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

Executive Summary for period September 1978—May 1979

MASTER

September 15, 1979

Work Performed Under Contract No. EM-78-C-02-4975

Detroit Edison Company
Detroit, Michigan

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

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EXECUTIVE SUMMARY

Introduction

Early in 1977 Detroit Edison renewed its investigation of cogeneration and district heating. By December of that year, Edison and the City of Detroit had outlined a plan for a district heating project centered around the possibility of cogeneration from Edison's urban electric plants. A team, consisting of Detroit Edison, the City of Detroit, Smith, Hinchman & Grylls Associates, Inc. and EKONO, Inc., was assembled, monies budgeted and work on the project was about to begin when DOE issued its RFP for District Heating and Cooling Through Power Plant Retrofit. A decision was made to respond to the RFP, even though it would mean some redirection of the planned project and a delay in starting.

The team, as assembled for the original project, had been carefully picked to provide the broad base of expertise necessary to fully evaluate district heating, and was the team used for the Phase I work. Detroit Edison, as prime contractor, provided expertise in power plant and steam district heating construction and operation, and in marketing; the City of Detroit provided its records of existing and future land use, of building heating and cooling systems and utility locations, and a direct working relationship with civic and business organizations; Smith, Hinchman and Grylls Associates, Inc. provided its expertise in HVAC systems and land use planning; EKONO, Inc. provided its expertise in hot water district heating systems and power plant retrofit. The team was structured with Detroit Edison assuming the technical management of the project, and with Smith, Hinchman & Grylls as administrative project manager and coordinator.

As noted above, there was a change in direction of the project in response to DOE's RFP. The objective of the DOE project was to assess the feasibility of supplying the energy needs of the community through district heating and cooling. Detroit, like many other large northern cities, also must face supplying the energy needs of its large industrial users which are the basis for community stability and growth. This facet of district heating was a prime consideration in addition to the DOE objective in the original project.

The team as assembled for Phase I has worked well and will be continued through Phase II.

Approach

The analysis performed was divided into six basic steps, or broad catego-

ries, which were developed approximately sequentially. Each step in the process further defined and restricted each subsequent step.

The first step was to identify the service area under the constraint that it be within the City of Detroit and in close proximity to the candidate plant. With the basic service area to be considered established, the load within the service area was defined for the five categories of end-users chosen: general residential, major residential, commercial, institutional and industrial. Parallel to all tasks and continuing throughout the phase, a definition of institutional requirements, including regulatory, legal and licensing aspects of a district heating and cooling project, was carried out to determine the ability of Detroit Edison to own and operate such a project and to define the limitations or problems which may be encountered in the project. The capacity of the retrofitted power plant to supply heating and cooling was determined as a basis for sizing the distribution systems and for determining which end-user loads could be served. The distribution systems were developed on an incremental basis to simulate the actual growth pattern of such a system, and were tested iteratively with the economic analysis to establish the optimum service area to produce the minimum cost to the end-user and a reasonable payback to the system owner. The economic analysis was performed based on matrices of cost parameters which determined the cost to the end-user, return to the system owner, and payback period for the system to determine the economic feasibility of the district heating and cooling system. From the analysis performed in the five steps described above, conclusions were drawn to establish the direction of the project for Phase II and to develop the proposal for continued work.

Definition of the Service Area

The Conners Creek power plant is located approximately six miles east of the central business district of Detroit. A general service area of approximately 13.6 square miles was defined around the plant, bordered by the Detroit River, the City limits, a major expressway, a major surface street, and the existing district heating system as shown in Figure A.

The bulk of the structures in the area are residential (55,545), of which 39 percent are single family homes. Commercial and industrial buildings total 2,397. In general, the industrial structures are small shops requiring no process steam. There are, however, six major industrial plants in the area which do require large quantities of high pressure process steam.

