a potential optimum split between absorption and electric Rankine cycle cooling for a coal-fired ICES plant that is operated only on demand for heating and cooling. However, this system does not meet the power plant needs for the city.

A.0.2 20-MWe Coal-Fired Plant Providing Heating and Cooling as Required (Cooling Provided by Absorption Cooling)

Figure A-2 is similar to Figure A-1, except that it describes the operation of a 20-MWe coal-fired power plant supplying heating and cooling as required. Again the cooling load is primarily supplied by absorption chillers run by the plant, and electric Rankine cycle machines supply any cooling needed in excess of the capacity of the absorption coolers.

As shown in curve 1, as the electric cooling capacity increases, so does the fuel consumption. Also, as shown by curve 4, the equivalent heat rate for the plant increases too.

The 1980 thermal load capital requirements will drop for the absorption coolers as the capacity of the electric Rankine cycle machines increases. Therefore, there is an initial lowering in supply cost, as shown in curves 2 and 3. Furthermore, a slight minimum (optimum split) cost occurs when the electric Rankine cycle machine capacity is 15×10^6 Btu/hr and the absorption capacity is 40×10^6 Btu/hr. However, because the initial capital requirements for the 20-MWe boiler and turbine generator do not change with the absorption unit size and the resulting increase in system heat rate, the decrease in actual supply cost is almost insignificant.

Figure A-2 shows that for this case (i.e., \$300/ton, \$500/kW), the supply cost for 100% absorption cooling is only 1.3% higher than for the apparent minimum value. Because the detailed estimated capital cost for this plant is much higher than for this case, approximately \$1000/kW, the effect of absorption cooling becomes even more insignificant, and therefore the 20-MWe plant should be designed to supply 100% of the cooling loads by absorption coolers.

A.1 Heating and Cooling Loads

A.1.1 Independence Shopping Center

Energy demands at Independence Center were based upon actual average daily electric loadings over a two-year period at the Center, plus records of operating practices. The Homart section of the Center runs lights for 13 hours per day. Stix, Baer and Fuller keeps 40% of its lights operating 24 hours. Therefore, the electric light and auxiliary loads of Independence Center are estimated to be 13.7 Btu/hr.ft.² from 9:00 a.m. to 10:00 p.m. and .98 Btu/hr.ft.² from 10:00 p.m. to 9:00 a.m.

Heat added or lost to the building by system air changes is estimated to be $.18(T_o - T_m)$ Btu/hr.ft.² when T_o = outside air temperature and T_m = inside air temperature. The above is based on 90% of the ventilation flow being recirculated and 10% lost to the outside.

The heat load for an active person in a shopping center is estimated to be 450 Btu/hr./person. The total heat gain into the shopping center is equal to the number of people per square foot times 450 Btu/hr.person. The number of people is assumed to vary as a cosine function starting at zero at 9:00 a.m. and reaching a maximum of 1 person per 30 ft.² at 3:30 p.m. and ending at zero at 10:00 p.m. The heat gain or loss through the shopping center walls was estimated to be $.34(T_o - T_m)$ Btu/hr.ft.².

The heating or cooling requirement for the shopping center is then estimated by the following energy balance equation:

$Q_{\text{electric}} + Q_{\text{ventilation}} + Q_{\text{wall conduction}} + Q_{\text{people}} - Q_{\text{cooling}} + Q_{\text{heating}} = 0$, assuming for this study that external cooling and external heating do not occur simultaneously.

Therefore, for the daytime operating (9:00 a.m. to 10:00 p.m.),

1) $13.7 + .523 (T_o - T_m) + 450N - Q_{\text{cool}} + Q_{\text{heat}} = 0$ (assume that for nighttime operation the ventilation is shut down). Night-time (10:00 p.m. to 9:00 a.m.)

2) $.98 + .343 (T_o - T_m) - Q_{\text{cool}} + Q_{\text{heat}} = 0$.

The heating and cooling units for equations 1 and 2 are in Btu's per hour per square foot of floor space.

A.1.2 Commercial Building Heating and Cooling Loads

By similar analysis as above, the heating and/or cooling loads for commercial buildings to be served by the proposed ICES were estimated. The electric light and auxiliary load (7.26 Btu/hr.ft.²) is less than for the shopping center (based on the average electric light load of 18 commercial buildings). Also the assumed maximum heating demand for commercial building with a 70°F drop from inside to outside is -50 Btu/hr.ft.². Therefore, the daytime heating and cooling load is estimated to be:

3) $.72 (T_m - T_o) - 7.26 - 450N - Q_{\text{cooling}} + Q_{\text{heating}} = 0$, and the nighttime heating and/or cooling load is estimated to be:

4) $.72 (T_m - T_o) - Q_{\text{cool}} + Q_{\text{heat}} = 0$.

For the commercial building sector, the daytime hours are assumed to be 9:00 a.m. to 6:00 p.m. The nighttime hours are assumed to be 6:00 p.m. to 9:00 a.m. The maximum number of people is assumed to be 1 person per 55 square feet. The number of people is assumed to vary as a cosine function starting at zero at 9:00 a.m. reaching a maximum at midday and ending at zero at 6:00 p.m.

A.1.3 Outside Air Temperature

The average outside temperatures were established using the monthly daily maximum and monthly daily minimum temperatures for the Independence, Missouri area. The formulas used to establish the 12 hour average daytime and 12 hour average nighttime temperatures are as follows:

$$\overline{T_{N_0}} = \frac{T_{\max} + T_{\min}}{2} + 1/4 (T_{\max} - T_{\min})$$

$$\overline{T_{D_0}} = \frac{T_{\max} + T_{\min}}{2} - 1/4 (T_{\max} - T_{\min})$$

where $\overline{T_{N_0}}$ = average daily outside nighttime temperature

$\overline{T_{D_0}}$ = average daily outside daytime temperature

The average daytime and nighttime temperatures are plotted as a function of calendar month in Figure A-3. These outside air temperature functions are employed to predict the building heating and cooling loads in a particular month as described in the above sections and also will influence the thermodynamic efficiencies of the ICES power plant.

A.1.4 Average Day and Night Heating and Cooling Loads per Month

From the information generated in Sections A.1.1 through A.1.3, Figures 1-11 and 1-12 were developed to illustrate the average

$$T_N = 48.3 - 25.7 \cos \left(\frac{2\pi M}{12} \right)$$

$$T_D = 57.7 - 25.7 \cos \left(\frac{2\pi M}{12} \right)$$

FIGURE
A-3

AVERAGE TEMPERATURES, INDEPENDENCE, MISSOURI

daytime and nighttime heating or cooling loads for each month as a function of daily time. The computer code developed for this study approximated these heating/cooling loads using mathematical techniques.

From the above information the computer code generates an hourly heating and cooling load as a function of month, day (weekdays, Saturdays, and Sundays), and time of day (night, day, people loading vs time of day). Typical examples are shown in Figures 1-13 and 1-14.

A.2 ICES System Energy Demands

A.2.1 Demand for Waste Heat

The hourly heating and cooling loads generated above were transformed into demands for waste heat. The waste heat demand is equal to the heating demand plus the cooling demand divided by the effective coefficient of performance of the cooling system.

A.2.2 ICES Plant Models

A.2.2.1 Gas Turbine Generator Operating on Demand for Waste Heat

The exhaust enthalpy from the gas turbine generator supplies the waste heat necessary to support building heating and cooling loads. The turbine mass flow rate is determined by dividing the waste heat demand by the available energy per pound of exhaust mass flow (the available energy per pound is a function of turbine generator output power, air inlet temperature, air-to-fuel ratio, and gas turbine pressure ratio). The fuel oil demand is then obtained by dividing the turbine generator mass flow rate by one plus the air-to-fuel combustion ratio.

The electrical output power is obtained by employing the turbine generator mass flow rate, gas turbine efficiency, generator

efficiency, and isentropic change in gas enthalpy through the turbine.

A.2.2.2 Diesel Generator Operating on Demand for Waste Heat

The waste heat requirements are supplied by the diesel generator from two sources. The major source of waste heat is from the exhaust gases. However, a smaller percentage of waste heat is supplied by the diesel engine cooling water system. The mass flow rate through the engine is computed knowing the waste heat demand, the percentage of combustion heat recovered from the cooling water system, and the exhaust enthalpy of the combustion gases. (The exhaust enthalpy is a function of compression ratio, scavenge air flow percent, inlet air temperature, air-to-fuel ratio, combustion efficiency, and cooling water heat gain.) Once the mass flow rate has been computed, the fuel oil demand is computed knowing the air-to-fuel ratio and the scavenge air percent.

The electric output power is obtained by computing the total system input enthalpy minus the exhaust gas enthalpy minus the heat lost to the cooling system and adjusting for generator efficiencies.

A.2.2.3 Coal Fired Steam Boiler Turbine Generator System Utilizing Extraction Steam for Waste Heat Recovery

A.2.2.3.1 Operation on Demand for Waste Heat

Extraction stage steam at approximately 250 to 350°F condenses in heat recovery equipment providing the necessary waste heat for building heating and cooling equipment. The steam turbine mass flow is computed by dividing the waste heat demand by the available recoverable energy per pound of steam. The heat added to the boiler is equal to the steam mass flow rate times the change in enthalpy between boiler steam flow outlet and returned steam condensate. The fuel demand is then determined factoring in

boiler efficiency, combustion efficiency, exhaust gas temperature, air inlet temperature, and air to fuel ratio.

Electric power generation is obtained by the steam turbine mass flow, change in turbine steam inlet and outlet enthalpy, and generator efficiency.

A.2.2.3.2 20-MWe Coal Fired Steam Boiler Base Loaded Providing Extraction Steam As Required

The steam boiler mass flow rate entering the turbine is fixed to provide a gross turbine output of approximately 22 to 24 MWe. Three turbine steam extraction stages are used to supply extraction steam to a deaerator feed tank and two feedwater heaters. In addition to the reheat steam, some of the extraction steam at approximately 130 psia is diverted to the community heating and cooling equipment where it condenses and the liquid condensate returns to the condensate inlet of the first reheat stage (the deaerator feed tank).

The fuel demand is essentially constant with fluctuations in waste heat demand. Only the output power from the turbine generator changes as the extraction steam flow serving the heating and cooling requirements vary.

Fuel demand is computed from the boiler mass flow rate, steam outlet enthalpy, condensate return enthalpy, boiler efficiency, exhaust combustion product temperature, air inlet temperature, and fuel inlet temperature.

The output electrical power is computed from the steam inlet enthalpy to the turbine, the exhaust enthalpy at the various stages of extraction steam, and turbine condenser, the mass flow at each extraction stage and the mass flow into the turbine condenser, and generator efficiency.

A.2.3 Net Energy Consumption in Providing the Heating and Cooling to the Community

The net overall consumption of energy resulting from only the heating and cooling loads of the community is computed by obtaining the annual fuel energy input to the TES (total energy system) and subtracting from this quantity the fuel energy saved from an alternate electrical generation source by the electrical kilowatt hours generated by the TES.

A.3 Computer Program Listing

A listing of the computer program developed for this project is enclosed. This program was used to predict the yearly heating and cooling load on a community located in Independence, Missouri. Also, the computer program computed annual fuel demands, maximum heating and coal supplied, system equivalent heat rate, net energy consumption, average capacity factor and economic performance for four total energy system concepts: fuel oil gas turbine ICES; fuel oil diesel generator ICES; coal fired steam boiler ICES; and a 20-MWe base loaded generating station providing heating and cooling as required.


```

//B571FELL JOB (B57F,511101),FELL,CLASS=8,NOTIFY=B571          JOB 7221
***ROUTE PRINT REMOTE50                                           00000020
***ROUTE PUNCH REMOTE50                                           00000030
//LIST EXEC PGM=IEBGENER                                           00000040
//SYSPRINT DD DUMMY                                               00000050
//SYSIN DD DUMMY                                                  00000060
//SYSUT1 DD DSN=B57F.FELL.FORT,DISP=OLD                          00000070
//SYSUT2 DD SYSOUT=4,DCB=BLKSIZE=80                               00000080
IEF236I ALLOC. FOR B571FELL LIST
IEF237I 144 ALLOCATED TO SYSUT1
IEF237I 687 ALLOCATED TO SYSUT2
IEF142I * STEP WAS EXECUTED - COND CODE 0000
IEF245I B57F.FELL.FORT KEPT SIO=0000141
IEF245I VOL SER NOS= 21PUB1.
IEF373I STEP /LIST / START 77145.1350
IEF374I STEP /LIST / STOP 77145.1350 CPU 0MIN 00.20SEC STOR VIRT 36K
***LRCC STEP /LIST / START I=0 COUNT DASD=00000141, TAPE=00000000
***LRCC STEP /LIST / PAGING STATS IN=00000001, OUT=00000000
//PCB EXEC PGM=IEBGENER                                           00000100
//SYSPRINT DD DUMMY                                               00000110
//SYSIN DD DUMMY                                                  00000120
//SYSUT1 DD DSN=B57F.FELL.FORT,DISP=OLD                          00000130
//SYSUT2 DD SYSOUT=4,DCB=BLKSIZE=80                               00000140
//
IEF236I ALLOC. FOR B571FELL PCB
IEF237I 144 ALLOCATED TO SYSUT1
IEF237I 654 ALLOCATED TO SYSUT2
IEF142I * STEP WAS EXECUTED - COND CODE 0000
IEF245I B57F.FELL.FORT KEPT SIO=0000141
IEF245I VOL SER NOS= 21PUB1.
IEF373I STEP /PCB / START 77145.1350
IEF374I STEP /PCB / STOP 77145.1350 CPU 0MIN 00.20SEC STOR VIRT 36K
***LRCC STEP /PCB / START I=0 COUNT DASD=00000141, TAPE=00000000
***LRCC STEP /PCB / PAGING STATS IN=00000001, OUT=00000000
IEF375I JOB /B571FELL/ START 77145.1350
IEF376I JOB /B571FELL/ STOP 77145.1350 CPU 0MIN 00.40SEC

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DIMENSION AA(10),BB(10),CC(10),DN(10),CK(10)
DIMENSION LVL(2),I(2)
REAL K,NGT,NG,MC,NST,NRCC,NAC,NMRC,KA,KCP,MOIL
REAL ICTES,ICEZ,I,LNO,MF,MOEC,MOEMW,LCC,NETFC,MOD,M4
REAL MOILS,MOD2,NOML,NCE,KO,MDE,NCP,MOD3,MOD5
REAL LICTE,LICEE,KMC,LVL,NPCTE,M1,MX,MIMX,NR,MT
INTEGER KOLD,KERCU,MEHWU,N,MW,II,NDT,O,M
READ(5,*) QCMH,Q3,QMW,PMWMM,NR,X
READ(5,*) MOD,M0,PCMH,TAMH
READ(9,*) MOD2,XO,Z,O
READ(5,*) STP,MON3,MOD3,ABC
READ(5,*) QCXK3,QMWX3,QWBMX,MT
TP(STP,EQ(1,)) GO TO 100
AA(1)=501.9
AA(2)=794.06
AA(3)=974.14
SM(1)=2214.9
SB(2)=880.0
SB(3)=350.16
CC(1)=1204.0
CC(2)=1144.16
CC(3)=1095.76
PA1=1170000.
PA2=850040.
CK(1)=0.0
CK(2)=.1449
CK(3)=.3617
CK(4)=1.0
DN(1)=629.8
DN(2)=238.76
DN(3)=99.46
QCWMX=70000000.
PMMA=.6
AE5=.02
BE7.77
CM=7.27
EM3=.63
FJ=12.4
FZM=.19
GM50A=.3
H=25.7
H=517.7
DT1=11.
HWE12
TQM=2260.
NGB=.05
NGTA=.6
NCS=.05
NST=.80
NRCC=5.0
NACE=.99
NAPCA=.8
NDML=.20
NCS=.05
RC=13.
XAB15=.03
H92=.96
TQUB=780.
XDA1.35
CPS=.25
CVA.171
W1=1204.4
W21=986.1

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00000630

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M3=227.9.
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 M2T=1212.1
 M4=198.2
 M6=68.0
 M5M1=2.033
 M2M1=1.92
 TMT=760
 TAT=540.
 P4=16.
 P5=270.0
 P6=271.2
 PAT=14.9
 CP1=74
 CP2=50
 T=520.
 QF1=12500.
 QF2=12500.
 QF3=12000.
 Y=1.
 WAF1=0.
 WAF2=0.00317
 WAF3=1
 K=1.0
 MCP=1.4
 CPC=25
 I(1)=.07
 I(2)=.1
 M=20
 CAPRG=1780000.
 CAPTG=5527000.
 CAPCB=5853000.
 CAPCG=200000.
 CAPTC=100000.
 CAPCA=300000.
 UFC=0.0
 P=1.1
 FCGT=2.89
 FCD=2.89
 FCC=1.05
 EC=.03
 FSC=.0
 AFTF3=.05
 AFEF=.05
 VGT=2800000.
 WOG=2620000.
 WGT=10000000.
 CSTG=2000000.
 CTG=1000000.
 CDEC=1100000.
 CFB=4.25
 CA=ME=75.
 CMM=10000.
 CMHF=10000.
 CMHF=10000.
 CSTRC=300.
 CABF=300.
 CABCD=350.
 CABCR=300.
 FT2=500.
 FT2=500.
 TRP=5000.
 TRPP=140.
 HLB=50.
 HGPC=10.

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 00001200
 00001210
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 00001230
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 00001250
 00001260
 00001270
 00001280
 00001290

53	GN1=GN2	00001960
	GN TO 55	00001970
54	GN1=GN2	00001980
55	IF(GT,0,001) GN TO 10	00001990
	GN 1 M=1,AM	00002000
	T=M-1	00002010
	ENDCOST(.520+T)	00002020
	TANSG=H*CN	00002030
	TADMR=H*CN	00002040
	S1=STN(.520+T)	00002050
	S2=STN((T-6)+.520)	00002060
	IF(T,GT,6) GN TO 440	00002070
	QNM1=(5.02+7.77*CN)+FA1	00002080
	QNM1=(7.27+13.43*CN)+FA1	00002090
	QNM2=(13.56+16.44*CN)+1.05*S1)+FA2	00002100
	QNM2=(1.6+18.5*CN)+FA2	00002110
	GN TO 440	00002120
440	QNM1=(5.02+7.77*CN)+2.4*S12)+FA1	00002130
	QNM2=(13.56+16.44*CN)+2.4*S12)+FA2	00002140
	QNM1=(7.27+13.43*CN)+1.05*S12)+FA1	00002150
	QNM2=(1.6+18.5*CN)+2.4*S12)+FA2	00002160
440	QNM1=QNM1+FA1	00002170
	QNM2=QNM2+FA2	00002180
	GN 2 J=1,3	00002190
	QCM1=0.	00002200
	QCM2=0.	00002210
	QCM3=0.	00002220
	QCM4=0.	00002230
	TF(J=2)4,9,13	00002240
4	IF(QCM1,GT,0.)GN TO 700	00002250
	QCM1=QCM1	00002260
	GN TO 701	00002270
700	QCM1=QCM1	00002280
701	IF(QCM2,GT,0.)GN TO 702	00002290
	QCM2=QCM2	00002300
	GN TO 703	00002310
702	QCM2=QCM2	00002320
703	QCM3=QCM1+QCM2	00002330
	QCM4=QCM1+QCM2	00002340
	QCM5=0.	00002350
	QCM6=0.	00002360
	QCM7=0.	00002370
	QCM8=0.	00002380
	QCM9=0.	00002390
	QCM10=0.	00002400
	QCM11=0.	00002410
	QCM12=0.	00002420
	QCM13=0.	00002430
	QCM14=0.	00002440
	QCM15=0.	00002450
	QCM16=0.	00002460
	QCM17=0.	00002470
	QCM18=0.	00002480
	QCM19=0.	00002490
	IF(Q,FO,(ADT+1))GN TO 2	00002500
	ENDT=ENDT	00002510
	Y21=QCM1+FA1+(S1*(3.101*QCM/ENDT))	00002520
	IF(Q,GT,(ENDT=0.))GN TO 704	00002530
	Y22=QCM2+FA2+(S2*(3.101*QCM/(ENDT+4.)))	00002540
	GN TO 705	00002550
704	Y32=QCM2	00002560
	GN TO 706	00002570
705	Y32=(Y12+Y22)/2.	00002580
706	Y31=(Y11+Y21)/2.	00002590
	Y11=Y21	00002600
	Y12=Y22	00002610

	DT=1.	00002620
	DM=21.7	00002630
	IF(Y31,GT,0.)GO TO 707	00002640
	QC=M1=V31	00002650
	GO TO 708	00002660
707	DM1=V31	00002670
708	IF(Y32,GT,0.) GO TO 709	00002680
	QC=M2=V32	00002690
	GO TO 710	00002700
709	DM2=V32	00002710
710	QM=QM1+QM2	00002720
	QC=QC1+QC2	00002730
	TA=TA0	00002740
	GO TO 10	00002750
13	L=1	00002760
804	IF(1,GT,1) GO TO 711	00002770
	QC=M1=QCX1	00002780
	DM1=0.	00002790
	IF(QDM2,GT,0.)GO TO 712	00002800
	QC=M2=QDM2	00002810
	DM2=0.	00002820
	GO TO 713	00002830
712	DM2=QDM2	00002840
	QC=M2=0.	00002850
713	QC=QC1+QC2	00002860
	QM=QM1+QM2	00002870
	DT=13.	00002880
	DM=0.3	00002890
	TA=TA0	00002900
	GO TO 10	00002910
711	IF(QDM1,GT,0.)GO TO 714	00002920
	QC=M1=QDM1	00002930
	DM1=0.	00002940
	GO TO 715	00002950
714	DM1=QDM1	00002960
	QC=M1=0.	00002970
715	IF(QDM2,GT,0.)GO TO 716	00002980
	QC=M2=QDM2	00002990
	DM2=0.	00003000
	GO TO 717	00003010
716	DM2=QDM2	00003020
	QC=M2=0.	00003030
717	QC=QC1+QC2	00003040
	QM=QM1+QM2	00003050
	DT=12.	00003060
	DM=0.3	00003070
	TA=TA0	00003080
	GO TO 10	00003090
10	QC=M1+QC=M	00003100
	QCL=2,=MGRD+TRD	00003110
	QML=2,=MLPH+TRD	00003120
	Q3=(1,=FCM)+QC=M	00003130
	QC=M+FCM+QC=M+QCI	00003140
	IF(QC=M,LT,QCMX3)GO TO 170	00003150
	QC=M+QCMX3	00003160
	Q3=QC=M+QC=M+QCL	00003170
	GO TO 170	00003180
170	QM=FC(1,=FMMX)*QM	00003190
	QM=M+FM=QM+QML	00003200
	IF(QM=M,LT,QMYS)GO TO 171	00003210
	QM=M+QMYS	00003220
	QM=FCQM=QM+QM	00003230
	GO TO 171	00003240
171	IF(MOR2) 200,25,300	00003250
25	S1=QC=M*(M1=M3=4EM1)	00003260
	S2=(M1=M21)*NST+NRCC+((M1=M3)*(M1=M21)*NS1)*NAC	00003270

	DEHMS=DFHMS+QFHH=HT+DM	00003280
	QELHMS1/32+FH=HH+DM	00003290
	Q1=(H1-H21)+NST+HNC=QC+H/32	00003300
	Q2=((H1-H3)-(H1-H21)+NST)+MAC=QC+H/32	00003310
	IF(MOD3.GT.0.1) GO TO 400	00003320
403	IF(QF=H.GT.0.001) GO TO 27	00003330
	SXF=0.	00003340
	SXS=0.	00003350
	QFO=0.	00003360
	GO TO 74	00003370
22	S6=1.+(CPH/PATH)*((K4=1.)/K4)=1./+C	00003380
	S7=1.-NGT*(1.+(Q4/P5)*((KCP=1.)/KCP))	00003390
	IF(MOD2.EQ.1.) GO TO 60	00003400
	SXF=CE=H*(1.+X)/((X+CPA+TAI)+S6+CPQ+TQ+QUTL)+S7=CPCP*(1.+X)+TOUT	00003410
	IF(MOD.LT.1.) GO TO 74	00003420
60	SXF=H4	00003430
61	X=QF+H+SXF*(CPCP+TOUT=(QUTL+CPQ+TQ)+S7)	00003440
	X=X/(SXF+CPA+TAI)+S6+S7=SXF+CPCP+TOUT=QF+H	00003450
70	T=QF+H/(SXF+CPCP)+TOUT	00003460
	IF(T0.LT.T4+H) GO TO 71	00003470
	GO TO 75	00003480
71	T=TX+H	00003490
	QED=TA+SXF+CPCP	00003500
	QFO=QED-QF+H+SXF+CPCP+TOUT	00003510
	X1=QED=(SXF+QUTL)+SXF+CPQ+TQ)+S7	00003520
	X=X1/(SXF+CPA+TAI)+S6+S7=QED	00003530
	GO TO 75	00003540
75	T5=T0/S7	00003550
	IF(T5.GT.T5+H) GO TO 74	00003560
	GO TO 77	00003570
76	SXF=SXF+H4	00003580
	GO TO 61	00003590
77	QUTL=SXF/(1.+X)	00003600
	S6=HMF*(CQCP+T4*(1.-S7)/S7*(X/(1.+X))+CPA+TAI*(S6=1.))	00003610
	A=HMF1+Q1+HMF2+CP+HMF3+Q9	00003620
78	QFO=S6+H6+HMF1+QC+H/32+H4	00003630
	H4=50	00003640
20	HMF1=(HED=Q3/(HMC+HCC)=(1.-FH+H4)+DM)/3.416	00003650
	IF(QF=H.GT.0.001) GO TO 34	00003660
	EFF=0.	00003670
	EFFP=0.	00003680
	GO TO 84	00003690
30	EFF=(HED+Q2+H4)/((CPQ+TQ+QUTL)+HMF1*(X+SXF+CPA+TAI)/(1.+X))	00003700
	EFFP=(HED+Q2+H4)/((CPQ+TQ+QUTL)+HMF1L)	00003710
80	QCFL=HMF1+HMF2+HMF3+HMF4	00003720
	QFTE=HED+H4/3012.	00003730
	IF(D.GT.0.001) GO TO 90	00003740
	HMF1L=S4HMF1L+HMF1L+HMF1L	00003750
	ELG=ELG+HED+Q2+H4/3012.	00003760
	EL3=EL3+HMF1+HMF1+HMF1/1000.	00003770
	QCFL3=QCFL3+QCFL3+HMF1	00003780
	QFTE3=QFTE3+QFTE3+HMF1	00003790
	QFHH3=QFHH3+QFHH3+HMF1	00003800
	Q3S=Q3S+Q3S+DT+0H	00003810
	Q4=H4+H4+H4+H4+HMF1	00003820
	IF(HMF1.GT.HMF1) HMF1=HMF1	00003830
	IF(HMF1.LT.HMF1) HMF1=HMF1	00003840
	IF(T0.GT.T4+H) T4=HMF1	00003850
	IF(T0.LT.T4+H) T4=HMF1	00003860
	IF(Q1.GT.Q1+X) Q1=HMF1	00003870
	IF(Q1.LT.Q1+H) Q1=HMF1	00003880
	IF(Q2.GT.Q2+H) Q2=HMF1	00003890
	IF(Q2.LT.Q2+H) Q2=HMF1	00003900
	IF(Q3.GT.Q3+H) Q3=HMF1	00003910
	IF(Q3.LT.Q3+H) Q3=HMF1	00003920
	IF(QH=H.GT.QH+H) QH=HMF1	00003930

00003900	IF(OMM.LT,OMM) OMM=OMM
00003950	IF(OMM.GT,OMM) OM=OMM
00003960	IF(OMM.LT,OMM) OM=OMM
00003970	IF(OMM.GT,OMM) OM=OMM
00003980	IF(OMM.LT,OMM) OM=OMM
00003990	IF(OMM.GT,OMM) OM=OMM
00004000	IF(OMM.LT,OMM) OM=OMM
00004010	IF(OMM.GT,OMM) OM=OMM
00004020	IF(OMM.LT,OMM) OM=OMM
00004030	IF(OMM.GT,OMM) OM=OMM
00004040	IF(OMM.LT,OMM) OM=OMM
00004050	IF(OMM.GT,OMM) OM=OMM
00004060	IF(OMM.LT,OMM) OM=OMM
00004070	IF(OMM.GT,OMM) OM=OMM
00004080	IF(OMM.LT,OMM) OM=OMM
00004090	IF(OMM.GT,OMM) OM=OMM
00004100	IF(OMM.LT,OMM) OM=OMM
00004110	IF(OMM.GT,OMM) OM=OMM
00004120	IF(OMM.LT,OMM) OM=OMM
00004130	IF(OMM.GT,OMM) OM=OMM
00004140	IF(OMM.LT,OMM) OM=OMM
00004150	IF(OMM.GT,OMM) OM=OMM
00004160	IF(OMM.LT,OMM) OM=OMM
00004170	IF(OMM.GT,OMM) OM=OMM
00004180	IF(OMM.LT,OMM) OM=OMM
00004190	IF(OMM.GT,OMM) OM=OMM
00004200	IF(OMM.LT,OMM) OM=OMM
00004210	IF(OMM.GT,OMM) OM=OMM
00004220	IF(OMM.LT,OMM) OM=OMM
00004230	IF(OMM.GT,OMM) OM=OMM
00004240	IF(OMM.LT,OMM) OM=OMM
00004250	IF(OMM.GT,OMM) OM=OMM
00004260	IF(OMM.LT,OMM) OM=OMM
00004270	IF(OMM.GT,OMM) OM=OMM
00004280	IF(OMM.LT,OMM) OM=OMM
00004290	IF(OMM.GT,OMM) OM=OMM
00004300	IF(OMM.LT,OMM) OM=OMM
00004310	IF(OMM.GT,OMM) OM=OMM
00004320	IF(OMM.LT,OMM) OM=OMM
00004330	IF(OMM.GT,OMM) OM=OMM
00004340	IF(OMM.LT,OMM) OM=OMM
00004350	IF(OMM.GT,OMM) OM=OMM
00004360	IF(OMM.LT,OMM) OM=OMM
00004370	IF(OMM.GT,OMM) OM=OMM
00004380	IF(OMM.LT,OMM) OM=OMM
00004390	IF(OMM.GT,OMM) OM=OMM
00004400	IF(OMM.LT,OMM) OM=OMM
00004410	IF(OMM.GT,OMM) OM=OMM
00004420	IF(OMM.LT,OMM) OM=OMM
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00004440	IF(OMM.LT,OMM) OM=OMM
00004450	IF(OMM.GT,OMM) OM=OMM
00004460	IF(OMM.LT,OMM) OM=OMM
00004470	IF(OMM.GT,OMM) OM=OMM
00004480	IF(OMM.LT,OMM) OM=OMM
00004490	IF(OMM.GT,OMM) OM=OMM
00004500	IF(OMM.LT,OMM) OM=OMM
00004510	IF(OMM.GT,OMM) OM=OMM
00004520	IF(OMM.LT,OMM) OM=OMM
00004530	IF(OMM.GT,OMM) OM=OMM
00004540	IF(OMM.LT,OMM) OM=OMM
00004550	IF(OMM.GT,OMM) OM=OMM
00004560	IF(OMM.LT,OMM) OM=OMM
00004570	IF(OMM.GT,OMM) OM=OMM
00004580	IF(OMM.LT,OMM) OM=OMM
00004590	IF(OMM.GT,OMM) OM=OMM


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      APTES=0.
31  TCFE=KEFCU*(MOPC+CLFC+CEFCU)+KEWU*(MOPH+CLEW+CFHU)
      ON AB I=1,2
      S=1/I
88  LVL(IT)*S*(1.+S)+M)/(I1.+S)+N=1.)
      LYTE=ICTES+LVL(I)
      LICEF=ICEF+LVL(I)
      WHULC=USRC+LVL(I)
      IF(ARC.LT.1.)NP=0.
      AOTE=ICTES+APTES+OP
      ANFE=ICEF+AFEE
      YLC=LICE+LICEF
      IF(MOD2) 91,92,93
91  FC=FCO
      GO TO 96
92  FC=FCGT
      GO TO 94
93  FC=FCC
94  MFTF=MHOTLS+OHTL*FC/100000.
      METFC=(MHOTLS+OHTL*FC/100000.-OHTLS*HFC/100000.)*
      ATESC=METFC+LICEF+AHTE
      PTFSC=MFTFE+LYTE+AHTEF
      FNTN=(MHOTLS+OHTL-OHTLS)
      OHTFC=MS+OHTS+FH+M
      IF((OC+MS+OHTS+FH+M).GT.0.)GO TO 95
      CSTE=ATESC/(OC+MS+OHTS+FH+M)*100000.
95  KMHFC=(Q3S/(MHOC+MHCC)+(1.-FH+M)*OHTS)/3412.
      AESC=LICE+ANFE+K+MC+FC
      QF=Q3S+(1.-FH+M)*OHTS
      AEFCK=K+MC+EC+ANFE
      IF(QE.EQ.0.) GO TO 96
      CSTE=ATESC/QF*100000.
96  SPQH=CESTE*P
      IF((OC+MS+OHTS+FH+M).GT.0.) GO TO 97
      MHURC=0.
      GO TO 98
97  MHURC=SPQH+MHULC/(OC+MS+OHTS+FH+M)*100000.
98  DFILPL=CESTE+MHURC
      RELPH=CESTE+MHURC
      THC=MFTFC+LYTE+AHTEF+OHTLS+EGC/3412.
      TUGR=ATESC*P+K+MC+FC
      IF(OC.EQ.0.)TUGR=K+MC+EC
      UPG=K+K+MC+FC+THC
      IF((OC+MS+FH+M+OHTS).GT.0.001) GO TO 97
      ZPSP=0.
      SPTF=0.
      GO TO 98
97  ZPSP=(TUC+K+MC+FC)/(OC+MS+FH+M+OHTS)*100000.
      SPTF=ATESC/(FLS+3412+OHTS)*100000.
98  SPUTE=TUC/(K+MC+3412+OHTS)*100000.
      UPRF=TUGR+TUC
      UESC=SPUTE*3412/100000.
      RESP=SPTE*3412/100000.
      TUGRS=(UESC+K+MC+OHTS+OHTS/100000.)*P
      UPRFS=TUGRS+THC
      PGRS=(PFSC+ELS+SPTF*OHTS/100000.)*P
      PPRS=PGRS+ATESC
      RFS=LICE+ANFE+K+MC+UPRF+P
      REFMC=OFE+K+MC+UESC+P
      IF(OC.EQ.0.)GO TO 99
      RCES=RESC/QF*100000.
      RCEM=REFMC/QF*100000.
      GO TO 99
99  RCES=0.
      RCEM=0.

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99	WRITE(6,100) M01L,MENET,DGFL,Q1,Q2,EFF,X,T5,T6,SMP,QE=M	00005260
	WRITE(6,100) EFFM,ICTES,ICER,ATESC,AESC,QG,QE,QE=M3	00005270
	WRITE(6,110) FNIN	00005280
	WRITE(6,111) METFC	00005290
	WRITE(6,112)TUC	00005300
	WRITE(6,113)IMRF	00005310
	WRITE(6,114)CSTFF	00005320
	WRITE(6,115)SPQ44	00005330
	WRITE(6,116)MMJRC	00005340
	WRITE(6,117)CSTPS	00005350
	WRITE(6,118)CSTEN	00005360
	WRITE(6,119)DELOM	00005370
	WRITE(6,120)DFLPL	00005380
	WRITE(6,121)UPGAM	00005390
	WRITE(6,122)ZWS9	00005400
	WRITE(6,123)SMTF	00005410
	WRITE(6,124) SMITF	00005420
	WRITE(6,125)UFSC	00005430
	WRITE(6,126)RESG	00005440
	WRITE(6,127)UMRF3	00005450
	WRITE(6,128)PPN3	00005460
	WRITE(6,129)RCFS	00005470
	WRITE(6,130) RCFM1	00005480
	GO TO 101	00005490
200	QF=H0000000+QCMH/NAC	00005500
	QF=H0000000+QF=H0000000	00005510
	IF(QF=H,GF,0.) GO TO 210	00005520
	EFF=0.	00005530
	EFFR=0.	00005540
	WLO=0.	00005550
	M01L=0.	00005560
	MDF=0.	00005570
	GO TO 220	00005580
210	X=X0	00005590
	S10=(Q01L+MCE+CP0+T0)/(1.+X)+CPCP+T01	00005600
	S11=RC+(1.-KN)	00005610
	S12=X+CPA/((1.+X)+CPCP)+S10+S11	00005620
	S13=(S12*(1.-NOML))+X0	00005630
	S14=X*(1.-Z)+CPA/((1.+X)+CPCP+Z)	00005640
	T0F=T01*(S13+S14)/(1.+S14)	00005650
	T3=(T01+S12)/S11	00005660
	S15=(T0E+T0UT)+CPE	00005670
	IF(QM=H,FG,0.) GO TO 211	00005680
	U0F=H0000000+CPCP+7*(1.+X)+T3/(X+Z)	00005690
	MDE=Q0E+H/(S15+U)	00005700
	IF(U+MDE,(T,0M=H) GO TO 212	00005710
	QF=H0000000+QM=H	00005720
	GO TO 211	00005730
211	MDE=Q0E+H/S15	00005740
212	SMP=Q0E	00005750
	SMP=MDE	00005760
	M01L=MDE/(1.+X/Z)	00005770
	MCP=Z*(1.+X)+MDF/(X+Z)	00005780
	T0UT=0	00005790
	IF(MDE,FG,0.) GO TO 215	00005800
	T0F=Q0E+H/(MDE+CP0)+T0UT	00005810
	IF(T0F,RT,T0E+X)+T0E+H+T0F	00005820
	IF(T0E,LT,T0E+H)+T0E+H+T0E	00005830
215	MN0MCP=((Q01L+MCP+CP0)+T0)/(1.+X)	00005840
	MN0MCP=(CV+T0-CV+T01*(X/(1.+X)+NOML+CPCP+T3)	00005850
	Q200F=H	00005860
	WLO=H0000000	00005870
	IF(MDE,FG,0.) GO TO 220	00005880
	S16=T01+CPA+MDF*(X/(X+Z))+M01L+(CPCP+T01)	00005890
	S17=MDF+CP0+T0UT	00005900
	EFF=(S16+S17)/S16	00005910