Natural gas is the primary fuel for all classes of structures in the service area. Some light oil is used in the commercial and industrial classes, but accounts for less than 20 percent of the equipment in these classes. Much

Figure A
PROPOSED POTENTIAL
SERVICE AREA

Conners Creek
Potential Service Vicinity

of this equipment has been connected to a dual (oil or natural gas) firing mode in the past few years. Coal firing is almost non-existent in the service area except at the Conners Creek power plant.

The major potential district heating and cooling loads for the area fall along two major corridors: Jefferson Avenue and Conners Avenue. The Jefferson Avenue corridor runs west from the Conners Creek plant to downtown Detroit, parallel to and near the Detroit River. This corridor contains a mix of heavy and light industry, commercial and major residential. The Conners Avenue corridor runs north from the Conners Creek plant to just north of the Ford Freeway, and is primarily industrial. Much of the rest of the service area consists of one and two family homes with pockets of commercial buildings on the major roads.

No major shifts in types of land use are expected in this area; however, the City of Detroit has targeted this area for rehabilitation and redevelopment, with particular attention to land use along the riverfront. The redevelopment includes a number of high rise apartments and townhouses, expanded and new industrial parks, and a community college.

The mix of end-users in the service area requires two different media. To achieve higher load densities as a basis towards reducing costs, other modifications to the Conners Creek plant must be realized and additional plants investigated. Because of the advantages of hot water systems and the need to supply industrial steam, a hybrid system should be investigated.

Definition of Load

Potential customers for a district heating and cooling system were classified into the five broad categories of general residential, major residential, commercial, institutional and industrial. For each category, information on the types of heating and cooling systems, type of fuel, age of the existing systems, and plans for new structures or expansions was obtained through personal contacts, the City Assessor's records, and was verified with street-by-street surveys. The information gathered was compiled and summarized into the 57 census tract areas within the general service area.

In existing heating systems, natural gas and heating oil are almost the only types of fuels used. The market shares of these fuels, as well as the shares of different heating systems for the five building type categories, are collected in Table A.

Table A

Existing Heating Systems and Fuels Used

<u>Building Type Category</u>	<u>Heating System</u>			<u>Fuel</u>	
	<u>Steam %</u>	<u>Hot Water %</u>	<u>Warm Air %</u>	<u>Gas %</u>	<u>Oil %</u>
General Residential	25.0	25.0	50.0	50.0	50.0
Major Residential	70.0	15.0	15.0	50.0	50.0
Commercial	60.0	10.0	30.0	70.0	30.0
Industrial	80.0	20.0	----	70.0	30.0
Institutional	80.0	20.0	----	70.0	30.0

Steam heating systems are predominant in oil type categories except the general residential category where warm air heating system is most commonly applied. This requires the use of district heating transport medium with somewhat higher parameters than are commonly used in Scandinavia.

For the five building type categories, specific heat consumption values were determined as shown in Table B.

Table B

Specific Heat Load Values for Different Building Type Categories
Hot Water/Steam

<u>Building Category</u>	<u>Specific Heat Load Value W/sq. ft.</u>	<u>Peak Load Duration Time h/yr.</u>	<u>Specific Annual Energy kWh/sq.ft. /yr.</u>
General Residential	7.91	1950	15.42
Major Residential	5.57	2320	12.92
Commercial	9.08	2077	18.86
Industrial	5.57/18.08	3424	19.07/102.58
Institutional	9.96	1885	18.77

These values were applied for all of the three building age categories due to the lack of more detailed data.

The heat load of each tract consists of the mixture of different building type categories characteristics to the tract considered. Adding up all buildings that exist or are to be built before the end of the year 2005, give the total sum of the heat load for all the tracts studied as shown in Table C.

The greatest share of heat load as a function of building type for hot water systems is contained in the "general residential" category. This makes the heat load concentration and consumer's unit size quite low. For the steam system the major heat load is in the industrial sector, which results in a much higher heat load concentration.

For the detailed economic analysis, two district heating service areas were developed within the general service area based upon the level of energy available from the power plant and the concentration of end-users capable of being served by that energy. A large dispersed system based upon hot water and a small concentrated steam system were evaluated. The difference in size of the two systems lies in the fact that steam distribution systems are more capital intensive than hot water. For full utilization of a steam system on the scale of the hot water system, additional plants would be required, which was beyond the scope of this work.