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      FPFQ8=(WEN+QFHM)/(M0)1+(M0TL+G00+T0)
220  WFMET=(WED+Q3/(NMRC+NRCC)=JM+1/3.412
      GO TO 40
250  KDU=1.+NMXX/(3.012+M0)
      IF(NMXX.E0.0.) KDU=0.
      CTF1=M011+CDEG+(QFHM/100000.)+CWMFO
      CTF2=0.
      CTF=(024/12000.)+C+450
      CTF3=CTF+K011+(PTPO+CALD+LYPO+CI+D)+CMDO+CLMD+(1.+MF1)
      CTF4=TPP+TQPC
      GO TO 60
180  GO TO 103
182  STOP
188  FORMAT(1X,19E12.3)
190  FORMAT(1X,1ANNUAL ENERGY CONSUMPTION/YR1,E12.3)
191  FORMAT(1X,1NET ANNUAL FUEL COST TO UTILITY=4/YR1,F12.3)
192  FORMAT(1X,1TOTAL UTILITY ANNUAL COST=4/YR1,F12.3)
193  FORMAT(1X,1ANNUAL UTILITY PURCH=3/YR1,F12.3)
194  FORMAT(1X,1TOT. FUEL, SYS. AVG. SUPPLY, CST.=4/MILLION BTU1,E12.3)
195  FORMAT(1X,1AVR. WASTE HEAT USER COST=3/MILLION BTU1,E12.3)
196  FORMAT(1X,1SPL. PRICE TO WASTE HEAT USER=4/MILLION BTU1,E12.3)
197  FORMAT(1X,1AVG. ELC. HT. ACI. CST. TO FLC. USER=4/MILLION BTU1,E12.3)
198  FORMAT(1X,1ELC. AND CST. TO USERS WITH FLC COP=4/MILLION BTU1,E12.3)
199  FORMAT(1X,1INCENTIVE UTILIZE WST. HT. SYS.=4/MILLION BTU1,E12.3)
200  FORMAT(1X,1INCENTIVE, FLC. POWER, SYSTEM, WST. HT. SYS. 3/MILLION BTU1,E12.3)
201  FORMAT(1X,1UTILITY, PURCH. WST. HT. CL. GIVE. =4Y.=3/YR1,E12.3)
202  FORMAT(1X,1ZRR. UTILITY, PURCH. WST. HT. CL. SEL. PRICE.=4/MILL BTU1,E12.3)
203  FORMAT(1X,1BRTV. SUP. CST. HT. CL.=4/MILLION1,E12.3)
204  FORMAT(1X,1UTL. SUP. CST. HT. CL.=4/MILLION BTU1,E12.3)
205  FORMAT(1X,1UTI. FLPC. SUP. CST.=1/KWH1,F5.3)
206  FORMAT(1X,1PRTV. ELEC. SUP. CST.=1/KWH1,F5.3)
207  FORMAT(1X,1UTL. PURCH. ELC. SEL. PURCH. CST.=4/YR1,F12.3)
208  FORMAT(1X,1BRTV. PURCH. PURCH. 3/YR1,E12.3)
209  FORMAT(1X,1REAL. ALL. ELC. CST.=4/MILLION BTU1,E12.3)
210  FORMAT(1X,1ELC. AND PURCH. PURCH. Y. CST. 3/MILLION BTU1,E12.3)
800  MXX=CCMXX/128.35
      KX=1
401  ZD0=(AA(KK)/RR(KK1+MX))**2+0.40CM+MX/RR(KK)
      ZP1=SCRT(ZD0)=AA(KK)/RR(KK1+MX)
      M1=ZP1/2.
      CMK=MI/MX
      ZP=AA(KK)+RR(KK1+CMK)
      IF(CMK.LF.CK(KK+1).AND.CMK.GF.CK(KK)) GO TO 402
      KK=KK+1
      GO TO 401
402  GFMM=PM+MM+QMM+MI+(M1+M3+ME+1)
      M2=CC(KK)=DD(KK)+CMK
      Q1=(M1+M2)*448T+400C+M1
      Q2=CC+M+G1
      GO TO 403
300  GFMM=QC+M/1.4C+0M+MM
      GFMM3=QFMM3+QFMM+0M+MM
      Q2=CC+M
      K=1
      IF(MT.GT.0.) GO TO 301
      Y=QFMM/QMM+M
      IF(Y.GF.1.) Y=1.
      IF(MD05.GT.0.) Y=Y5
      M3=1+M+M0+45T+(M1R+M2[M1)
      M1=QFMM/(Y+M3)
      IF(M1.GT.M1MX) M1=M1MX
      MM=MG+45T+M1+(M1R+M3[R1)+Y+(M2[R+M3[R1)
      OM=M1R+M3R+MFM2+Y+(M3R+MFM2+M0R+FM1)
302  SM=(X+CPA+T01+CP0+T0+Q0T1)*MR0(1.+X1+CP0+T0UT)
      SMF=(1.+X1)*M1+MM/SM
      MC1=SMF/(1.+X1)

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301

$EFB = (M + QEM) / (M) \cdot L + (Q) \cdot T + (P) \cdot T + 1$
 $EFB = (1 + X) \cdot (X + CPA + T + 1 + P) \cdot T + (Q) \cdot L + (1 + X) \cdot (P + T + U + V)$
 $EFB = (M + QEM) / EF$
 $EFB = M$
 $YAB = AF1 + Q1 + MAF2 + Q2 + MAF3 + M4$
 $YBET = (M + Q3) / (M + P + R + C) - PM + E = A \cdot 1 / 3, 412$
 $GN \cdot T \cdot Q$
 $M10R = 1453, 4$
 $M0B = 6A$
 $M1B = 1020, 5$
 $M2R = 1173, 5$
 $M3R = 1212, 4$
 $M5R = 1260, 2$
 $M6R = 127A, 0$
 $M7R = 29A, 4$
 $M9R = 250, 4$
 $M0C = 1AA, 13$
 $YCB = 254, 4$
 $M0R = 321, 6$
 $M0C1 = 0A, 4$
 $MFC2 = 2, 5A$
 $MAB = 21A, 2$
 $FAR = QF + M / (M + T + (M + R + M + R))$
 $FAR = (M + R + M + R) / (M + R + M + R)$
 $F3B = (M + R + M + R + M + R + M + R + M + R) / (M + R + M + R)$
 $FAR = F3A + F5A$
 $F10R = 1, 4 = FAR + F5A + F3A$
 $F1B = (M + R + F5A + M + R + F5A + M + R + F10R + M + R) / (M + R + F5A + M + R)$
 $F2R = F10R + F3A$
 $M1B = F1A + (M10R + M1R) + F2R + (M10R + M2R) + F3R + (M10R + M3R)$
 $M2R = F5R + (M10R + M5R) + F6R + (M10R + M6R)$
 $M0R = G + T + (M1 + M2)$
 $M1B = T$
 $M0R = M0B$
 $GN \cdot T \cdot Q$
 350
 $M0R = 1, 4 + M + X / 1, 412 + 5971$
 $CTF1 = M1 + X + CCA + M0R + T + CBT + (F + M + X / 100000, 1) + C + M + R$
 $CTE = 20, 4$
 $CTE = (Q2M + 120001 + C + A + R)$
 $CTE3 = CTE + AL + R + 1 + M + R + C + M + R$
 $CTF = T + R + T + R + C$
 $GN \cdot T \cdot Q$
 FAR

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APPENDIX B
PERSONNEL RESUMES

The resumes for each of the key proposed project participants in Phase II are presented in this appendix.

CITY OF INDEPENDENCE

City Manager's Office

R. L. Svehla
L. C. Kaufman

Planning Department

W. C. Bullard
C. D. McDole
L. L. Mlnarik
P. A. Mosiman
D. E. Proske

Power & Light Department

B. J. Barnett

Public Works/Engineering Department

W. L. Welch
H. E. Nickols
D. A. Wheaton, Sr.

PUBLIC TECHNOLOGY, INC.

P. W. Homer
G. W. Casserly
W. M. Mascenik, Jr.
R. J. Philips
R. N. Sockwell
T. V. Tiedeman
F. H. Gibel

NUS

P. D. Arrowsmith
T. A. Russell
L. Breitstein
W. Ellison
E. J. Ricer
R. W. Fell
C. A. Negin
T. B. Mullarkey
L. D. Kenworthy
W. J. Israel
J. E. Reuter
S. P. Verma
G. C. Rudy
B. D. Sullivan
I. L. Whitman
R. W. Robertshaw

CITY MANAGER'S OFFICE
Independence, Missouri

Robert L. Svehla, Assistant to City Manager/Technology Agent

B.A., Mathematics, Doane College

M.A., Mathematics, University of Montana

M.B.A., Xavier University

Graduate courses in Operations Research, Ohio State University

Mr. Svehla has over 15 years experience in program evaluation and project leadership involving operations research, systems analysis, and management science methodologies. He has led projects involving economic analyses, the evaluation of alternative design, life-cycle costing, and technological data gathering and dissemination. He joined the City of Independence in July 1974 as a technology agent in the Urban Technology System (UTS) Program. The UTS program, which is sponsored by the National Science Foundation and administered by Public Technology, Inc., is designed to transfer technology to both Cities and full-service Counties. As the technology agent for Independence, Mr. Svehla has led several innovation projects aimed at cost reduction and/or avoidance in the delivery of City services. These include the evaluation of sites for fire stations, improved methods for ice and snow removal, an analysis of alternative City transportation systems, and the feasibility of using high-altitude (satellite) imagery for urban land-use planning. Mr. Svehla currently has responsibility for the Management Systems and Community Development Division within the City organization.

Before joining the City staff, Mr. Svehla was employed for eight years by Battelle's Columbus Laboratories as a senior researcher. While at Battelle he was a principal investigator and project leader on numerous projects for federal agencies and private firms. Many of these projects involved an economic and technological evaluation of alternative systems, methods, and policies. He was a member of the project team for the Central Control System at the Seattle-Tacoma International Airport which was selected by the National Society of Professional Engineers as one of the top ten engineering achievements of 1972.

Prior to Battelle, Mr. Svehla spent over 5 years in the Aerospace industry with the Boeing Company and North American Aviation, Inc. He was a reliability and maintainability engineer on several military programs including the Bomarc and Minuteman missiles and the Polaris submarines. This experience included statistical analyses of test results and reliability project leadership.

Larry C. Kaufman, Administrative Assistant II

B.S., Public Administration, Southwest Missouri State

Postgraduate: Central Michigan University Extension Program

As Community Development Administrator Mr. Kaufman is responsible for the preparation, submission and administration of a \$1.3 million Community Development Program including: (1) development of City's Affirmative Action Program, (2) preparation of City's housing program including operation of housing rehabilitation program through coordination with Independence Housing Rehabilitation Advisory Board, minimum housing code inspection division, preparation and review of bidding documents, and administration of final inspections by building inspection division, (3) City's liaison to various neighborhood groups and organizations and, (4) coordination of various departments and divisions carrying out community development activities.

Mr. Kaufman is also the Federal Contracting Officer with the responsibility for the enforcement and review of all federal requirements related to City programs involving federal funds as related to advertisement, contracting, employment, acquisition, disposition and equal opportunity regulations. He also serves as member of the City's labor negotiations team; principally for purposes of maintaining status of negotiations with respective employee bargaining units. Mr. Kaufman also serves as a representative of City Council on two Mid American Regional Council committees - Housing Review Technical Committee and Housing Policy subcommittee, and as the Mayor's representative to the U.S. Conference of Mayors' subcommittee on community development.

Mr. Kaufman is a member of the International City Management Association and the American Society of Public Administration.

**PLANNING DEPARTMENT
Independence, Missouri**

William C. Bullard, Planning Director

B.A., Hendrix College

University of North Carolina Graduate School, Summer, 1955.

The Georgia Institute of Technology, Summer, 1958.

The University of Arkansas, Research Assistant, 1955.

Visiting lecturer in housing, Central Missouri State College Residence Center, 1971-1975, and in regional government, Park College, 1976.

Has been the Director of the Planning and Permits Department in the City of Independence, Missouri since 1968. The 29-man department includes Building Inspection, Minimum Housing Code Enforcement, Business Licensing, Liquor Licensing, Long Range Planning, Zoning and Subdivision Administration, Mass Transit Operation, Federal Grants Administration, Community Development Act Administration, and Heritage Commission Administration (historical preservation). The department has an annual budget of over \$375,000 and directly administers over \$1,500,000 in public expenditures.

The officers and agencies to which the staff has primary responsibility are the City Manager, Mayor and Council, Planning Commission, Board of Adjustment, Board of Standards and Appeals, Heritage Commission, Board of Electrical Examiners, and Board of Plumbing Examiners.

Mr. Bullard previously worked for the Leo A. Daly Company (Omaha) from 1965 to 1968 as a Planning consultant. He was a team captain of a 10-man staff handling approximately 30 jobs at any given time. Major responsibilities included tornado recovery plan for Topeka, downtown plans for Cheyenne and Omaha, first metropolitan-area plan for Omaha-Council Bluffs, industrial development plans for Union Pacific and Omaha, comprehensive plans for Mills County, Iowa, and Ottumwa, Iowa, and campus plan for Dana College.

He also worked as a Planning consultant for Allgeler, Martin and Associates (Joplin, Missouri) from 1961 to 1965 and for Wittenberg, Delony and Davidson (Little Rock), 1960-1961. His duties included housing and urban renewal plans for Arkansas, Missouri and Texas communities. A major project was an urban renewal plan for downtown Little Rock.

Mr. Bullard also held positions with the Metropolitan Area Planning Commission of Pulaski County (Little Rock metropolitan area) 1956-1960; University of Arkansas Industrial Research and Extension Center, 1955; and the Arkansas Industrial Development Commission, 1954.

Mr. Bullard is a member of the American Institute of Planners and is registered as Planner-in-Charge by the States of Missouri, Texas, Kansas, Colorado, Wyoming, South Dakota, North Dakota, Iowa and Nebraska.

Cal D. McDole, Administrative Assistant I

A.A., Social Studies, Graceland College

B.A., Speech, University of Missouri-Kansas City

M.P.A., University of Missouri-Kansas City

Mr. McDole joined the City of Independence in 1971. His duties include municipal research and analysis involving the application of research methods to administrative systems, policies, and procedures. Recent duties have included grants preparation and administration with the federal government; municipal ordinance review and recodification; survey study and data collection for use in administrative, fiscal, budgetary, and procedural analyses; and assistance on forms design. A considerable amount of time has been spent conducting bond and sales tax election campaigns. His work has required him to become acquainted with every department and aspect of city government.

Mr. McDole is a member of the American Association of Public Administrators.

Larry L. Minarik, Zoning and Subdivision Administrator

Urban Studies, University of Nebraska, 1961-63 and 1968-69

Mr. Minarik has over ten years of experience in urban planning and zoning and subdivision administration. His experience is with both a private planning and consultant and a municipal corporation. He has participated in all phases of the comprehensive planning process, Urban Renewal planning and zoning and subdivision administration. Before joining the City of Independence in 1969, Mr. Minarik was a planning technician for the Leo A. Daly Company (Omaha) for over 3 years.

Mr. Minarik has developed comprehensive plans and Urban Renewal programs for several cities and metropolitan areas.

Paul A. Mosiman, Planner II

Bachelor of Architecture, Kansas State University

Mr. Mosiman has over seven years of professional experience, both with a private consultant and two government agencies. During this time he has participated in many types of general planning programs, including comprehensive plans, urban design programs, environmental impact studies, and a number of Federal program applications. Before joining the City of Independence in 1972, Mr. Mosiman was employed by the Land Clearance for Redevelopment Authority, Independence (1970-72) and Howard, Needles, Tammen and Bergendoff Consulting Engineers (1968-70).

David E. Proske, Environmental Planner

Southeast Missouri State College, 1963-65

Southwest Technical Institute, 1967-69

University of Missouri-Kansas City, 1970-71

Mr. Proske's duties include the preparation of Environmental Impact Statements with written text and drafting of figures, diagrams, tables, etc., for submission to proper agencies where Federal funding is anticipated on projects within the City of Independence. These projects include but are not limited to, roads, sewers, parks, buildings, etc. He also has responsibility for the City's 208 Water Quality Management Planning Program. This program's purpose is to eliminate point and non-point pollution, including existing facilities and planned improvements.

Before joining the City of Independence in 1969, Mr. Proske was employed by the City of Berkeley, Missouri as an engineering aide (1968-69) and by the Western Electric Company as an installer of central office equipment (1965-68).

POWER & LIGHT DEPARTMENT
Independence, Missouri

Bobby J. Barnett, Electric Utility Director

B.S., Civil Engineering, Finlay Engineering College

A.C. and D.C. Electrical Courses (Night School)

Mr. Barnett has sixteen years experience in the electric utility industry beginning as a field engineer in April 1959 with the City of Independence Power & Light Department. Advanced to District Engineer in October 1960 and to Power Distribution Manager in October 1964, serving for 9 years in that position. Promoted to Electric Utility Director in June of 1973 after two months as Acting Director. He is a Missouri State Registered Engineer and a member of the Institute of Electrical and Electronic Engineers, and Second Vice-President of Missouri Association of Municipal Utilities.

PUBLIC WORKS/ENGINEERING DEPARTMENT
Independence, Missouri

Warren L. Welch, Director of Public Works/Engineering

B.S., Civil Engineering, University of Kansas

Mr. Welch joined the City of Independence in January 1969. As Director of Public Works/Engineering, he is responsible for all phases related to preparing plans, designs, estimates and specifications for city streets, sanitary sewers, and storm sewers. He is also responsible for engineering plans prepared by private engineering firms relating to the development of subdivisions and commercial building, processing assessment district improvements projects and inspection service on all work to be accepted by the City. He supervises a total of 53 employees within four divisions.

From August 1966 to January 1969, Mr. Welch was a design engineer with Schlup, Becker & Brennan Consulting Engineers. His duties included highway and street design, sanitary and storm sewer design, earthwork computations, site grading, detailing of reinforced concrete bridges, grading, detailing of reinforced concrete bridges, drainage facilities, retaining walls and quantity takeoffs. Prior to that he worked on various engineering projects for Douglas County, Kansas; the N. R. Hamm Construction Company, Perry, Kansas; and Loyandotte County, Kansas.

Mr. Welch is a member of the American Public Works Association and is an officer in the Kansas City Chapter. He is a registered Civil Engineer in the State of Missouri.

Haze E. Nickols, Civil Engineer II

B.S., Civil Engineering, Finley Engineering College

Mr. Nickols has over 19 years experience, about 10 years in Civil and 9 years in Mechanical engineering. The heaviest experience is in Sanitary Engineering and Service Piping Systems for industry. He is experienced in all phases of client relationships in consulting work. He joined the City of Independence in April 1975 as a Sanitary Engineer. He is responsible for liaison with Federal & State Government Agencies involved in Sanitary Grant Programs (EPA, HUD, etc.) and with Engineering Consultants involving design and construction supervision. Present projects include pump stations, trunk sewers and a new activated sludge treatment plant with sludge incineration. He is also in charge of the sanitary sewer design section.

Prior to that he worked for Armco Steel (contract through Jensen Engineering) on hydraulic systems and support piping facilities for rod mill

expansions. Duties included design, layout, material and equipment specification, requisition and installation supervision. He was also employed by direct contract and on contracts through Southern Design Services, and Midwest Technical Services to Enwright Associates, Greenville, S.C. and Harwood Beebe Engineers, Spartanburg, S.C. as a Civil Design Engineer, Project Engineer, and Environmental Projects Group Leader. Projects included lateral sewer collection systems up to 150,000 lineal feet, trunk sewers, water distribution systems, sanitary landfills, trickling filter plant modification, aeration basins, and municipal sewerage systems.

As a Mechanical Engineer for Southern Design Services, Inc., Spartanburg, S.C., his projects included steam & condensate systems, compressed air systems, pneumatic conveying systems, waste heat discovery systems, chilled water systems for air conditioning, and various process piping systems. His work included design, systems layout, equipment selection, and specification writing.

Mr. Nickols has worked as a project engineer for several other engineering firms besides those mentioned above. His duties included planning, design, estimating, specification preparation, etc. for a wide variety of projects. These projects involved liquid propane storage and vaporization stations, gas and water distribution systems, street improvements, and manufacturing systems, to name a few.

Mr. Nickols is a licensed professional engineer in the State of Missouri.

Duane A. Wheaton, Sr., Engineering Technician III

Attended University of Missouri-Kansas City, Penn Valley Community College, and Central Missouri State College at Independence. Majored in Civil Engineering.

Attended numerous courses and seminars in the field of Surveying and Land Acquisition.

Mr. Wheaton has over thirteen years experience in Civil Engineering, primarily in the surveying field with the last 7 years being primarily in the land acquisition field. Since joining the City of Independence in June 1965 he has had responsibilities in construction inspection, surveying, drafting, and land acquisition. He was promoted in 1967 to Survey Party Chief where he was responsible for obtaining engineering design surveys, construction surveys and land surveys. During this time many legal descriptions for easements and right of way documents were prepared under his direction. In 1969 he was promoted to Engineering Technician III, Section Chief. Mr. Wheaton assumed responsibility for the acquisition of all

easements, rights of way, and land acquisitions for the various divisions of the City of Independence, in addition to responsibilities for surveys. During this period of time he has been responsible for the development and training of a full acquisition and relocation staff consisting of four negotiators, one relocation agent, and a 3-man survey party.

Before joining the City of Independence Mr. Wheaton was employed by Howard, Needles, Tammen & Bergendoff, Consulting Engineers. His responsibilities were in bridge construction inspection, material testing, surveying and drafting. Projects included major highways, bridges, and photogrammetrics.

Mr. Wheaton is a Certified Engineering Technician. He is a member of the American Congress on Surveying & Mapping, the American Right of Way Association, and the American Public Works Association.

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PUBLIC TECHNOLOGY, INC.

PORTER W. HOMER

EXPERIENCE: October 1970 to Present: Public Technology, Incorporated
President. (Formerly the Technology Application Program of
the International City Management Association.)
May 1, 1965 - October 1970: Metropolitan Dade County, Florida
County Manager.
March 1962 - May 1965: Rochester, New York
City Manager
October 1955 - March 1962: Tucson, Arizona
City Manager
July 1949 - October 1955: Kansas City, Missouri
Director of Research and Budget (and various staff positions)
World War II Veteran - U. S. Infantry Officer (Postwar service
with Connecticut National Guard)
Also taught basic Political Science at Syracuse University and the
University of Kansas City. Has lectured at several colleges and
universities and at professional conferences, and has authored
several articles in professional journals.

EDUCATION: B.A., University of Connecticut, 1948
Graduate work in Public Administration of Maxwell School at
Syracuse University

**PROFESSIONAL
MEMBERSHIPS:** International City Management Association
National League of Cities
Municipal Finance Officers' Association
American Society for Public Administration
National Municipal League
Systems and Procedures Association of America

**PROFESSIONAL
MEMBERSHIPS:
(Continued)**

American Legion

Veterans of Foreign Wars

National Association of Counties

OFFICES HELD:

Board of Directors, American Society of Planning
Officials (Presently)

Former President, Missouri-Kansas Chapter, American
Society for Public Administration

Former President, Arizona City Manager's Association

Former Chairman, Personnel Policy Committee,
National League of Cities

Member, Performance Budgeting Committee, Municipal
Finance Officers' Association

Former Vice President of International City
Managers' Association

Former Chairman, Goals Committee, ICMA

GRAHAM W. CASSERLY

EXPERIENCE: 1974 to Present: Public Technology, Inc.

Regional Manager. Responsible for the Southern Regional activities of the Urban Technology System. Southern Region includes 7 participating local government, 7 on-site Technology Agents and 3 supporting R&D organizations. Also responsible for supporting activities within the Program Office such as planning, budgeting, etc.

Later, Program Manager in UTS responsible for developing, proposing and managing major technical projects in relation to the identified needs of local government.

1969 to 1974: Champlain Technology, Inc.

Senior Member of the Technical Staff. Responsible for defining, proposing and managing technical studies in the area of navigation and control systems for commercial aircraft, with particular emphasis on operational requirements related to the safety of aircraft landing and aircraft takeoff.

1964 to 1969: University of Michigan

Associate Research Engineer, Willow Run Laboratories. Responsibilities included research on navigation satellite systems and guidance and control systems for satellites.

1961 to 1964: Johns Hopkins University

Senior Staff Engineer, Applied Physics Laboratory. Responsibilities included guidance studies related to U.S. Navy Missile systems, and later, managing product improvement efforts related to the shipboard fire control computer for the Terrier missile system.

1956 to 1961: Lear, Inc.

Section Head for Analytical Design. Responsibilities included the management and execution of analytical studies related to the preliminary design and to the product improvement of flight controls and flight instruments for manned aircraft.

GRAHAM W. CASSELY

EXPERIENCE: 1955 to 1956: Polytechnic Institute of Brooklyn
(Continued)

Research Fellow. Carried out research on nonlinear servomechanisms.

1952 to 1955: Sperry Gyroscope Company

Assistant Product Engineer. Support of product and product improvement activities on airborne electronic systems. This period included a 2 year leave of absence for military service.

1951 to 1952: U.S. Naval Proving Ground

Electronic Engineer. Responsible for design construction and maintenance of instrumentation for interior ballistics research.

EDUCATION: B.S. in Electrical Engineering, University of Michigan (1951)
Graduate Studies in Automatic Controls, Polytechnic Institute of Brooklyn
Graduate Studies in Random Processes, University of Michigan

PUBLICATIONS: Measurement and Stabilization of Nonlinear Feedback Systems, co-authored with J. G. Truxal, a technical paper presented at the I. R. E. National Convention, 1966.

Research and Guidance Design Analysis for Military Space Operations, contributor, Final Report, Contract 33 (657) -11501, University of Michigan, August, 1964.

Satellite Navigation Studies, co-authored with L. D. Filkins and W. K. Hall, 3rd Quarterly Progress Report (1 April through 30 June 1966), Report No. 7657-4-P, Navigation and Control Systems Group, Willow Run Laboratories, Institute of Science and Technology, University of Michigan, Ann Arbor, Michigan, 1966.

The Potential Use of Satellites in Hyperbolic Position Finding, co-authored with L. D. Filkins, published in Navigation, the Journal of the Institute of Navigation, Winter, 1966-67.

Satellite Navigation Studies, co-authored with Y. Morita, 4th Quarterly Progress Report (1 October through 31 December 1966), Report No. 7656-6-P, Willow Run Laboratories, Institute of Science and Technology, University of Michigan, March 1967.

WILLIAM M. MASCENIK, JR.

EXPERIENCE: 1974 to Present: Public Technology, Inc.

Regional Manager. Responsible for management of Technology Agents and technical institutions for the western cities in the Urban Technology System. Conduct User Requirements Committees which match local and state government needs with available technology. Develop methodologies for technology dissemination. Responsible for Energy Programs for various local and state governments.

1971 to 1974: National Society of Professional Engineers

Project Director. Responsibilities included development and management of a program for the Environmental Protection Agency's Data Analysis of individuals working in the private sector of air pollution control. Directed the Transportation Planning Program under contract to the U.S. Department of Labor and U.S. Department of Transportation to assist displaced aerospace professionals in career changes. Researched the Air Pollution Control field for the Skills Conversion Study.

1966 to 1971: TRW Systems

Member of the Technical Staff. Systems and Project Engineer for propulsion systems which involved all aspects from conceptual requirements, through design coordination to testing and customer acceptance. Responsible for program plans and budgets. Conducted development and design verification tests and presented formal design reviews.

1962 to 1966: Hughes Aircraft Company

Member of the Technical Staff. Responsible for propulsion system components, including pressure tanks, for various spacecraft. Directed a program to develop a metallized Teflon expulsion bladder which was subsequently used on spacecraft. Achieved goals in the manufacturing process by designing and developing electrical and pneumatic precision assembly devices.

EDUCATION: B.S., Mechanical Engineering, Ohio University, 1962

Graduate, Environmental Management Institute, University of Southern California, 1971

PROFESSIONAL MEMBERSHIPS: American Institute of Aeronautics and Astronautics

Former Advisor on Environmental Curriculum, Los Angeles Community College

PUBLICATIONS: Technology Utilization Project -- Transportation Planning, Final Report, prepared for the U.S. Department of Labor, January 1973.

A Manpower Conversion Program for Transportation Planners, AIAA Paper No. 73-954, Third Urban Technology Conference, September 1973.

An Urban Technology System (coauthored by J. L. Mercer), The American Institute of Industrial Engineers, September 1974.

UTS: Accelerating Public Sector Technology Utilization (co-authored by J. L. Mercer), The American Society for Mechanical Engineers, Winter Annual Meeting, December 3, 1975.

RONALD J. PHILIPS

EXPERIENCE: July 1971 - Present, Public Technology, Incorporated

Senior Vice President and Treasurer. Responsible for directing hardware and large systems related product development and market research and analysis programs for PTI. Also has responsibility for PTI's overall industrial affairs and liaison program.

October 1968 - June 1971, National Aeronautics and Space Administration.

Director, Technology Utilization Office. Responsible for planning, directing and evaluating the NASA Technology Utilization Program. The Program was designed around various experimental technology transfer projects ranging from technical information preparation and dissemination to application engineering in public sector areas. The Program was conducted by in-house NASA laboratory personnel and contractor groups in industry, universities, not-for-profit research institutes, other Federal, state and local government entities, technical trade media and professional societies.

Consultant to the National Academy of Engineering and Committee on Human Resources, 1972.

Member (NASA) Ad Hoc Committee on Intergovernmental Science Relations Federal Council on Science and Technology, 1971.

Member (NASA) Committee on Excavation Technology of the Federal Council on Science and Technology, 1971.

Project Director, Joint U.S. -South Korean "Pilot Project in International Technology Transfer." Sponsored by the Agency for International Development (AID), NASA, and Korean Institute for Science and Technology (KIST), 1970-71. Headed a Technical Mission to South Korea in 1970.

U. S. Representative, Organization for Economic Cooperation and Development (OECD) Seminar, "Governmental Responsibilities in Information for Industry." Jouyn Josas, March 2-5, 1970.

November 1967 - October 1968, NASA

Executive Assistant to Harold B. Finger, Associate Administrator

RONALD J. PHILIPS

EXPERIENCE

(Continued)

for Organization and Management, NASA.

June 1966 - November 1967, NASA

Principal Staff Assistant to NASA Administrator James E. Webb.

June 1964 - June 1966, NASA

Program Management Specialist - Flight Operations Directorate,
Manned Spacecraft Center.

PUBLICATIONS:

(Articles)

"Technology, Education and Progress." Science and Children,
Volume 8, Number 7, April 1971.

"Technology Utilization: Supplying the Blueprints." Public
Management, Vol. 53, No. 2, February 1971.

(Papers)

"Politics of Technology: An Approach." Presented to the Final
Plenary Session of the Urban Technology Conference, sponsored
by the American Institute of Astronautics and Aeronautics, the
National League of Cities, the U. S. Conference of Mayors, and
the International City Management Association, New York City,