For the hot water systems, the district heating load will develop as shown in Table D, based upon the joining schedule of buildings developed. In the year 2005, about 73 percent of the total load in the highest density tracts would be connected to the district heating system.

The steam system's initial load of 870 GWh and a demand of 153 MWe is concentrated in one tract. One additional large block of load can be added to the system from a nearby tract. This system could continue to expand as does the hot water system, but without factoring in the effect of other plants on the direction of system development, the results become uncertain and questionable.

The final heat load densities, reached at the end of the year 2005, are typical to small house residential areas: the highest value about 122 kW/acre for tract number 515 is only a half of the load density typical for district heated Finnish downtown areas.

A steam system has the potential for ten times the load of a hot water system. By the inclusion of the eight major industrial plants in the area that require high pressure process steam, a load of 3,674 GWh/year is available; however, it is not possible to serve this total load from the Connors Creek power plant because of limitations on the plant, and high distribution system losses. The industrial plants offer the high base load necessary

Table C

Total Heat Load of the Area

Hot Water/Steam

<u>Building Category</u>	<u>Floor Area</u>		<u>Heat Load</u>		<u>Annual Energy</u>	
	<u>10⁶ sq. ft.</u>	<u>%</u>	<u>MW</u>	<u>%</u>	<u>GWh</u>	<u>%</u>
General Residential	43.07	57.2/47.5	341	60.7/35.1	664	54.9/18.1
Major Residential	10.85	14.4/12.0	60	10.8/ 6.2	140	11.6/ 3.8
Commercial	7.06	9.4/ 7.8	64	11.4/ 6.6	133	11.0/ 3.6
Industrial	10.61/26.0	14.1/28.7	59/470	10.5/48.4	202/2661	16.7/72.6
Institutional	<u>3.72</u>	<u>4.9/ 4.1</u>	<u>37</u>	<u>6.6/ 3.8</u>	<u>70</u>	<u>5.8/ 1.9</u>
Total	75.31/90.70	100.0	561/972	100.0	1209/3674	100.0

Table D

District Heating Load for Hot Water Systems

<u>Year</u>	<u>Demand MW</u>	<u>Annual Energy GWh</u>
1985	121	148
1986	142	320
1987	164	365
1988	186	411
1989	208	457
1990	229	503
1991	245	542
1992	261	573
1993	277	605
1994	292	637
1995	308	669
1996	319	696
1997	330	718
1998	341	739
1999	352	761
2000	363	783
2001	372	804
2002	381	823
2003	390	843
2004	399	862
2005	408	882

to achieve economic viability. In addition, the potential loss of these plants from the area means the loss of existing revenues.

Institutional Requirements

A broad range of legal and regulatory requirements were assessed to determine the ability to proceed with the district heating and cooling project and to identify problems which may hinder or delay the implementation of the project. The requirements identified are in many cases dependent upon whether the distribution system is owned by Detroit Edison or the City of Detroit. Because Detroit Edison has owned and operated a district heating system throughout its seventy-five year history, the implementation of a new district heating project would not involve breaking new regulatory or legal ground. The corporate charter specifically provides for the ownership and operation of a district heating system.

Regulation of rates and services for district heating has been in place in Michigan since 1921. As a public utility, Detroit Edison is well versed in all facets of the existing regulations and is well staffed to handle the rate cases and financing hearings necessary in the State of Michigan. Although these may be long and difficult processes, they are considered a normal part of Detroit Edison's business.