May 1971.

"Technology Utilization and Systems Management." Presented at
the Systems Management 1970 Conference (SM 70), March 1970.

"The NASA Technology Utilization Program and Biomedical Appli-
cations." Presented at the American Education Research Associ-
ation Annual Meeting, February 1969.

(Numerous other speeches and papers on Technology Utilization)

EDUCATION:

B.A., Nebraska Wesleyan University, 1962 (With Distinction)

M.A., Arizona State University, 1963

University Fellow, University of Texas, 1963 - 1964

George Washington University, 1964 - 1965.

PROFESSIONAL

MEMBERSHIPS:

American Association for the Advancement of Science

American Political Science Association

RONALD J. PHILIPS

PROFESSIONAL MEMBERSHIPS

(Continued) American Society for Public Administration
International City Management Association

HONORS: Nebraska Wesleyan University "Outstanding Citizen Award," 1970
William A. Jump Memorial Foundation's Meritorious Award in
Public Administration, 1970
Outstanding Young Men of America, 1967
Blue Key Academic Honorary Fraternity
Pi Sigma Alpha Honorary Professional Fraternity
University Fellowship, University of Texas.

ROBERT N. SOCKWELL

EXPERIENCE:

December 1976 - Present: Public Technology, Incorporated

Project Architect: Responsible for conduct of R & D projects related to design, construction and maintenance of public facilities. Current topics include, the applicability of master specification systems to public facilities and, development of seismic design criteria for police and fire stations.

1975-1976: Harry Weese and Associates, LTD., Washington, D. C.

Station Designer: Developed designs and criteria, program evaluation and site analysis for intercity rail stations for high speed passenger route between Washington and Boston.

1974-1975: LBC & W, Inc. Alexandria, Virginia

Designer: Principal designer for educational facility project. Additional activities included design and user requirement involvement with county court facility, urban police station and high rise housing for the elderly.

1968-1974: Harry Weese and Associates, LTD., Washington, D. C.

Designer-Draftsman: Prepared designs for stations of Washington, D. C. Rail Transit System. Work included station furniture and graphics studies, site analysis and planning.

EDUCATION:

Bachelor of Architecture (Design), Howard University
Washington D. C. 1972

Graduate Study: Transportation Principles & Policy,
American University, Washington, D. C. 1975

REGISTRATION:

NCARB Professional Licensing Examination, 1975

LICENSE:

Washington, D. C. #A2580

**PROFESSIONAL
MEMBERSHIPS:**

Corporate Member, American Institute of Architects
Corporate Member, Washington Metro Chapter, AIA

THOMAS V. TIEDEMAN

EXPERIENCE:

May 1975 to Present: Public Technology, Incorporated.
Project Manager. Responsible for program development in public building construction and public safety related to buildings. Includes maintaining liaison with Federal, state, and local agencies and major segments of the construction community.

Serve as secretariat aiding in program development for the Association of Major City Building Officials.

January 1974 to May 1973: The American Institute of Architects, Washington, D.C.
Assistant Director, AIA Codes and Regulations Center. Responsible for support and representation of the architectural profession in the area of building codes and standards. Involved liaison with Federal agencies, building officials organizations, and standard writing institutions. Functions included congressional testimony, encouragement of related research, and participation on national task forces on building regulatory matters.

August 1973 to January 1974: AIA Research Corporation, Washington, D.C.
Research Associate. Responsible for analytical work in research primarily involving building regulation, especially potential computer application areas.

June 1971 to June 1973: Research Foundation, State University of New York at Buffalo.
Research Associate. Engineering work and later research project management involving life safety simulation, building regulation and regulatory agency management.

EDUCATION:

Masters of Architecture, State University at Buffalo, Buffalo, New York
B.S.; Aerospace Engineering, University of Michigan, Ann Arbor, Michigan

**PROFESSIONAL
MEMBERSHIPS:**

National Conference of States on Building Codes and Standards

FRANCES H. GIBEL

WORK EXPERIENCE:

6/74 - present: Public Technology, Inc.

Assistant to Information Director
Responsible for daily external telephone and mail queries. Handle internal PR needs as appropriate. Work on 3 regularly published newsletters, with varying degrees of responsibility for each. Newsletter duties cover writing, editing, design decision, and supervising print production of all 3 bulletins. Designed format and control computerized mailing lists with complex multiple sorting facilities. Assisted production of new PTI conference exhibit. Responsible for 1976 exhibit budget and conference arrangements. Helped coordinate and produce PTI slide show. Tangential aid to Ford Foundation, which is producing promotional motion film on PTI. Assist on production of product awareness packages, technical handbooks and technical guides. Recently finished one-year assignment as professional Secretariat for Urban and Regional Information Systems Association. Created their newsletter, giving them "logo" and organizational image at same time. Wrote, edited and produced same. Was solely responsible for most other URISA publications and all promotional pieces. Was asked to help plan, organize and run annual conference held in Seattle. Handled all membership services.

1/72 - 8/72

Del Laboratories

Publicist. Organized and ran new Publicity/PR Department for this conglomerate of cosmetic, hair care and drug companies. Martin Revson, Chairman of the Board. Wrote all consumer and trade releases. Helped organize sales promotions and point-of-purchase displays. Assisted production TV commercials. Wrote co-op radio ads.

1/71 - 1/72 Charter Oak Tele-Pictures

Assistant to Producer. Worked on commercials, features, documentaries. Script writing and film cutting, administrative and client liaison responsibilities. Major client was Pan Am.

1/70 - 6/70 The Rowland Company

Public Relations. Mainly involved with Chesebrough-Pond's account (Vaseline & Q-Tips). Helped plan introduction of "Vaseline Intensive Care Lotion" through press releases, cocktail party for press, etc. Exposure on Clairol's "Brunettes" campaign & Foster Grant sunglasses

3/69 - 9/69 Tempo Advertising Agency

Classified Ad House. Account Exec for some existing house accounts and obtained new clients. Worked with Pitman-Moore Division Dow Chemical Co., Yale Medical School, New American Library, agglomeration divisions (plastics, perfumes) of Borden, etc.

9/68 - 3/69 Remer-Ribolow Employment Agency

Placement Manager -- handled "Advertising" desk.

2/66 - 7/67 City of New York, Dept. of Welfare
Queens General Hospital location.

"Caseworker" & "Hospital Care Investigator".

EDUCATION:

Boston University -- College of Liberal Arts
 '65 B.A. Speech major, (minors: psych, ed, english)
 '67 - '68 Reaccepted for courses to fulfill pre-med major

Hofstra University
 summer '70 courses in economics and anthropology

George Washington University
 summer '73 Public Relations/Editing seminar

AWARDS:

New York State Regents Scholarship
 Special Merit Award - Long Island Speech Association

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NUS PERSONNEL RESUMES

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PETER D. ARROWSMITH

VICE PRESIDENT - ENGINEERING DIVISION

EDUCATION

University of Kansas, B. S. in Chemical Engineering, 1956
George Washington University, Washington, D.C.,
(evening) mathematics courses, 1967
Oak Ridge School of Reactor Technology, 1958

REGISTRATION

Professional Engineer, State of Maryland, 9952
Professional Engineer, State of Virginia, 9059
Professional Engineer, State of Florida, 23913
Professional Engineer, State of Washington, 16127
Professional Engineer, State of Michigan, 23908

EXPERIENCE

NUS CORPORATION, 1963-Present
SUNTAC Nuclear Corporation, (NUS affiliate) 1969-1975
USAEC, 1960-1963
Senior AEC Representative, General Dynamics, Electric
Boat Division, 1962-1963
Schenectady Naval Reactors Office, Natural Circulation
Reactor Project, Project Engineer, 1960-1962
United States Navy, 1956-1960
Assistant to Senior AEC Representative, 1958-1960
AEC Naval Reactors Branch, 1956-1957

NUS - Division General Manager, responsible for management and technical direction of all nuclear, power, water conditioning, and wastewater projects being performed by NUS Corporation's Engineering Division.

SUNTAC - President, was responsible for the management and technical direction of engineering, procurement and construction projects associated with backfits to nuclear power plants. Typical projects included:

Monticello Nuclear Plant Off-Gas System
Installed Cost \$10,000,000
Vermont Yankee Nuclear Plant Off-Gas System
Installed Cost \$10,000,000
Big Rock Point ECCS
Installed Cost \$3,700,000

Design and Analysis of Spent Fuel Shipping Casks
Facility to Support Decontamination of Dresden
Nuclear Unit #1

As NUS Vice President for Development, was responsible for the development of proprietary processes, the design, construction and operation of large scale pilot plant facilities in the areas of tertiary treatment of domestic sewerage waste waters and radiation catalysis of complex chemical reactions.

USAEC - Directed construction, quality control, testing, maintenance and initial startup of nuclear power plants for a dozen submarines in various stages of construction at the Electric Boat Shipyard.

Directed work at Knolls Atomic Power Laboratory in design and development activities associated with the AEC's Natural Circulation Reactor Plant. Specific activities included development test programs, equipment specifications and procurement, systems design, and plant arrangements.

11/76 ED

THOMAS A. RUSSELL

PROJECT MANAGER

EDUCATION

State University of New York, Maritime College, B. S.,
Marine Engineering, 1955
University of Pittsburgh, graduate course in Business
Administration, 1966
University of Washington, graduate course in Nuclear
Engineering, 1963

REGISTRATION

Professional Engineer, State of Florida
Professional Engineer, State of Maryland
Professional Engineer, State of Massachusetts
Third Assistant Engineer, U.S. Coast Guard
Engineer-in-Training, State of New York

EXPERIENCE

NUS CORPORATION, 1974-Present
Hittman Corporation, 1972-1974
Stone & Webster Engineering Corporation, 1969-1972
ATCOR, Inc., 1966-1969
USAEC, 1963-1966
Burns & Roe, Inc., 1959-1963
Combustion Engineering, 1957-1959

NUS - Responsible for the design and engineering of waste-water systems and facilities at six operating stations of the Florida Power and Light Company. In a prior assignment was project manager for an offgas system modification at the Monticello Generating Station of Northern States Power Company. Was responsible for the high-pressure water and chemical cleaning of palladium-contaminated piping and backfitting of offgas system recombiner vessels and associated equipment.

Participated in various assignments pertaining to the processing, handling, and disposal of radioactive and nonradioactive waste for several utilities.

Hittman - Vice President, directed the operation of HND's waste disposal business. Designed, engineered, and installed liquid and solid waste processing systems and equipment at five utilities.

Stone & Webster Engineering - Served as assistant project engineer on the Shoreham Station and assistant project engineer on the Nine Mile Point Station, Unit 2. Later assigned as project engineer, was responsible for the design and installation of a new diesel generator building and safety injection system at the Yankee Rowe Station.

ATCOR, Inc. - Manager of Operations, directed all phases of company activities in waste disposal, transportation, and decontamination operations. Developed procedures, engineered and directed the decontamination of primary and associated systems at Dresden Unit 1 and Pathfinder stations.

USAEC - Served as LSBR/LWB project engineer. Coordinated the preparation of site plans, preliminary reactor vessel designs, schedules, and cost estimates for a 480-MWe light water breeder reactor for the California Department of Water Resources. As Shippingport project engineer, was responsible for the construction, decontamination, and modification of plant systems and facilities.

Burns & Roe - Nuclear engineer, responsible for the primary system design and layout of the 800-MWe New Production reactor. As resident nuclear engineer, had responsibility for supervising the field installation of the primary system components, piping, and associated systems.

Combustion Engineering, Inc. - Served as components engineer on the SIC/S2C submarine project. Was responsible for the preparation of specifications for the primary loop pipe and fittings, check and relief valves. Also served as lead components engineer for the preparation of inquiry specifications and reactor plant equipment selection for PWR conceptual design study for the USAEC.

MEMBERSHIPS

American Nuclear Society
Economics Subcommittee for the Peaceful Uses of Nuclear
Explosives
ANS-22 Standards Committee

LEONARD BREITSTEIN
AIR POLLUTION ANALYST

EDUCATION

Columbia University, New York, New York, Eng. Sc. D.,
Chemical Engineering, 1972
Lehigh University, Bethlehem, Pennsylvania, M. S.,
Chemical Engineering, 1966
Tufts University, Medford, Massachusetts, B. S.,
Chemical Engineering, 1964

EXPERIENCE

NUS CORPORATION, 1973-Present
Oak Ridge National Laboratory, Oak Ridge, Tennessee,
1972-1973
Columbia University, New York, New York, 1966-1971

NUS - Conducts evaluations of the environmental impacts of heat dissipation systems for central power stations, with emphasis on atmospheric effects such as fogging, icing and salt deposition. Performs heat dissipation system studies on natural draft cooling towers, mechanical draft cooling towers, spray canals and cooling ponds. Prepares chapters on alternative cooling systems for Environmental Reports for nuclear power stations. Evaluates meteorological suitability of candidate regions for siting power stations. Performs evaluations of air quality impact of coal-fired central power stations. Participated in a study to develop models and computer programs for prediction of radiation doses resulting from radioactive discharges into air.

Oak Ridge National Laboratory - Evaluated air quality impact of onsite utility systems for supplying electrical and thermal energy requirements of residential, commercial and industrial facilities. Conducted analytical studies of effects of meteorological conditions, aerodynamic downwash, and building configurations on atmospheric dispersion. Conducted evaluations of emission control technology for combustion processes including mobile and stationary sources of air pollutants.

Columbia University - Conducted doctoral research on heat transfer properties of elemental selenium. Designed, built and successfully operated complex apparatus for collecting pool boiling and condensation heat transfer data

with selenium at high temperatures. Utilized regression analyses and best available predicting equations for correlation of heat transfer data. Developed qualitative models for boiling and condensing selenium, based on molecular structure.

HONORS

Columbia University Graduate Research and Teaching Assistantships, 1966-1971
New York State Scholar Incentive Awards, 1967-1969
Esso Education Foundation Research Fellowship, 1965

MEMBERSHIPS

American Institute of Chemical Engineers
Air Pollution Control Association
American Nuclear Society

PUBLICATIONS

Breitstein, L. and C.F. Bonilla, "Heat Transfer in Pool Boiling and Condensing Selenium," Fifth International Heat Transfer Conference, Tokyo, Japan, September 1974.

Breitstein, L., A.J. Miller, G. Samuels, and W.J. Boegly, "Technology Evaluation for MIUS," Eighth Intersociety Energy Conversion Conference, Philadelphia, Pennsylvania, August 1973.

Breitstein, L., "The Collection and Correlation of Heat Transfer Data in the Pool Boiling and Condensation of Elemental Selenium," Doctor of Engineering Science Dissertation, Columbia University, 1972. (NTIS document COO-3027-6, Springfield, Virginia).

Breitstein, L., "Pressure Drop and Heat Transfer in Forced-Convection, Horizontal Boiling," M. S. Thesis, Lehigh University, 1966.

10/74 ESD-8
12/5

WILLIAM ELLISON

**ASSISTANT GENERAL MANAGER
AIR QUALITY PROGRAMS**

EDUCATION

City University of New York, M. E., Environmental Pollution Control, 1969
Polytechnic Institute of Brooklyn, graduate studies, Thermodynamics and Fluid Mechanics, 1956-1959
Stevens Institute of Technology, M. E., 1947; M. S., Heat Power, 1956

REGISTRATION

Professional Engineer, State of New York, 1960
Professional Engineer, State of Pennsylvania, 1972

EXPERIENCE

NUS CORPORATION, 1976-Present
Envirotech Corporation, 1970-1976
Chemical Construction Corporation (Chemico), 1963-1970
M.W. Kellogg Company, 1952-1963

NUS - Responsible for the technical supervision of engineers, designers, and air quality analysts in providing consulting services in air pollution control, stack gas cleaning and disposal of collected wastes, dispersion analysis and environmental monitoring.

Envirotech - Marketing Manager, SO₂ Systems, directed the technical development, pilot/demonstration operation, and basic design of flue gas desulfurization systems. Developed and coordinated design of zero-effluent wet collection systems for acid gas emission control. Devised patent-pending process design and provided technical project coordination for an advanced zero-effluent double-alkali FGD system for high-chloride, high-sulfur coal being installed in a 600-MW grassroots power plant.

As Manager, Air Pollution Control Systems, directed R&D, design, and costing of stack gas cleaning systems. Prepared assessments of control equipment suppliers and state of the art of stack gas cleaning. Provided system design and project coordination for an advanced-technology double-alkali FGD pilot/demonstration program.

WILLIAM ELLISON
Page Two

Chemico Pollution Control Division - Manager of Technical Development and Industry Sales, directed technical development, marketing and performance testing of gas cleaning processes and equipment components. Supervised field pilot plant operations in development of commercial pollution control systems. Directed design and engineering of off-site support systems for oil refinery and chemical plant complexes.

M.W. Kellogg Co. - Developed processes and system design for upgrading and beneficiation of iron ore and iron. Designed early continuous process for handling concentrated iron-ore pulp in tubular heat exchangers. Devised optimum technique for outdoor storage of sponge iron utilizing briquetting system. Performed field testing of prototype and full-scale facilities. Supervised control of contract performance and approval of certified drawings of process system and mechanical equipment suppliers for oil refinery installations. Prepared detailed specifications for purchase of special and proprietary equipment and systems.

MEMBERSHIPS

Air Pollution Control Association
National Society of Professional Engineers
American Society of Mechanical Engineers

PUBLICATIONS

Ellison, W., et al., "Environmental Management: Zero-Effluent SO₂ Throwaway System," Power, August 1976.

Ellison, W., et al., "Waste Disposal from Arco Wet Scrubbers," Power, October 1973.

Ellison, W., et al., "Zero-Effluent Throwaway SO₂ System Design for High-Chloride High-Sulfur Coal," Annual Meeting, American Power Conference, Chicago, Illinois, 1976.

Ellison, W., et al., "System Reliability and Environmental Impact of SO₂ Scrubbing Processes," Coal and the Environment Technical Conference, National Coal Association, Louisville, Kentucky, 1974.

Ellison, W., et al., "Designing Large Wet-Scrubber Systems," Power, February 1972.

1/77 ESD

EDWARD J. RICER

**MANAGER, ESTIMATING, PLANNING AND COST ANALYSIS
DEPARTMENT**

EDUCATION

Union College, Extension courses
Rutgers University, Testing Material
Princeton University, Civil Engineering (off site)
New York University, Military Sanitation

REGISTRATION

Professional Engineer, State of New Jersey

EXPERIENCE

NUS CORPORATION, 1975-Present
Consulting Practice, 1969-1975
Stone & Webster, 1962-1969
Consulting Engineer in the Middle East and Europe,
1956-1961
Burns and Roe, 1953-1956
The Ralph M. Parsons Company, 1940-1944; 1950-1953
New York University, 1937-1940

NUS - Responsible for the development and approval of all project and construction cost estimates prepared by the Engineering Division.

As a Chief Estimator for several engineering and construction firms, was responsible for the preparation and approval of engineering, sub-contract and lump sum estimates at home and abroad, such as:

Nuclear Projects Preliminary and Control Estimates

- o The Physics Building and two other facilities at Los Alamos
- o Arco Proving Ground Nuclear Powered Plant
- o Shippingport Nuclear Plant
- o Connecticut Yankee Nuclear Plant - Haddam, Connecticut
- o Shoreham Atomic Power Station - Long Island
- o Oyster Creek Station - New Jersey
- o Proposed experimental reactor for Iraq

Highly Technical Test and Laboratory Facilities

- o United Aircraft Intermittent Flow Laboratory
- o Test Facilities at Edgewood Arsenal, Maryland; Experimental Laboratory, Low-Temperature Test Chamber, Protective Equipment and Radiological Laboratories
- o Static Test Tower - Huntsville, Alabama
- o Chemical and Bacteriological Facilities

Utility and Industrial

- o Electric Generating Station - South Amboy, New Jersey
- o Electric Generating Station - Rockland County, New York
- o Oakland Port of Embarkation
- o Transportation System (River) - Canada
- o Danskammer Generating Stations - Newburgh, New York
- o The Baraboo and Green River Ordnance Works
- o A plant for the synthesis of anhydrous ammonia

FOREIGN ACTIVITY

- o Korea - Rehabilitation of Hydroelectric Facilities
- o Brazil - Dams and Hydroelectric Facilities
- o Saudi Arabia - Electric Distribution Facilities
- o Venezuela - Power plants and transmission lines
- o Philippines - Shipyard, Hospital and Laboratory, Port and Petroleum Facilities, and U. S. Military Bases
- o Okinawa - Shipyard and facilities rehabilitation
- o Turkey - Labor and Material Schedules - Power Plant
- o Canada - Refinery, Waterfront Improvements and Airports
- o Puerto Rico - Chlorine Plant

As Chief Engineer at New York University, directed research, field and laboratory activity to determine the rate of stabilization of organic material and other characteristics of sanitary land fills.

MEMBERSHIPS

Fellow, American Society of Civil Engineers
Member, National Society of Professional Engineers
Member, American Association of Cost Engineers

PUBLICATIONS

Land Fill Survey, New York University, 1938

5/75 ED-12

ROBERT W. FELL

STAFF ENGINEER

EDUCATION

University of Maryland, Ph. D. candidate, Energy Conversion (Mechanical Engineering), 1972-Present
University of Michigan, M. S., Electrical Engineering, 1967
University of Michigan, B. S. E., Electrical Engineering and Engineering Mathematics, 1966
Bettis (Westinghouse) Atomic Power Laboratory Reactor Engineering School, Nuclear Engineering Certificate, 1969

REGISTRATION

Professional Engineer, State of Maryland, 9515

EXPERIENCE

NUS CORPORATION, 1971-Present
Division of Naval Reactors (USAEC), 1967-1971
University of Virginia, 1969-1971
University of Michigan, 1966-1967
International Business Machines, 1963-1967

NUS - Responsible for assessment and evaluation of energy conversion systems; total energy system analysis and optimization; cost estimates for boilers firing various coals; and assessments of major oil-burning facilities (for process heat) to incorporate coal as an alternate fuel.

Set up NUFUEL computer code for demand, supply, and cost studies for various nuclear fuel cycles. Established and carried out seismic testing and electron beam irradiation testing on boron carbide material for spent fuel pool assemblies. Performs demand and supply studies for the nuclear fuel cycle and coal mining cost studies. Participated in all phases of design, licensing, and procurement of components for gaseous and liquid radwaste systems. Performed process and engineering design and analysis of gaseous radwaste treatment systems. Designed the gaseous waste treatment system for South Texas Units 1 and 2. Participated in startup testing of the Monticello offgas system. Performed cost-benefit analyses of various cooling water systems for environmental reports. Developed methods, systems, and equipment for testing HEPA and charcoal filters.

Doctoral studies include all forms of energy conversion systems (e.g., multiple cycles, magnetohydrodynamics, solid-state devices, gas turbines, solar and geothermal systems).

Division of Naval Reactors - Responsibilities included the technical administration for fabrication and procurement of nuclear fuel assemblies; review of technical requirements and manufacturing techniques for nuclear units; review of the technical acceptability of products manufactured with defects; review of design changes to simplify the manufacture of nuclear power units.

University of Virginia and University of Michigan - Taught calculus and electrical engineering.

University of Michigan - Conducted research on microwave antennas, antenna couplings, and high-speed switches.

IBM - Performed circuit design and development; conducted research experiments on high-frequency pulse transmission; participated in devising circuit testing systems.

MEMBERSHIPS

Tau Beta Pi
Eta Kappa Nu
Phi Kappa Phi

PUBLICATIONS

Fell, R. W., "Multi Hundred Watt Radioisotope Thermoelectric Generator Program: Detection and Retrieval of Lost Radioisotope Heat Sources of the MHW/MJS-RTG Design," prepared for ERDA, September 1976.

Steyn, J. J., and R. W. Fell, Edison Electric Institute Nuclear Fuels Supply Study Program, December 1975.

Fell, R. W., "Boron Carbide Test Program for Use in High Density Spent Fuel Storage Racks," prepared for Northeast Utilities, April 1976.

Steyn, J. J., and R. W. Fell, "Worldwide Separative Work Supply/Demand," Atomic Industrial Forum International Conference on Uranium Enrichment, New York, June 30, 1976.

CHARLES A. NEGIN

MANAGER, MECHANICAL ENGINEERING

EDUCATION

Rensselaer Polytechnic Institute, Graduate courses in
Nuclear Engineering, 1966
Massachusetts Institute of Technology, M. S., Mechanical
Engineering, 1961
Massachusetts Institute of Technology, B. S., Mechanical
Engineering, 1960
Massachusetts Institute of Technology, Oak Ridge Practice
School, 1961

REGISTRATION

Professional Engineer, State of Maryland
Professional Engineer, State of Minnesota
Professional Engineer, State of Illinois

EXPERIENCE

NUS CORPORATION, 1967-Present
Combustion Engineering, Naval Reactor Division Nuclear
Submarine Prototype, Shift Supervisor, 1964-1966
Mare Island Naval Shipyard, Production Department,
1963-1964
U.S. Navy, Main Propulsion Assistant on DD468, 1961-1962
Massachusetts Institute of Technology, Research Assistant,
1961

NUS - Currently acting manager, mechanical engineering, is responsible for the activities of all lead and discipline engineers and the compliance of the mechanical engineering department work with the NUS Quality Assurance program.

Provided project management for a modification to the Oyster Creek core spray system, the Monticello off-gas system and several other backfit/modification projects. Responsible for cost and schedule control and for the direction of engineering and procurement activities. Experience includes nuclear reactor plant systems operation, design and analysis. This experience has been utilized extensively in fluid, instrumentation and electrical system applications, solid radioactive waste system design review for a pressurized water reactor; and a redesign study for a spent fuel facility.

Operation, test and training experience includes eleven months supervising comprehensive startup and testing of Monticello off-gas system (a retrofit system which required minimal impact on the operating plant); development testing of a sonic flowmeter for LNG pipeline application; instruction of nuclear utility prospective reactor operators; San Onofre 1 startup assistance and Elk River Fuel inspection.

Design tasks have included conceptual design and feasibility evaluation of icebreaker propulsion systems, including comparison of nuclear, diesel and boiler concepts; programming a simulation of the control loop for the Monticello off-gas system in which a safety and control response analysis was conducted as decisional information for selecting a mode of control for the system; and containment response analysis, including preliminary functional design of BWR reactor building in which the secondary containment transient pressure and temperature response analyses were required to conceptualize this design for AEC/ACRS approval. Design review and PSAR review and licensing follow-up has included participation in HTGR licensing and preparation of permanent license applications for two light water reactors.

Analytical applications have included PWR thermal-hydraulic core analysis applied to the design of a PWR replacement core, technical bid evaluations and training of utility personnel in methods and analysis; programming a BWR/core flow distribution code for use with neutronics codes; PWR accident and transient analyses which include LOCA analysis using RELAP 3 and THETA-1B, standard accident and transient analysis for safety analysis reports, anticipated transient without scram as required by WASH-1270, comparative reliability analysis of emergency core cooling system for ORNL; and analysis of transient fission product release and resulting dose rate for LOCA without reflood.

Combustion Engineering - Assigned to land-based nuclear submarine propulsion prototype for two years. Acted as shift supervisor the last year with responsibilities including the operation of the reactor, engines and support facilities. Also responsible for the qualification training of naval personnel in reactor plant operations.

U.S. Navy - Engineering Duty Officer at Mare Island Naval Shipyard; was a member of the ship superintendent's staff, coordinated construction and testing of steam and submarine systems on FBM ships followed by sea trial testing.

5/77 ED-11

THOMAS B. MULLARKEY

STAFF ENGINEER

EDUCATION

Pennsylvania State University, M. S., Chemical Engineering,
1970 Thesis: Heterogeneous Catalytic Dehydration of
Ethanol
Rensselaer Polytechnic Institute, B. S., Chemical
Engineering, 1964

REGISTRATION

Professional Engineer, State of Maryland

EXPERIENCE

NUS CORPORATION, 1973-Present
Knolls Atomic Power Laboratory, 1966-1973
Pennsylvania State University, Department of Chemical
Engineering, Graduate Teaching Assistant, 1964-1966

NUS - Currently providing project coordination for nuclear engineering systems design and shielding for the Tokamak Fusion Test Reactor. Responsibilities include preliminary design of tritium handling and cleanup systems and radioactive waste systems.

Directed a study of Nuclear Fuel Cycle Radioactive Solid Waste Management for the Atomic Industrial Forum including a detailed evaluation of waste types, generation and processing methods, projected volumes, disposal methods, land burial, and alternatives to reduce the impact of solid radwaste.

Prepared an evaluation of materials for use in spent fuel storage racks including corrosion characteristics, relative neutron absorption, stability under effects of radiation, temperature, moisture, and preliminary costs. Evaluated methods for reactor plant decontamination including plant modifications required, equipment needed, chemical methods available, and waste handling systems and volumes.