Similarly, because of the large number of power plants in operation or under construction by Detroit Edison, there is extensive experience in dealing with the federal regulatory agencies, particularly regarding air and water quality and siting. Since the modifications anticipated for the Conners Creek power plant will not change the type of fuel used or its rate of consumption, there will be no effect upon Detroit Edison's existing compliance with the Clean Air Act for the Conners Creek plant. In fact, the implementation of the district heating project would result in a net reduction of air pollution in the area through the elimination of many small sources. A number of potential problem areas were identified relative to existing National Pollution Discharge Elimination Permits and Corps of Engineers Permits relative to changes in the power plant intake structure. However, since no changes to the intake structure are planned, a careful choice of design for the retrofit will avoid these problems.

Many of the permits, and certificates, required are obtained from the City of Detroit. Since Detroit Edison currently operates a district heating system in Detroit and the City is a key member of the demonstration team, obtaining City approval has been and is expected to continue to be a routine matter. This is emphasized by the City's desire to implement district heating and cooling as a development tool.

There are no major institutional problems associated with the systems investigated. Although some potential problems areas have been identified these can be circumvented through a proper choice of power plant retrofit and distribution system designs.

Power Plant Retrofit and Distribution System

Nine retrofit alternatives were analyzed for the Conners Creek power plant, five of which applied to the 150 MW coal-fired, high pressure units, three to the 30 MW and 60 MW oil and gas-fired, low pressure units and one included a new 30 MW live steam inlet back pressure turbine installed parallel with the existing 150 MW condensing turbines. The last alternative produces steam at a pressure level required by large industrial consumers; the other eight alternatives produce steam at a lower pressure level, which is sufficient for district heating of buildings.

The analysis showed that only retrofit of the high pressure turbines is practical from a heat recovery and economic point of view. The low pressure boilers will be considered as a back up steam supply for district heating in the case that the high pressure units are not available.

For district heating of buildings (Scheme 1), only one of the possible power plant retrofit alternatives has been used as a basis for the economic analysis. The criteria for selection of the alternative have been the certainty that the modification can be realized and the cost of heat and retrofitting can be calculated reliably enough. This kind of retrofitting scheme is the extraction of steam for heating from the cross-over pipe of the turbine (Figure B). This scheme has been reviewed by the turbine manufacturer and accepted as an alternative which with some temperature and pressure limitations, requires construction changes only in the cross-over pipe itself.

As a result of the construction limitations, the maximum amount of steam available for one of the 150 MW turbines is 690,000 lb/hr. at 104 psia and an enthalpy of 1,229 Btu/lb. Consequently, the heat recovery ratio is 3.3, which has been used for the calculation of the heat production cost at the plant. This value is very conservative and it is likely that a more detailed analysis would produce a feasible alternative which would give a better heat recovery ratio and thus, lower heat production costs.

By means of the retrofitting alternative selected for the base of the analysis, a 190 MW heat output rating can be obtained for one of the 150 MW turbogenerator units. This results in a derating of the unit to 90 MW electric.

For Scheme 2, process steam supply and limited district heating, where most of the heat load is due to the two large industrial consumers, a new back pressure turbine is installed using steam from the high pressure boilers in parallel with the 150 MW condensing turbines (Figure C). The 150 MW turbines remain untouched, but the electric output is reduced when the new back pressure turbine is running due to the reduction in the available steam flow. An old 60 MW turbine is removed to give place for

Figure B

ONE STAGE EXTRACTION DH-WATER HEATING
FROM TURBINE CROSS-OVER PIPE

NEW 30 MW ONE STAGE
BACK PRESSURE TURBINE

Figure C

the new back pressure turbine. The old generator is connected to the new turbine and utilized with reduced output.

In the case of Scheme 2 the output of one of the 150 MW condensing turbines is down to 60 MW and the new back pressure turbine produces about 30 MWe and 187 MW heat. This gives the heat recovery ratio of about 3.1. The high value can be reached because the turbine can be designed for the conditions required. In the economic analysis a slightly reduced operating value of 3.0 has been used.

Steam as a heat distribution medium is attractive because a very large portion of the consumers have steam heating. Since they do not require a high pressure, steam at a lower pressure level is a feasible alternative. The optimization of the pressure level, in general, is an involved process in which power yield, steam supply and condensate return line costs and applicable transmission distances should be considered.