Evaluated hydrogen monitoring methods for a BWR off-gas system including response time, methods of sample conditioning, and system installation requirements. Performed a study on methods of deactivating catalyst used in the off-gas recombiner with respect to permanency of deactivation and compatibility with the system materials of construction.

Prepared a detailed work program for the leak testing of containment isolation valves per Appendix J of 10 CFR 50. Specific test methods, test equipment design, reactor plant modifications, and test acceptance criteria were developed for the particular reactor plant.

Provided licensing direction for decontamination of a reactor plant and the installation of additional radwaste treatment equipment. Prepared a safety evaluation of the process including consideration of off-site doses, equipment design codes, and solid waste disposal.

Provided conceptual design of a steam generator blowdown system and a process sampling system and prepared preliminary safety analysis sections for the systems. Evaluated tritium buildup and release associated with evaporation from spent fuel pools and refueling canals as related to building ventilating and purge systems, water surface area, and environmental conditions of the pool.

Knolls Atomic Power Laboratory - Design Engineer for Trident Project, responsible for the design of the reactor coolant purification, sampling and decay heat removal systems. Performed detailed sizing of components, determined fluid flow and pumping characteristics and heat exchanger performance analysis.

Radiation and Coolant Technology, Chemical Engineer. Wrote test proposals, procedures, and evaluation of comparative tests designed to characterize purification media and methods. Directed startup of first new shipboard purification system. Developed water analysis methods, sampling systems and decontamination of components. Provided project support on water chemistry problems and environmental discharge methods. Standardized prototype testing requirements in the area of chemistry control.

Pennsylvania State University - Designed senior level experiment in heat transfer, chemical kinetics and separation processes. Taught unit operations laboratory course.

MEMBERSHIPS

Sigma Xi,
The Scientific Research Society of North America

6/76 ED 9

LARRY D. KENWORTHY

STAFF ENGINEER

EDUCATION

New York University, M. S., Nuclear Engineering, 1973
Miami University, B. S., Physics, 1959
U.S. Merchant Marine Academy, Reactor Technology Training,
1966

EXPERIENCE

NUS CORPORATION, 1974-Present
Public Service Electric and Gas Company, 1968-1969;
1971-1974
First Atomic Ship Transport, Inc., 1965-1968; 1969-1970
U.S. Navy and Merchant Marine, 1959-1965

NUS - Responsible for design of nuclear auxiliary systems for power reactor facilities, including BWR offgas systems, fuel pool cooling, and general cooling water systems. Activities include preparation of system specifications and flow diagrams, P&IDs, equipment specifications, and technical support for system licensing. Conducts conceptual engineering feasibility and economic analyses for naval nuclear power applications, involving selection of thermodynamic cycles, plant arrangement, and definition of plant capabilities.

Prior assignments included the engineering analysis and design relating to modifications (back-fit) of existing power generating plant water and materials handling systems required to allow the processing of wastes. Specific system experience includes steam generator blowdown, demineralizer regeneration, building drainage, and bottom and flyash handling systems.

Was also responsible for the designs of process systems for the treatment of industrial and utility wastewater streams. Tasks included detailed system design including equipment design, sizing, arrangement, specification, and design calculations required for process development and equipment selection.

Public Service Electric and Gas Company - Performed engineering design associated with reactor coolant and spent fuel cooling systems for PWR generating stations. Was responsible for the design review and coordination of the

engineering effort involved in the installation of the reactor pressure vessels and other large NSSS components. Prepared system test specifications and installation procedures.

Provided design assistance and consulting services to architect-engineer for the floating nuclear plant project. Evaluated systems proposed for handling and solidifying liquid radioactive waste. Served as member of ANSI Committee investigating the water-borne transport of radioactive waste and spent fuel.

Also had the responsibility for supervision of maintenance work in large, super critical cycle, fossil fuel generating stations, including boiler work, turbine plants, and gas turbine units.

First Atomic Ship Transport - Reactor operator aboard NS Savannah. Participated in primary and secondary plant operation and maintenance activities. Supervised plant water chemistry program, and performed health physics monitoring work. Assisted in the training of future reactor operators.

U.S. Navy and Merchant Marine - Performed various engineering duties as Commissioned Officer in the Navy and as Licensed Marine Engineer aboard merchant vessels.

MEMBERSHIPS

American Nuclear Society

3/77 EO-10

WALTER J. ISRAEL
SENIOR ENGINEER

EDUCATION

B. S., Mechanical Engineering

EXPERIENCE

NUS CORPORATION, 1977-Present
Multinational Agribusiness Systems, Inc., 1975-1977
URS/Madigan-Praeger, 1974-1975
Meridian Engineering Company, 1972-1974
Ammann & Whitney, 1969-1972
Pope, Evans, and Robbins, 1967-1969
Burns & Roe, 1963-1967
Reals Construction Company, 1958-1963
Gibbs & Hill, 1950-1958
Johns-Manville Company, 1947-1950
Colgate-Palmolive-Peet Company, 1943-1947
The Lummus Company, 1941-1943

NUS - Provides engineering consulting services in the field of mechanical engineering, from conceptual design to detailed specifications.

Multinational Agribusiness Systems, Inc. - As consultant and construction specialist, was responsible for preparing feasibility report on specifications and vendor proposals for a sugar factory and a bagasse-fired power plant in the Ivory Coast, Africa. Was also responsible for preparing test procedures for piping and equipment startup.

URS/Madigan-Praeger - Project engineer in charge of mechanical design for a \$1 million prototype RCA satellite station and the Baltimore, Maryland, subway station. Responsible for piping and adherence to all codes.

Meridian Engineering Co. - Resident engineer responsible for supervising the construction of a \$160 million power plant, science building, medical and dental school, and hospital for the State of New Jersey.

Ammann & Whitney - Resident engineer responsible for all mechanical construction on the \$100 million Pan American 747 jet facility at the John F. Kennedy International Airport. The facility included a power plant, waste treatment plant, maintenance facilities, and hangars.

Pope, Evans, and Robbins - Mechanical engineer responsible for design, cost estimation, and specifications for a wasteburning power plant and other projects.

Burns & Roe - Resident engineer responsible for the specification and construction of a 66-MW thermal power station.

Reals Construction Company - Supervising engineer responsible for supervising all engineering and construction for city, state, and federal agencies, primarily in the area of piping, boilers, and underground utilities.

Gibbs & Hill - Resident engineer responsible for supervising the construction and startup of a thermal power plant and the design and construction of a large railroad station and yard facilities. Was involved in field studies for the Arabian American Oil Company for field pumping stations, including the design of pressurized containment buildings, economic comparisons of diesel, gas turbine, and motor-driven pumps, and the operational costs of each. Other projects included the design supervision for an agricultural processing (bagasse) plant and the design and construction of various chemical plants, including a fiber plant, an Arnel plant, and an acetylene plant for major U.S. manufacturing companies.

Johns-Manville Company - Plant engineer responsible for the design and layout of building products equipment.

Colgate-Palmolive-Peet Company - Plant engineer responsible for the design and construction of new engineering and renovations. Gained operating plant experience in soap/detergent, pharmaceutical, and building materials plants.

Lummus Company - Responsible for the design and construction of a large petroleum tank farm.

JAMES E. REUTER

MANAGER, ELECTRICAL ENGINEERING DEPARTMENT

EDUCATION

Illinois Institute of Technology, B. S. E. E., 1940

REGISTRATION

Professional Engineer, State of Illinois, 18388
Professional Engineer, State of New York, 038612
Professional Engineer, State of Massachusetts, 19103
Professional Engineer, State of Oregon, 6103
Professional Engineer, State of Maryland, 6277

EXPERIENCE

NUS CORPORATION, 1975-Present
Bechtel Power Corporation, 1972-1975
Ralph M. Parsons Company, 1967-1972
Laramore, Douglass and Popham, 1962-1967
Vitro Engineering Company, 1959-1962
Vern E. Alden Company, 1956-1959
Sargent and Lundy, Engineers, 1946-1956

NUS - Responsible for all design and engineering of electrical and instrumentation and control systems for all projects under the cognizance of the NUS Engineering Division. Performs system feasibility studies, electric power rate studies, and economic evaluation of power supply alternatives for municipal and industrial complexes.

Bechtel Power Corporation - As Assistant Project Engineer, was responsible for all phases of engineering and design for the Joseph M. Farley Nuclear Plant, two 840-MWe PWR units.

Ralph M. Parsons Company - As Chief Electrical Engineer, was responsible for all electrical engineering and design work for a fast breeder reactor site survey; a liquid-metal fast breeder reactor demonstration plant study; a 400-ton per day electrolytic zinc plant; and a 130,000-ton per year electrolytic aluminum plant. Conducted numerous studies and economic evaluations of electric power supply alternatives.

Laramore, Douglass and Popham - As Chief Electrical Engineer, directed all engineering and design work on projects handled by the company as well as the preparation of feasibility studies. Typical projects included a 125-MW steam power plant, a 50-MW steam power plant, a 15-MW gas turbine plant, a 150-ton per day paper mill, and various power systems feasibility studies. Responsible for the engineering and design of combustion control systems, steam-temperature control systems, and coal-handling systems for large fossil-fueled steam generators.

Vitro Engineering Company - As Chief Electrical Engineer, was responsible for all electrical and instrumentation engineering and design work on the following projects: 275-MW nuclear power plant; a high-temperature static aircraft test facility; an engine maintenance, assembly, and disassembly facility; and a research laboratory.

Vern E. Alden Company - As Assistant Chief Electrical Engineer, was general administrative assistant to the Chief Electrical Engineer as well as Project Engineer and Job Engineer on specific projects, including the 450-MW Philip Sporn Supercritical Steam Power Plant Unit 5; the 50-MW Alma Power Plant Unit 5; a 17,000-ton per day cane sugar mill; and power distribution systems.

Sargent and Lundy - As Electrical Engineer, was responsible for the electrical engineering and design of steam power plants, power transmission systems, and heavy industrial plants. Typical projects included 60-MW Kramer Plant Units 1 and 2; 125-MW Waukegan Plant Unit 6; 107-MW Joliet Plant Unit 5; 300-MW Will County Plant Units 1 and 2; 345-kV substation projects for the Ohio Valley Electrical Corporation; and paper mill expansions. Responsibilities included the design and specification of systems for electrical, electronic, and pneumatic systems for combustion control, steam temperature/pressure control, and precipitators and ash-handling systems for large coal-fired steam generators used in reheat turbine cycles in electric generating stations.

S. P. VERMA

MANAGER, CIVIL/STRUCTURAL DEPARTMENT

EDUCATION

Queen's University, Ontario, Canada, M. Sc., Engineering
(Structures)
Bihar University, Bihar, India, B. Sc., Engineering
(Cum Laude)

REGISTRATION

Professional Engineer, State of Maryland
Professional Engineer, State of New York
Professional Engineer, State of Illinois
Professional Engineer, State of Pennsylvania
Professional Engineer, State of New Jersey
Professional Engineer, British Columbia, Canada

EXPERIENCE

NUS CORPORATION, 1975-Present
Stone & Webster Corporation, 1974-1975
Roy F. Weston, Incorporated, 1972-1974
Strescon Industries, 1971-1972
H. Gordon & Associates, 1970
Conforce Division of B.A.C.M Industries, 1968-1970
W. L. Wardrobe & Associates, 1966-1968

NUS - Responsible for all civil structural design work in the Engineering Division, including preparation of design criteria, and supervision of design and drafting associated with site preparation and the design of buildings and structures.

Stone & Webster Corporation - Responsible for the design of structures for missile, tornado, and seismic load; design and analysis of shear walls and bracing system for Category 1 structures. Coordinated nuclear, mechanical and electric disciplines. Prepared structural design and supervised drafting of a reactor building (Category 1) including steel-concrete floor framing system, column and column base plate design, and seismic load analysis of structures. Performed the structural design, analysis and supervision of drafting for a normal switch gear building including braced steel framed structure, concrete wall and floor and design of insert plate and anchorage.

Roy F. Weston, Incorporated - Responsible for preparation of structural-architectural design criteria and standards for environmental projects. Performed structural design

and supervised design and drafting for preparation of contract drawings, including planning and layout, site-work, and preliminary estimates. Duties included field contact with construction personnel, client liaison and coordination with mechanical, electrical and other disciplines. Responsible for the complete structural, architectural design and specifications according to the requirements of ACI, AISC & OSHA for an incinerator, a 30 m.g.d advanced wastewater treatment project, an industrial wastewater treatment plant, reinforced concrete clarifiers, a pumping station, and rigid frame and braced steel structures.

Strescon Industries - Chief Engineer, responsible for establishing design criteria, standardizing prestressed-precast products, preparation of strength charts, supervision of design, drafting, quality control, scheduling of precast projects and coordination with federal, state and local regulatory agencies. Duties included general planning and construction coordination with client, architects and engineers. Prepared structural design and drawings for precast-prestressed beams, columns, planks, panels and connection for precast system building projects.

H. Gordon & Associates - Structural Consultant, performed structural design and seismic analysis for a multistorey reinforced concrete motel complex, including design and analysis and supervision of shear wall drafting, flat slabs, columns, and beams.

Conforce Division of B.A.C.M Industries - Structural Design Engineer, responsibilities included structural design for pretensioned and posttensioned bridge girders, prestressed single T, double T, columns, beams and panels and preparation of strength charts.

W. L. Wardrobe & Associates - Structural Design Engineer, was responsible for the structural design of reinforced concrete flat slab, two way, circular slab. Used computers for the analysis and design of structures with both packaged and original programs.

MEMBERSHIPS

American Society of Civil Engineers
American Concrete Institute

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GEORGE C. RUDY

MANAGER, CONTROL AND RELIABILITY ENGINEERING DEPARTMENT

EDUCATION