In this case the steam distribution system has been designed and sized for the maximum pressure level available from the cross-over pipe for the economic analysis. The results show that the pipe sizes even for the reduced service area considered become so large that the distribution system would be more expensive than in the case of hot water system.

Also in the case of the hot water district heating system, a thorough optimization of the supply and return water temperature levels is an involved process. For the economic analysis of this study the temperature levels have been, however, selected based simply on the following facts.

If the heat transmission water in the distribution system has high enough temperature it can be used to produce steam at those consumers who have steam heating systems. This way the expensive replacement of the steam heating system is avoided and hot water district heating can also become attractive for buildings with steam heating. Since the steam pressure in the cross-over pipe is also limited (without major turbine modifications) by the turbine construction to a relatively high level, 302° F (150° C) supply and 212° F (100° C) return water temperatures were selected for the economic analysis of Scheme 1.

These temperatures in a hot water system, as well as steam as a distribution medium, make the utilization of absorption coolers for air conditioning possible, and the centralized scheme can serve as a district cooling system also. The effects of district cooling have not, however, been taken into account in the economic analysis. If feasible, the district cooling would make the economic results more favorable.

In the final analysis the long lasting effect of the initial temperature level selection should be very carefully considered, taking into account its in-

fluence on the power yield of a new combined heat and power plants which will later be built to serve the area.

Since the low pressure section of the Conners Creek power plant can serve as a back up and reserve capacity for the main heat supply system by means of a pressure reduction station, no additional back up boiler capacity has been included in the economic analysis. Because ample peaking and reserve capacity is available, also the heat storage system has been excluded from the economic analysis. Another factor contributing to this decision is the fact that the selected temperature level of the heat distribution system is relatively high ($300^{\circ}\text{F} - 232^{\circ}\text{F}$), thus requiring a pressurized heat storage system. A pressurized heat storage of such a size, which would be beneficial for the district heating scheme considered, would be so expensive that it does not appear economically feasible.

In order to avoid the high investment of a large heat distribution network Scheme 2 comprises an alternative, where steam is supplied to two large industrial consumers and those small consumers located near the industrial ones. The high pressure process steam is produced by a new back pressure turbine, since the modification of the old ones is too complicated and the new turbine can be designed in an optimum way to achieve maximum back pressure power yield with the steam outlet parameters set up by the requirements of process steam consumers.

The pressure of the steam delivered to the consumers is 150 psig (11.34 bar (abs)) and 90 percent of the condensate is assumed to be returned back to the power station.

Cost Benefit Analysis

For Scheme 1, calculations based on the large district heating network covering the total study area show that the district heating from the heat supplier's viewpoint would in this case be profitable only with a large difference between the escalation rates of the cost of individual heating (i. e., price of gas and oil) and of the cost of district heat (i. e., price of coal). Consequently, detailed economic analysis has been carried out for a smaller service area. The tracts included and the district heating mains serving them are presented in Figure D.

The reduced service area consists of those tracts that can be considered the most feasible ones from the point of view of district heating; i. e., the tracts with a high heat load density and a location near the power plant or the proposed route of district heating main trunk lines.

In addition to those tracts, tracts with lower heat load density have also been included in the reduced service area due to their favorable location with regard to the district heating mains.

ΔX

Figure D
Reduced Service Area

In order to avoid the great investment costs of a large heat distribution network the service area in the case of Scheme 2 is limited to two large industrial plants and to those small consumers which are located in the same tracts as the two industrial plants.

The industrial plants are:

- Chrysler Corporation Jefferson Plant in Tract No. 755, and
- Chrysler Corporation Mack Plant in Tract No. 778

The Jefferson and Mack plants are already now connected by an internal steam line so that a part of steam supplied to the Jefferson plant could also serve the Mack plant. Therefore, the supply of steam to the customers requires only a new main steam line from Conners Creek power plant to the Jefferson plant and steam distribution networks in tracts 755 and 778. Figure E shows the service area of the alternative called Scheme 2.