Marquette University, M. S. in Physics, 1966
Pennsylvania Military College, B. S. in Electrical
Engineering, 1960
University of Maryland, graduate student, courses in
Mathematical Physics, 1966 to Present

REGISTRATION

Professional Engineer, State of Maryland

EXPERIENCE

NUS CORPORATION, 1968-Present
Booz-Allen Applied Research Inc., Computer Applications
Group, Senior Engineer, 1967-1968
Allis-Chalmers, Atomic Energy Division, Reactor Dynamics
Group, Engineer, 1960-1967

NUS - Responsible for the technical management of a multi-discipline department which performs electrical and mechanical system fault and probability analysis, evaluates and engineers system configurations, engineers and develops information control and safety systems using hardwired and computerized techniques.

Directed the development of software, digital computer systems and plant control room systems as required for NUS nuclear power plant training simulators. Directed the development of digital system techniques for real-time information systems, real-time data collection and reduction systems, and plant system control.

Directed nuclear system evaluation studies using failure modes and effects analysis statistical techniques. Directed nuclear power plant system design development supported by transient and statistical analysis. Directed a System Analysis and Electrical Group which performed statistical and dynamic analyses of nuclear and non-nuclear systems; designed, specified and implemented automatic data collection/reduction systems, logic systems, nuclear safety systems, nuclear and non-nuclear monitoring systems, and control systems. Directed the development of

analytical techniques and digital codes required to support system's development and/or operation.

Designed and directed the development of multi-station environmental monitor systems with real time central computer facilities. Developed all software required by these systems for data reduction and system control.

Responsible for the collection and reduction of data and the development of mathematical models used in performing nuclear facility reliability analysis. Developed digital code for analyzing system statistical models.

Booz-Allen Applied Research Inc. - Participated in operations research studies which were designed to establish automatic data processing management information systems for NASA Headquarters.

Allis-Chalmers - Responsible for developing mathematical and computer (both analog and digital) techniques used in performing steady-state and transient studies of nuclear reactor systems. Designed, built and implemented a reactor transfer function analyzer, a superheater in-core flux monitoring system, and a nuclear safety instrumentation system. Designed reactor plant instrumentation and safety system concepts using reliability techniques in conjunction with digital computer analysis. Conducted reactor transfer function experiments and performed data analysis to determine reactor stability margins. Developed conceptual design and specified instrumentation for an on-line computerized noise analysis system.

MEMBERSHIPS

Maryland Society of Professional Engineers
American Society for Testing and Materials

PUBLICATIONS

"Use of Reliability Theory to Compare Safety System Designs," American Nuclear Society Transactions, Vol. 8, No. 1, 1965.

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BARRY D. SULLIVAN
PRINCIPAL ENGINEER

EDUCATION

Hofstra University, M. B. A., 1964
Rutgers University, B. S. in Electrical Engineering, 1960
Polytechnic Institute of Brooklyn, Graduate Student,
Statistical Analysis, 1967-1968

REGISTRATION

Professional Engineer, State of California

EXPERIENCE

NUS CORPORATION, 1974-Present
Grumman Aerospace Corporation, 1964-1974
Fairchild Hiller Corporation, Republic Aviation Division,
1963-1964
AMBAC Industries, Inc., ARMA Division, 1960-1963

NUS - Responsible for development of system simulations for analyses to evaluate detailed system design, performance criteria, and operational parameters. Responsible for the operation of in-depth failure mode and effect analyses (FMEA), common mode failure analyses (CMFA), event sequence analyses, and quantitative reliability analyses at the functional and integrated levels for all plant systems.

Performed numerous event (sequence, fault tree, FMEA, and CMF) analyses on LMFBR, PWR and BWR plant protection systems, safety injection systems, safe shutdown systems, and balance of plant systems in support of anticipated transients without scram (ATWS) studies, emergency core cooling studies, fire protection studies, and design reviews of nuclear power plant safety systems. Developed conceptual and detailed designs for process control and protection systems based on fault, reliability, maintainability, testability, and transient system studies.

Participates in IEEE Power Engineering Society subcommittee working groups which are investigating risk assessment and public acceptance of nuclear power generating stations and developing standards for establishing component initial test intervals and inservice adjustment of test intervals. Participated in working groups which generated new, and

revised existing, standards which establish the minimum acceptable requirements for the performance of reliability analyses in the design and operation of nuclear power generating station safety systems (IEEE Std 352-1975 and 577-1976) and generated the reliability data manual for nuclear power generating station components (IEEE Std. 500-1977).

Grumman Aerospace Corporation - As a systems engineer, developed a broad spectrum of system analyses on classified study contracts. Typical analyses included development of mission scenarios, system synthesis, support requirements, reliability, maintainability, system effectiveness and life cycle costing. Developed a technique for the implementation of integrated Lunar Module mission success and mission safety reliability models. Performed design reviews on aerospace systems. Generated failure effect analyses, contingency analyses, and quantitative analyses on aerospace systems.

Fairchild Hiller Corporation - Senior reliability engineer, developed reliability program plans, math models, failure time distributions and mission completion probabilities for aircraft and aerospace systems. Performed design reviews, failure effect and quantitative analyses on aerospace systems. Prepared and delivered technical lectures in the Reliability Training Program. Performed monitoring and analyses during reliability demonstration programs to evaluate efficiency of corrective action.

AMBAC Industries, Inc. - Reliability engineer, performed analysis of defective components that failed during acceptance, qualification, or evaluation testing. Analyses included electrical, mechanical, metallurgical, radiographic, and other physical testing. Worked with vendors to correct component deficiencies and developed techniques for the dissection of failed components. Initiated additional test procedures and specification changes to eliminate conditions of failure.

MEMBERSHIPS

IEEE, Reliability Group
IEEE, Power Engineering Society
IEEE Joint Committee on Nuclear Power Standards,
 Subcommittee 5, Reliability
 Subcommittee 7, Editorial

PUBLICATIONS

Selected list of Co-authored Publications

"Assessment of Clinch River Breeder Reactor Plant Reliability Program and Safety Systems". Prepared for the U.S. Nuclear Regulatory Commission. NUS-2001. December 1976.

"Single Failure Analysis of San Onofre Unit 1 Emergency Core Cooling Systems". Prepared for Southern California Edison Company. NUS-1792. December 1976.

"Big Rock Point Plant Reactor Depressurizing System Integrated Reliability Analysis of Final System Design". Prepared for Consumers Power Company. NUS-TM-240. February 1976.

"Oyster Creek Plant Nuclear Generating Station Single Failure Analysis and Modifications for ECCS System". Prepared for Jersey Central Power and Light Company. Docket No. 50-219. June 1975.

"Palisades Plant Reactor Protection System Common Mode Failure Analysis". Prepared for Consumers Power Company. NUS-TM-EP-97. November 1974.

"Reactor Shutdown System Failure Modes and Effects Analyses". Prepared for Southern California Edison Company. NUS-TM-EP-104. December 1974.

"Big Rock Point Plant Reactor Depressurizing System Equipment Test Schedule Analysis". Prepared for Consumers Power Company. NUS-TM-EP-97. November 1974.

"Analysis of Anticipated Transients Without Scram". Prepared for Southern California Edison. Docket No. 50-206. October 1974.

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IRA L. WHITMAN

MANAGER, PUBLIC WORKS PROGRAMS

EDUCATION

The John Hopkins University, Ph. D., Environmental Engineering, 1968
The Polytechnic Institute of Brooklyn, M. S., Civil Engineering, 1963
Cooper Union, B. C. E., Civil Engineering, 1961
University of Illinois, Water Resources Planning, 1963
George Washington University, Regional Air Quality Management, 1970

REGISTRATION

Professional Engineer, State of Ohio

EXPERIENCE

NUS CORPORATION, 1976-Present
Ira L. Whitman, P.E., 1975-1976
Ohio EPA, Ohio Department of Health, 1972-1975
Battelle Memorial Institute, Columbus Laboratories, 1968-1972
U.S. Corps of Engineers, Baltimore, Md., 1967-1968
City of Baltimore, 1966
U.S. Corps of Engineers, New York, 1963-1964

NUS - Responsible for project management and business development of NUS energy and environmental projects for state and local government. Develops and directs NUS' expertise in executing projects in energy development, solid waste, resource and fuel recovery, wastewater treatment and water resources management in the public sector. Serves as the primary point of contact with all municipal, county, sewer district, regional planning and state officials on public works and management projects.

Ira L. Whitman, Consulting Environmental Engineer - Provided consulting services in environmental engineering and management to government, industry and professional organizations. Directed projects on wastewater treatment, plant operations, environmental monitoring, solid waste and sludge disposal, energy utilization and water quality management. Clients included American Public Works Association National Academy of Sciences, ORSANCO, The

National Commission on Water Quality, as well as several major industrial clients.

Ohio EPA and Ohio Department of Health - Served as first Director of Ohio EPA. Directed state technical projects and regulatory programs in water pollution control, solid waste, air pollution, drinking water, environmental impact and comprehensive water planning. Supervised a staff of 550, including over 250 engineers and scientists involved in construction grant authorization, "208" and basin planning, resource recovery of solid wastes, water quality and biological lab analyses, air quality monitoring, and many other technical projects in environmental control. In addition to designing and supervising the staffing, budgeting and organization of Ohio EPA programs, was the Agency's principal spokesman and representative with officials of municipal and county governments, and with USEPA. Served as Chairman of the Ohio Power Siting Commission, Commissioner of ORSANCO, Great Lakes Basin Commission, and in the Governor's cabinet. As the Deputy Director for Environmental Programs at the Ohio Department of Health, provided supervision of all state pollution control programs within the Division of Engineering.

Battelle Memorial Institute - Developed and supervised research programs in environmental planning and urban and regional development. Directed projects on environmental evaluation (Bureau of Reclamation), water quality management (EPA), urban water resources (Department of the Interior), mine drainage abatement (Appalachian Regional Commission) and Great Lakes resource management (Battelle).

U.S. Corps of Engineers, Baltimore, Md. - Performed research on urban rivers, flood plains and water quality. Studied water quality and land use problems in six major U.S. cities, Washington, Baltimore, Bridgeport, Milwaukee, Fort Wayne and San Antonio. Worked with local officials in determining the factors which lead to degradation and pollution in urban water resources.

City of Baltimore, Consultant - Consulted on problems of water quality, flooding and recreation. Performed detailed field studies on all streams and park areas in Baltimore, providing detailed recommendations to the Baltimore Department of Public Works on measures for stream protection and improvement.

IRA L. WHITMAN
Page Three

U.S. Corps of Engineers, New York - Performed flood plain management studies and hydrologic analyses on streams throughout the New York-New Jersey area. Developed maps of flood prone areas and recommended measures of flood prevention and protection.

HONORS

Listed in Who's Who in Ecology
Chi Epsilon, Honorary Civil Engineering Society
Jaycees, Ten Outstanding Young Men, Columbus, Ohio 1973

MEMBERSHIPS

Member, Environmental Impact Analysis Research Council,
ASCE
Advisor, Ohio Citizens Task Force on Environmental
Protection
Advisor, National Academy of Sciences Committee on Recre-
ational Water Quality Criteria
Past President, Ohio Section, American Water Resources
Association
American Society of Civil Engineers
American Public Works Association
Water Pollution Control Federation
American Water Works Association
National Water Well Association

PUBLICATIONS

Whitman, I. L., "Environment - 25 Years Ahead," Civil Engineering, January 1976.

Dee, N., Whitman, I. L., et al, "An Environmental Evaluation System For Water Resources Planning," Water Resources Research, June 1973.

Butrico, F. A., Touhill, C. J., & Whitman, I. L., Resource Management in the Great Lakes Basin, Heath-Lexington, 1971.

Ostrom, V., Ostrom, E., & Whitman, I. L., "Problems for Institutional Analysis of the Great Lakes Basin," Proc, Annual Conference on Great Lakes Research, 1970.

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RONALD W. ROBERTSHAW

SENIOR ENGINEER

EDUCATION

Nuclear Power Plant Course, Certificate, Nuclear Power,
1972
Electric Utility Systems & Practices, Certificate, Power
Distribution, 1973
American Management Association Course, Certificate,
Management, 1974

EXPERIENCE

NUS CORPORATION, 1975-Present
Bechtel Power Corporation, 1972-1975
Kaiser Engineers, 1966-1972
Swindell-Dressler Company, 1962-1966
Houser and Carafas Engineers, 1958-1962
Union Switch and Signal Company, 1952-1962

NUS - Responsible for design and engineering of electrical systems for nuclear and fossil power plants and other projects under the cognizance of the Engineering Division.

Bechtel Power Corporation - Physical Group Supervisor, responsible for layout and design of all tray, conduit, lighting and grounding drawings for two 850-MWe nuclear power plant units.

Kaiser Engineers - Senior Electrical Designer, responsible for layout and design including embedded and exposed conduit, tray systems, schematics and interconnections, scheduling and instrumentation for blast furnace, teeming facilities, melt shop, continuous casting machine (2' strand), car type annealing furnace, and services and support facilities.

Swindell-Dressler Company - Electrical Design Draftsman, contract worked included electric arc furnaces, car bottom furnaces, annealing furnaces, kilns, melt shops, malleable furnaces, brick plants, and bus bar details and arrangements. Responsible for layout and design work, instrumentation and control and the ordering of equipment for installation and erection of jobs.

Houser and Carafas Engineering Company - Duties included preparing electrical equipment layout designs, electrical

RONALD W. ROBERTSHAW

Page Two

schematics and interconnections, conduit layout sections and details, conduit and cable schedules and bills of materials.

Union Switch and Signal Company - Duties included layout and design of railway signal systems and air traffic control equipment. Began on wiring diagrams and gained much experience with equipment circuitry.

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