The investment costs required to retrofit the power plant and to install the distribution system were estimated in the case of Scheme 1, district heating of buildings, to be the following:

Power Plant	\$ 10,250,000 per unit
Transmission	\$ 14,870,000
Distribution	<u>\$ 98,340,000</u>
Total	\$123,460,000

All the above cost figures are based on the 1981 cost level and escalated for the calculations to the actual construction year cost level. Of the total cost of \$123,500,000, approximately \$80,000,000 is expended prior to and in the first year of operation. The remaining \$43,500,000 is distributed over the 20-year development period used in the analysis.

In the case of Scheme 2, process steam supply and limited district heating, the investment costs were estimated to be the following:

Power Plant Retrofit	\$13,400,000
Main Steam Line	\$ 4,424,000
Metering Centers for Industrial Consumers	\$ 100,000
Distribution Pipelines	<u>\$10,922,000</u>
Total	\$28,846,000

A base escalation rate of 6 percent was used with a minimum return to the owner of 11.5 percent. The cost of natural gas and No. 2 oil for 3, 6 and 10 percent differential escalation rates used are shown in Table E. Tariffs

for the district heating system were set at \$4.98/MBtu and \$6.15/MBtu and escalated at the same rate as natural gas. For Scheme 1 a joining fee was also applied for end-users to tie in the district heating system at the rates of \$14.65/Btu/hr. demand for general residential and \$29.30/Btu/hr. demand for other categories. In the case of Scheme 2, no connection charges have been applied to the large industrial customers because their present steam boilers are in operating condition and can serve in a peaking and back up capacity.

Table E

Fuel Prices
(\$/MBtu)

<u>D. E. R.</u> <u>%</u>	<u>Gas</u>	<u>Oil</u>
3	4.63	7.09
6	4.89	7.50
10	5.24	8.06

A comparison of the replacement cost for end-user heating and domestic hot water with the cost of conversion to steam and hot water district heating in a "typical building" is shown in Table F. In all cases, the cost of conversion is less than the replacement cost with the greatest differential occurring for the largest systems. Because many of the systems are nearing their life expectancy, it was assumed that the buildings would join the district heating system at the time the heating and hot tap water system was to be replaced, thus eliminating the need for special compensation to join the district heating system.

Table F

End-User Cost for "Typical Building"
in 1979 Dollars

	<u>Replacement</u>	<u>Steam District Heating</u>	<u>Hot Water District Heating</u>
General Residential	\$ 8,925	\$ 3,843	\$ 6,384
Major Residential	\$ 213,750	\$13,500	\$ 170,624

Table F - End-User Cost for "Typical Building" in 1979 Dollars (cont'd.)

	<u>Replacement</u>	<u>Steam District Heating</u>	<u>Hot Water District Heating</u>
Commercial	\$ 24,150	\$ 6,330	\$ 21,630
Institutional	\$ 880,000	\$10,000	\$ 224,000
Industrial	\$1,500,000	\$25,000	\$1,225,000

Although district cooling was not analyzed in detail, the temperature chosen for the hot water system is sufficiently high to employ absorption cooling.

The summary of results can be seen from the economic sensitivity displays showing the payback periods as a function of the differential escalation rate of coal as parameter. Figure F shows the sensitivity display of Scheme 1, district heating of buildings, in the basic case of 17 \$/MWh heat price. The payback periods are rather long in all conditions studied. In most cases they are, however, below 15 years. In the municipal service system such as district heating this, in Europe, is not considered very long taking into account that the operating life of the system can be over 40 years. Also for the municipal service systems money for the investments is normally available in more favorable terms than used in this study.

There are a number of potential benefits to the implementation of district heating and cooling systems which can offset some of the negative results described above; however, they are difficult to quantify in terms of dollars. The higher fuel efficiency of district heating results in a scarce fuel savings of 6.95×10^5 MBtu/year by the year 2005. The replacement of many point sources of emission results in overall improved air quality; a particularly important point in an EPA non-attainment area. For the end-user, district heating offers greater safety and lower operating and maintenance costs. Finally, its implementation offers an economic development tool to the City of Detroit at a time when the future availability of energy is a problem.

The sensitivity display of Scheme 2, process steam supply and limited district heating (Figure G) shows that with district heating price of 17 \$/MWh the payback period are 3 to 6 years and thus, the profitability is good. To study the sensitivity of the profitability to the cost of heat, the calculations have also been made with a 20 percent lower heat price for large industrial consumers.

Figure F
Sensitivity Display

FIGURE G

SENSITIVITY DISPLAY, SCHEME 2

SENSITIVITY DISPLAY, SCHEME 2

SENSITIVITY DISPLAY, SCHEME 2

A hot water district heating system alone is not profitable based upon private investment criteria. In the case of Scheme 1, where the heat load consists of space and domestic hot water heating only, the average heat load density is relatively low due to the type of town plan and buildings in the area. Therefore, the investment cost of the heat distribution system per energy unit supplied becomes relatively high and the scheme does not appear profitable based on the investment criteria of private companies. If the district heating scheme, however, is considered as a municipal service as is the case in most European countries, and corresponding criteria are applied, the district heating is feasible and even profitable in the case of high escalation rates of fuels especially when the very long service life of the distribution system is considered.

The potential for an economic steam system near the Conners Creek plant exists. Development of a district heating island to the north of the Conners Creek plant with the potential for future expansion further north and east along the Detroit River appears economically feasible without special incentives and at reasonable escalation rates for the price of natural gas.

Proposal for Phase II

Based upon the conclusions drawn above, the proposed continuation of the project into Phase II is based upon a redefined service area and the same demonstration team used in Phase I.

The revised service area, as shown in Figure H, was established to produce a more economically viable system through concentration of load to achieve a reduction of cost to the end-user and shorter payback to the system owner. Incorporating the high load areas from the Phase I analysis and the existing system into one integrated system provides a higher reliability of service and an incremental step in development a city-wide system.

The analysis will generate a business development plan with three major components: the Conners Creek power plant; the existing central heating system; and a potential new plant located between these two near the Uniroyal Plant. This approach assures proper line sizing for future expansion and the ability to serve specific areas from more than one plant. The result is Conners Creek as one key anchor point on the system.

The load for the revised area will be developed by concentrating on the dense load areas in the major residential, commercial, institutional, and industrial categories. Intensive onsite data gathering, much as used in Phase I, will be employed to firmly establish the quantity and types of energy required by the end-users.

Figure H
PROPOSED POTENTIAL
SERVICE AREA

Conners Creek
Potential Service Vicinity

A redefinition of system capacity will be made based upon, 1) a re-evaluation of the Conners Creek plant, 2) an evaluation of the applicability of existing industrial and heating boilers, and 3) an evaluation of the capacity and location of new plants to meet the needs of the end-users. Both steam and hybrid (combined hot water and steam) distribution systems will be considered to achieve minimum cost to the end-user and highest market penetration with a reasonable payback period. An analysis will also be made of the impact of district heating upon future development in the City of Detroit.

The results of the institutional analysis performed in Phase I will be reviewed to define areas requiring future analysis and to establish guidelines for implementation of the district heating and cooling systems. By the completion of Phase II, a determination of distribution system ownership will be made, and financial arrangements based upon the ownership established. Preliminary approvals necessary to begin design and construction will also be obtained.

A cost-benefit analysis will be performed based upon the results of the analyses described above, similar to that performed in Phase I but in greater detail. Using the financial parameters established as a basis for profitability to the system owner, and a cost to the end-user competitive with natural gas, consumer inducement programs will be developed to fill the gap between these two basic requirements.

Finally, the project design and construction schedules will be outlined for implementation.

There are three possible approaches to achieving economic viability for district heating in Detroit. A number of small island systems can be built based upon use of service to a specific area, or the service area analyzed can be integrated with the existing district heating system as a basis for building a city-wide system.